PRODUCTION AND NUTRIENT CYCLING IN THREE SCOTTISH OAK WOODS ON CONTRASTING SOILS.

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ABSTRACT

Studies were made in three ancient Scottish Oak woods on contrasting soils: Ross (podzols) and Gartfairn (gleys) near Loch Lomond, and Methven (brown earths) near Perth. The annual rainfalls (mm) are : Ross and Gartfairn, 1700; Methven 700. Soil nutrient (0-10 cm) contents were ranked Methven> Gartfairn> Ross> except for total nitrogen which was Gartfairn> Methven> Ross. Each wood was sampled from three 1000 m^2 plots. Tree (≥ 5 cm dbh) density and basal area were : 343 ha^{-1} and 21.7 m^2 ha^{-1} for Ross; 410 ha^{-1} and 30.4 m^2 ha^{-1} for Gartfairn; and 280 ha^{-1} and 37.8 m^2 ha^{-1} for Methven. Small litterfall, measured in eighteen traps per plot, had mean values (kg ha^{-1}): Methven, 5368; Gartfairn, 4476; and Ross 3607. The values are in the same rank order as soil nutrients (except nitrogen). Litter layer mass was highest in Ross and least in Gartfairn while its nutrient content (for all elements) was least in Ross and highest in Methven. The turnover rates (k_L) of litter mass and nutrients were least in Ross and (except for nitrogen) highest in Gartfairn. Studies of leaf decomposition were made in bags of two mesh sizes (64μ and 5mm) of 144 cm^2 and in open frames of 225 cm^2. Leaf mass was lost fastest in the frames and slowest in the fine mesh, except for Ross where there was no difference between the two meshes. Coarse-mesh decomposition was fastest in

Gartfairn and slowest in Ross; fine-mesh decomposition was fastest in Ross, slowest in Methven. There was a linear relationship between mass of litter lost and time elapsed. The litter mass losses were often significantly correlated with the initial nutrient content. Patterns of nutrient accumulation and release differed between elements, sites, and containers. Nutrients were usually released faster in coarse-mesh compared with fine-mesh bags.

CHAPTER 1

INTRODUCTION : AIMS, STUDY SITES AND PLOTS

Although an understanding of production and nutrient cycling remains a key part of understanding ecosystems there is surprisingly little information available on these topics for Scottish woodlands. The surviving Scottish Oak (*Quercus* sp.) woodlands represent an important type and although managed and much modified, some examples are amongst the closest to primeval broad-leaved woodland still extant in Scotland. The surviving woods occur under a range of climates and on a range of soil types. My first aim in this thesis was to look at one aspect of production, that of litterfall, and to quantify its contribution to nutrient cycling in three contrasting Oak woods. My second aim was to look at the turnover times of the litterfall by calculating k_L values from the relationship between litterfall and litter layer mass and nutrient composition. Thirdly I aimed to look at litter disappearance from the measurement of litter loss from bags of two sizes. The three aims are to be seen in the context of a comparative study between the woodlands on contrasting soil types.

1.1 *THE STUDY SITES*

1.11 LOCATION

The choice of site was determined by considerations of: old woodland; contrasting soil types with the other sites; dominance of Oak; accessibility from Stirling; low altitudes (<90 m); slopes <20°; and permission from landowners for access. Two of the chosen sites (Gartfairn and Ross Woods) were on the east bank of Loch Lomond whilst the third (Methven Wood) was near Perth.

Ross Wood (NGR NS371959)is situated on Ross Point (10 - 93 m above mean sea level (a.s.l.)). It is on a podzolic soil, which is developed on glacial drift, and which is very stony in places and gleyed or peaty in hollows. Oak is by far the most abundant tree with a few individuals of Birch (*Betula* sp) and Rowan (*Sorbus aucuparia*).

Gartfairn wood (NGR NS439896) is on the northeast of the mouth of the river Endrick. It is located in a low-lying area 9-10.5 m a.s.l. on an alluvial soil which is gleyed and often water-logged in the lower parts of the site. These are flooded by the river Endrick during high rainfall periods and inundated by storm waves from Loch Lomond when its water level is high. The average water level in the Loch, which is regulated by a barrage built in 1972 across the River Leven, is 7.9 m a.s.l. with recorded fluctuations between 7.20 - 9.15 m a.s.l. during 1973-80. The level is highest in January and reduces gradually to its lowest in July (Alexander 1986). Oak is the dominant tree in Gartfairn and there is abundant Birch.

Methven Wood (NGR NO057262) (60 -91 m a.s.l.) is located to the west of Almondbank (near Perth) and is on a typical brown forest soil. Oak is the dominant tree with some Birch and Hazel (*Corylus avellana L.*).

1.12 HISTORY

Ross, Gartfairn and Methven Woods are old plantations (Tittensor 1969; Cameron 1986; Hobson 1988).

Ross, as a part of the Buchanan Wood, was acquired by the Montrose family in 1682 and was managed as coppice from about 1700 until about 1920. On early maps of Ross Point, woodland is shown as fringe only, but an Ordnance Survey map of 1864 shows that conifers had been planted in the centre (Mitchell 1973).

Gartfairn Wood dates from the late eighteenth or early nineteenth centuries. Ainslie's (1788 map) (cit. Cameron 1986) had shown the area of Gartfairn to be farming land, of which traces of ridges and furrows are still seen. An estate account book of Montrose muniments shows payment for enclosing the plantations at Gartfairn with hedges and drainage ditches, shortly after the time Ainslie's map was produced (Cameron 1986).

Both Ross and Gartfairn were managed on a 24-year rotation of Oak coppice with standards to provide bark for the leather tanning industry and wood for a 'pyroligneous acid' factory at Balmaha (Idle 1974). After several rotations the land was planted with acorns or Oak seedlings which were often imported and were most probably *Quercus robur* rather than the indigenous *Quercus petrea*. There may have been introgression between the exotic and native Oaks (Tittensor 1969) but this is by no means the certain cause of the difficult taxonomic status of the Loch Lomond and many other Scottish Oaks (Cousens 1963). The coppice system declined from the mid - 1800's because of low bark and timber prices and was completely abandoned by 1920. The woodlands were used for grazing and game cover later (Mitchell 1973). Many of the standard trees were felled during the two world wars (Anderson 1967).

Ross Wood was purchased by the Forest Commission as a part of the Rowardennan forest in 1951. It was reenclosed and much of the wood (not including the study sites) was planted with exotic conifers in the 1950's. These are now being removed. In 1953 Ross Wood was declared part of the Queen Elizabeth Forest and in 1971 was included in the new Buchanan forest (Mitchell 1973). Ross Wood is not grazed by domestic animals but there are many deer. Gartfairn Wood was included within the Loch Lomond National Nature Reserve on 8 June 1974 and domestic grazing animals have been excluded from it since then but deer are common.

Methven Wood has documented evidence from the fourteenth century. The area had been under continuous woodland cover since primeval times but the native stock was augmented by tree planting on a large scale after 1644 after the Methven estate had passed into the hands of the Smythe family. Planting continued in the late eighteenth and early nineteenth centuries and after 1744 *Quercus petraea* was added to the original stock that was said to be *Quercus robur* (Hobson 1988). The woodland was managed in a coppice system, the traces of which are still apparent. In 1979 this wood was declared a Site of Special Scientific Interest (Hobson 1988). Domestic animals are excluded but it is grazed by deer. Exotic trees are now being removed from the wood.

1.2 *THE STUDY PLOTS*

Within the Oak-dominated stands in each of the woodlands, three square plots of 33.3 x 33.3 m were marked out. Plots 1-3 were in Ross, 4-6 in Gartfairn and 7-9 in Methven. A correction for slope was made to make sure that the surface of each plot was 1000 m^2 on a horizontal projection. Altitude, aspect and slope of the plots are given in Table 1. Each plot was divided into nine 11.1 x 11.1 m sub-plots.

Table. 1 The site, altitude, aspect and slope of the nine 33.3 x 33.3 m plots.

Wood	Plot	Altitude m (a.s.l.)	Aspect	Slope (°)
Ross	1	19-25	S.W	11
	2	79-83	E	15
	3	55-58	N.NW	8
Gartfairn	4	9-10	W	<1
	5	9-10.5	W	<1
	6	9-10	W	<1
Methven	7	79.9-82.5	W.SW	7
	8	80.6-83.7	SW	9
	9	64.1-68.2	SW	10

CHAPTER 2

THE CLIMATE, SOILS AND VEGETATION

2.1 *CLIMATE*

Climate was assessed from the data of the stations nearest to the study sites. For Ross and Gartfairn climatic data were available for 1972 -1988 from Arrochymore (30 m a.s.l.) which is 6 km south east of Ross and 3.8 km north west of Gartfairn. For Methven, records for two stations: 1971-1979 from Perth (23 m a.s.l. and 3.5 km ESE of the site) and 1983-1988 from the Aerodrome (118 m a.s.l. and 10.5 km ENE of the site) were assessed. The rainfall and temperature data arc summarised in Figures 1 and 2.

Average annual rainfall is much higher in Arrochymore (1688 mm) compared with Perth (655 mm) and the Aerodrome (767mm). Most rainfall occurs in November for Arrochymore and January for the Perth stations (Figs 1 a & b). The driest month is April at all stations.

Mean, mean minimum and absolute minimum temperatures at Arrochymore (Fig 2a) were higher than at the Perth stations (Fig 2b) during November to March. February had the lowest mean monthly minimum temperature in all stations but the absolute minimum of -11.9 °C at Arrochymore (1982), -14.9 °C at Perth (1974) and -17 °C at the Aerodrome (1984), occurred in January. Mean maximum temperatures were not significantly different between the stations and the absolute maximum (occurring in July) was slightly higher at Arrochymore (30 °C in 1983) following

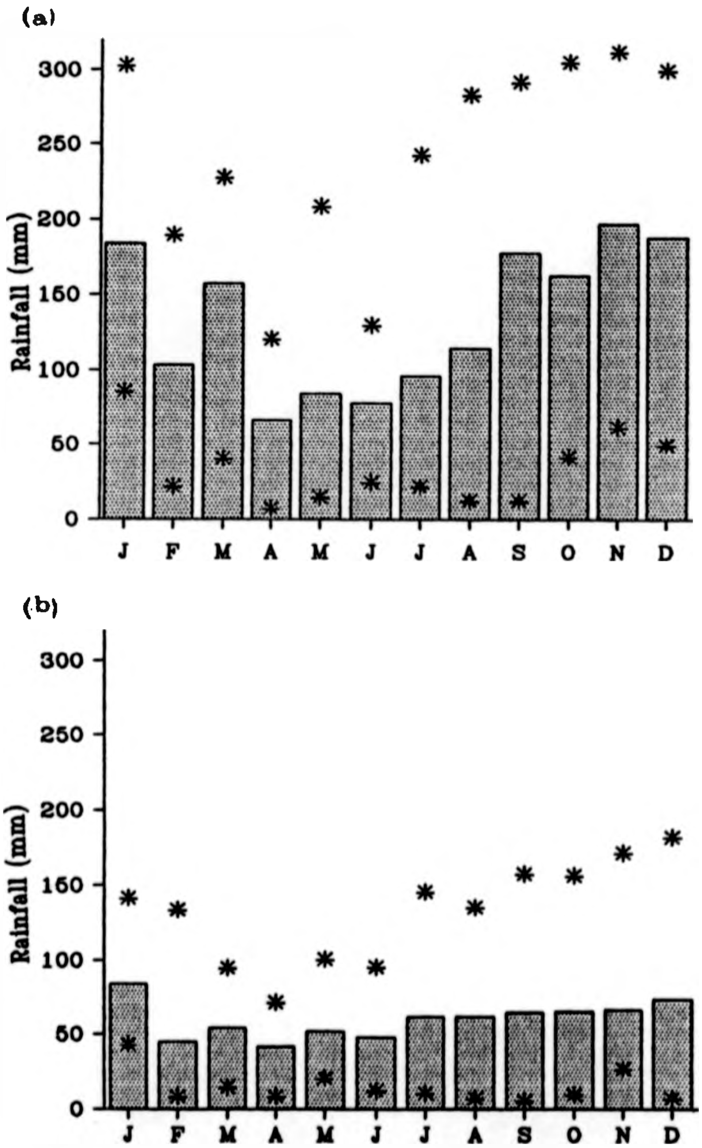


Fig. 1. Mean monthly rainfall for (a) Arrochymore (1972-1988) and (b) Perth (1971-1979, and 1983-1988) The asterisks indicate the highest and least rainfall recorded for the month.

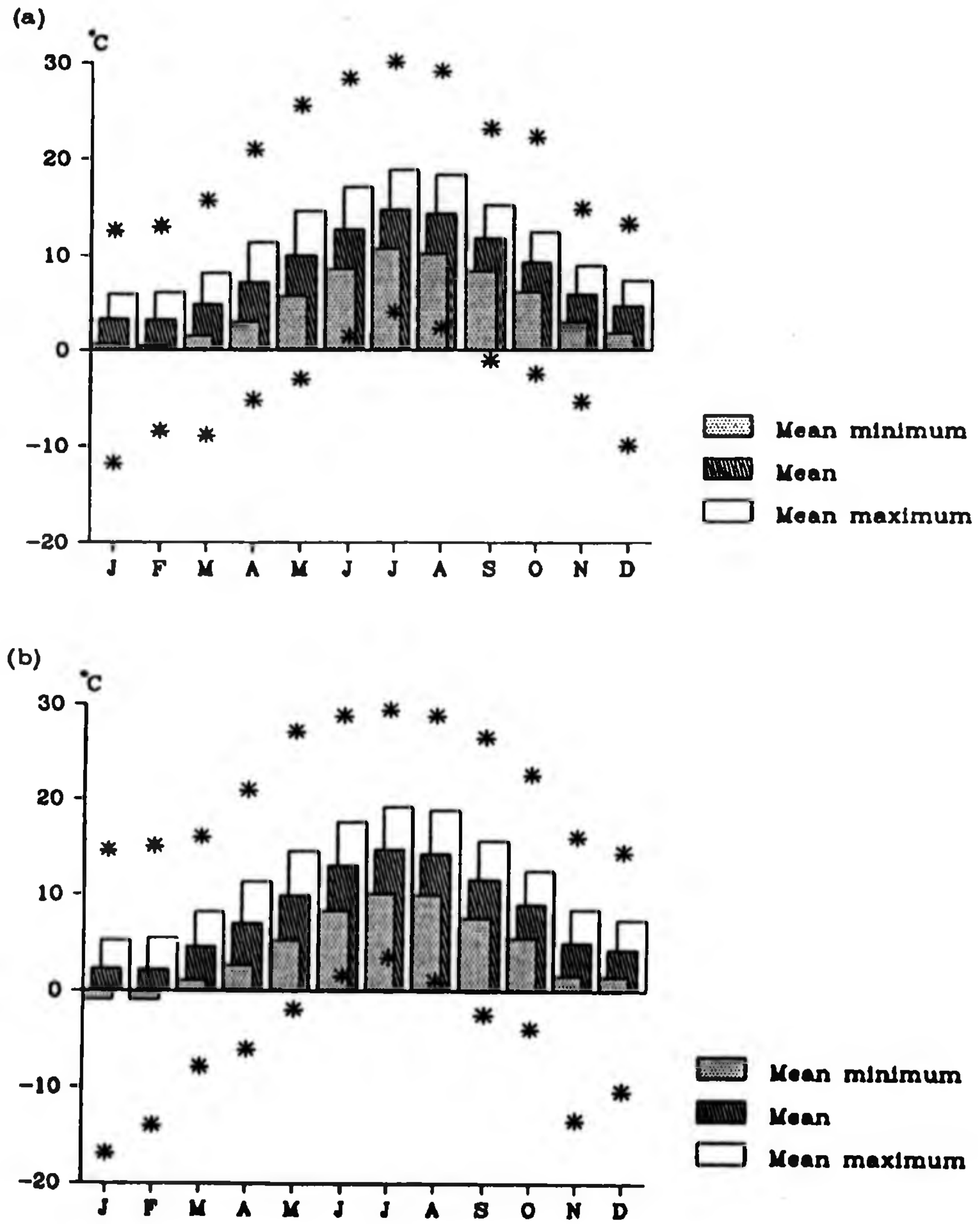


Fig. 2. Mean monthly temperatures for (a) Arrochymore (1972-1988) and (b) Perth (1971-1979, and 1983-1988) The asterisks indicate absolute (daily) maximum and minimum for each month.

Perth (29.4 °C in 1972) and the Aerodrome (28.8 °C in 1983).

Based on accumulated temperature above 5.6 °C, potential water deficit, exposure and accumulated frost Ross Wood and Gartfairn were described as 'warm wet' and 'warm rather wet' respectively and both as 'lowland, moderately exposed with fairly mild winter' while Methven Wood is 'warm rather dry lowland, sheltered with moderate winter' (Birse & Dry 1970 and Birse & Robertson 1970). The bioclimatic map for Britain (Birse 1971) shows Ross Wood as 'extremely humid northern temperate', Gartfairn as 'very humid northern temperate oceanic' and Methven Wood as 'humid northern temperate hemioceanic'.

2.2 *SOIL*

2.21 MATERIALS AND METHODS

Sample collection and treatment

Soils were studied from profiles and surface samples. Pits were dug and samples were collected during September and October 1988.

Soil pits

One soil pit (0.5 x 1 m and about 1 m deep) was dug about 1 m outside the boundary of each of plots 4-9. On Ross Wood because of steeper slopes two pits were dug near the highest and lowest points on each of plots 1-3. All the pits were described following Hodgson (1976). One pit per plot was used for bulk density measurement and chemical analysis.

For bulk density measurement a single sample of 10 x 10 cm was removed from 0-10 and 20-30 cm depth from each pit using a box corer. The sample was air-dried and weighed intact. For chemical analysis three samples were taken from each horizon of the soil pits using a corer of 5 cm diameter inserted horizontally for 7 cm.

In pits where there was standing water the water levels were measured on several occasions below the highest corner of the soil pits from September 1988 until November 1989.

Surface soils

Surface soils were investigated by taking one sample at random using a box-shaped sampler of 10 x 10 x 10 cm from the top of each sub-plot (nine samples per plot). To avoid compressing the soil a sharp knife was used to cut along the edge of the sampler during insertion. One to four of these samples in each plot were measured for bulk density.

Sub-samples of all pit and surface samples were air dried, ground using a mortar and pestle and sieved through a 2 mm mesh. Sub-samples were taken and oven dried (80 °C) to enable results to be expressed on this basis where appropriate.

Chemical analysis

pH was measured in a 1:2.5 soil : water suspension and also (except for some of top 10 cm samples, appendix

1C) in a similar proportion in 0.01 M $CaCl_2$. For soil samples with a high content of organic matter (> 50% loss-on-ignition) the pH was measured in a 1:20 w/v soil : water suspension. Sub-samples were oven-dried and ashed at 375 °C for 24 h to calculate the loss-on-ignition of each sample. Exchangeable K, Na, Ca and Mg were determined from 5 g sub-samples, leached with 100 ml of 1 M ammonium acetate using leaching tubes (Avery & Bascomb 1974) and analysed using a Perkin Elmer 303 spectrophotometer. Potassium and sodium were measured by emission and magnesium by absorption. Calcium was measured by emission-and several samples also by absorption (there were no differences in the results for emission and absorption). An air-acetylene flame was used except for calcium where a nitrous oxide-acetylene flame was used. 0.5 g air dried soil sub-samples were digested in a mixture of 6 ml concentrated sulphuric acid and 3 ml hydrogen peroxide using a selenium catalyst by the method of Allen *et al* (1974) and analysed for total nitrogen and phosphorus colorimetrically by an auto-analyser technique (Technicon Industrial Systems 1976).

Statistical treatment

A nested method of analysis of variance was employed to compare surface soil samples within and between the sites.

2.22 RESULTS

Soil pits

All the profiles (seven in Ross, three in Gartfairn and three in Methven) are described (pp. 13-15 and appendix 1A).

At Ross the soil is highly acid and organic in the upper horizon, shallow in places, stony with boulders, sandy-clay-loam textured in the lower horizons and is typically podzolic. Most parts of the study plots are well drained except in hollows which are peaty (profile 3c).

Comparing soil pits 1a (uphill) and 1b (downhill) on plot 1 the transfer of iron, aluminium and clay from the upper horizons downward and also down the slope was evident (I.C. Grieve personal communication). These transformations (observed as changes in colour) were also seen in plot 2 (between profiles 2a and 2b) and plot 3 (between profile 3a and 3b).

At Gartfairn the soil is mostly waterlogged, slightly peaty with a weak podzolization in places (profile No. 4) and more strongly peaty in the lower parts of the forest. The texture is sandy loam with changes to fine sand in the lower horizons. The land was permanently waterlogged in a few places (due to impeded drains) and abundant rubbish showed that the soil had been submerged on the lower parts of plots 4 and 6.

Profile description for one soil pit in each of Ross, Gartfairn and Methven woods (the rest of the profile descriptions are given in appendix 1A). The terminology and code numberings are from Hodgson (1976).

Profile No: 1a

Location : Plot 1 (top of slope), Ross Wood.

Altitude : 25 m. Slope : 11°. Aspect : S.SW.

Soil type : Podzolic.

Horizons

L Few mm	Litter layer almost complete Oak leaves on the top with some broken down underneath.
F&H 0-15 cm	Black colour (5YR 2.5/1), very organic without stones. Roots were woody mixed with fibrous, sized (1 to 4) and with an abundance of (4).
H 15-17 cm	Reddish black colour (10R 2.5/1) mor humus, silty loam texture, stone size and abundance are (1 to 2) and (1) respectively. Root size (1 to 3) and abundance (4).
Ea 17-20 cm	Reddish grey colour (10R 6/1). Leached eluvial of iron and humus. Texture is loamy sand, stone size (2 to 3),abundance (1), with root size and abundance(1 to 3) and (3) respectively.
Bh 20-45 cm	Strong brown (7.5YR 5/6). Enriched in iron transferred from top layers. Loamy sand with stone size (2 to 3), abundance (2). Root size (1 to 3) and abundance (2).
BC 45-85 cm	Olive brown (2.5Y 4/4). Sandy loam with stone size (1 to 3),abundance (3). Root size (1 to 3), abundance (1).
C (85 cm)	Light brownish grey (2.5Y 6/2). Compact sandy loam.

The soil pit was dry on all sampling visits indicating a low water table and high permeability.

Profile No : 4

Location : Plot 4, Gartfairn Wood.

Altitude : 10 m. Slope : 0-1°. Aspect : West

Soil type : Peaty weakly podzolic, with gleying

Horizons

L	Thin layer of dead (Oak and some Birch) leaves. Plastic and glass bottles and other waste materials, driven by waves are indications that lower part of the plot had been flooded.
F&H 0-10 cm	Black colour (5YR 2.5/1), mor humus slightly peaty sandy loam texture and stones are rounded to sub-rounded shape with size and abundance of (1 to 3) and (1) respectively.Roots are of woody, fibrous and fleshy nature with size and abundance of (1 to 3) and (1) respectively.
Ah 10-22 cm	Dark brown (10YR 3/3), sandy loam texture. stones are rounded to sub-rounded shape with size and abundance of (1 to 3) and (2) respectively.Roots are of woody and some fibrous nature with size and abundance of (1 to 3)and (2) respectively.
Eb(g) 22 cm	Colour is a mixture of three major mottling with almost the same abundance within a background of strong brown colour (7.5YR 5/6). The mottlings are grey (5Y 6/1), dark reddish brown (5YR 3/4) and some dark red (10R 3/6). Fluctuation of water is usually within this layer and causes a patchy reduction of iron. Texture is variable from sand with very low clay on some points to sandy loam and clay loam on the others. This is originally a non calcical glacial till from Devonian sand stone. Stones are of rounded shape of schist and other metamorphics with size and abundance of (1 to 4) and (3) respectively.

Profile No : 9

Location : Plot No 9, Methven Wood.

Altitude : 65 m. Slope : 10°. Aspect : S.W.

Soil type : Brown forest soil.

Horizons

Ah 0-10 cm	Dark brown (7.5YR 3/2), clay loam texture, with rounded and sub-rounded stones sized (1 to 2) with abundance of (1). Roots are woody, fibrous and a few fleshy, sized (1 to 4) with abundance of (2). Earthworm activities (casts) are common. Rabbits and hare activities, as burrows, through which the top soil is mixed with the lower horizon can be seen.
Bs 10-65 cm	Reddish brown (5YR 4/4), clay loam texture, with rounded and sub-rounded stones sized (1 to 4) with abundance of (1). Roots are woody with few fleshy, sized (1 to 3) with abundance of (2). Signs of rabbit burrows, filled with surface organic matter and casts of earthworm, are also seen within the top 15 cm of this horizon.
Cgf 65-98 cm	Dark reddish (5YR 4/3), clay loam texture, with rounded and sub-rounded stones sized (1 to 5) with abundance of (1), originally glacial till.

Methven Wood has uniform deep brown forest soils with a clay loam texture and considerable signs of faunal (rabbit, hare and earthworm) activity. The soil surface is drier than the other woods and the leaf litter layer is easily blown and is discontinuous (not seen as a significant L horizon on the edge of the soil profiles).

Standing water was recorded in the pits: at Ross , pits 1a, 1b and 3a never had standing water while 2b and 3b had water on one occasion only: (2b had water at 68 cm depth on 8 October 1988, 3b at 80 cm depth on 21 December 1988); Ross pits 2a and 3c, and all the pits at Gartfairn and Methven had standing water on many sampling occasions

(Table 2). Only Ross pit 3c (on one occasion) and Gartfairn pits 4 and 6 (more or less continuously from 5 September 1988 until 5 April 1989) had water within 35 cm of the soil surface.

Table 2 Water depth (cm below the highest corner of the soil pits) in two pits at Ross, and all pits at Gartfairn and Methven. D denote dry; - no measurement.

Ross			Gartfairn				Methven			
Date (1988-89)	2a	3c	Date (1988-89)	4	5	6	Date (1988-89)	7	8	9
16 Sep	50	35	5 Sep	16	53	31	13 Sep	-	67	83
8 Oct	40	31	15 Sep	36	74	50	18 Sep	69	87	83
12 Oct	55	40	09 Oct	10	61	28	20 Oct	60	58	40
31 Oct	60	48	13 Oct	35	71	39	2 Nov	67	70	57
20 Nov	50	40	01 Nov	30	69	35	24 Nov	62	68	55
29 Nov	50	45	22 Nov	22	62	32	20 Dec	74	70	58
21 Dec	53	42	31 Jan	20	67	31	30 Jan	68	61	55
1 Feb	57	46	25 Feb	18	65	30	25 Feb	69	61	54
16 Mar	56	46	15 Mar	24	70	31	29 Mar	65	60	54
4 Apr	57	48	5 Apr	30	75	32	22 Apr	70	65	60
10 May	75	D	25 May	D	D	D	18 May	80	85	85
16 Jun	60	D	17 Jun	D	D	D	15 Jun	D	D	D
17 Jul	60	44	15 Jul	60	95	75	21 Jul	D	D	D
23 Aug	58	40	23 Aug	55	75	70	23 Aug	D	D	D
22 Nov	56	43	23 Nov	40	75	45	21 Nov	D	D	D

In Gartfairn signs of a flood were noticed in parts of the plots 6 and 4 in February 1989.

Bulk density

The 10 cm top soil bulk densities (Table 3) in Ross were low (due to a high content of organic matter) and varied greatly between plots. Methven by contrast had the highest bulk densities and the lowest variation between plots. The bulk densities of the soils at 20-30 cm depth are all higher than the corresponding surface (top 10 cm) soils and the differences are high at Ross and low in Methven. Gartfairn had the densest soils at the greater depth.

Table 3 Soil bulk density (g dry weight / cm^3 of fresh soil) of top 10 cm and 20-30 cm depth. Mean values are given with the values for individual samples (except when n = 1) in parentheses.

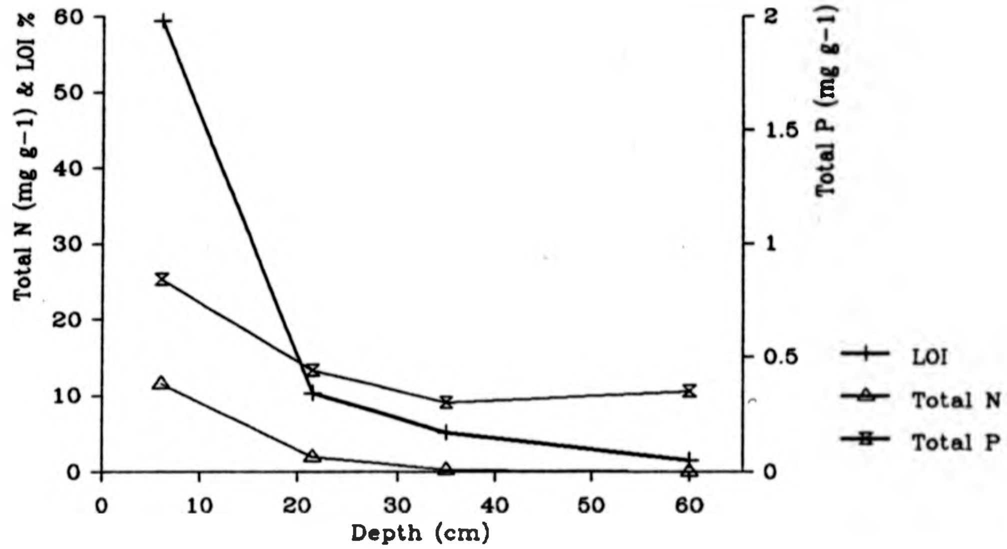
Wood	Plot	0-10 cm	20-30 cm
Ross	1	0.16 (0.16, 0.16)	1.04
	2	0.36 (0.38, 0.35, 0.34)	0.90
	3	0.24 (0.29, 0.28, 0.13)	1.07
Gart-fairn	4	0.68 (0.57, 0.67, 0.79)	1.61
	5	0.59 (0.57, 0.78, 0.36, 0.66)	1.70
	6	0.63 (0.66, 0.54, 0.56, 0.74)	1.19
Meth-ven	7	0.98 (1.03, 1.03, 0.87)	1.21
	8	1.05	1.49
	9	0.86	1.34

Soil pit chemistry

Loss-on-ignition (LOI) and all the nutrients decreased with depth at the three sites except for exchangeable Ca and Mg at Methven which showed an increase in the deeper soils (Fig 3, Tables 4.1 to 4.9, appendixes 1B and 1C). The decrease with depth in LOI and nutrients and the increase in pH is sharpest at Ross.

Fig. 3. Changes in soil loss-on-ignition (%), total N & P (mg g^{-1}) (up), exchangeable K, Na, Ca & Mg (m equiv. kg^{-1}) and pH (log units) (down), with depth in Ross (a), Gartfairn (b) and Methven (c). The corresponding plots and profiles are shown.

Fig. 3a. Ross (plot 1, profile No. 1 a)



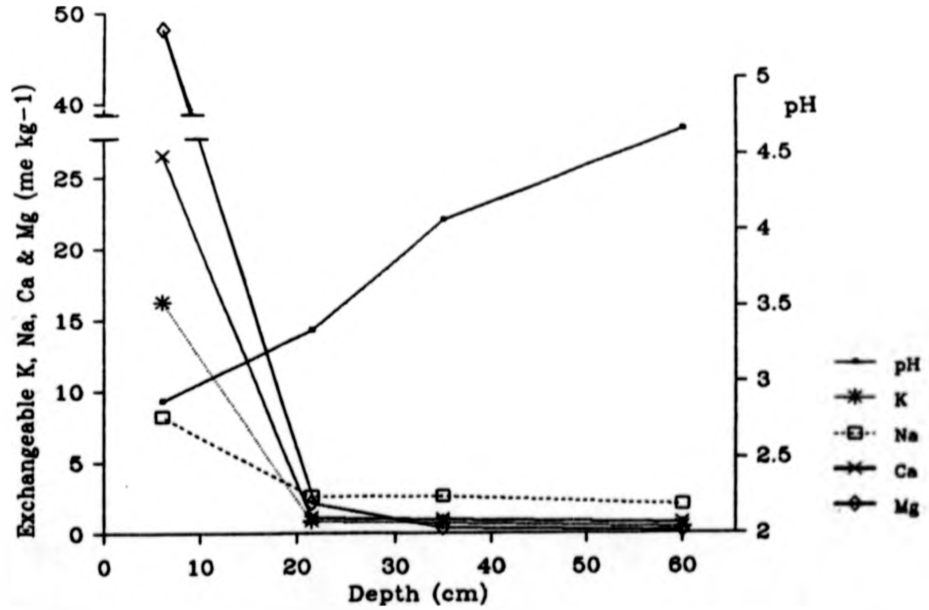
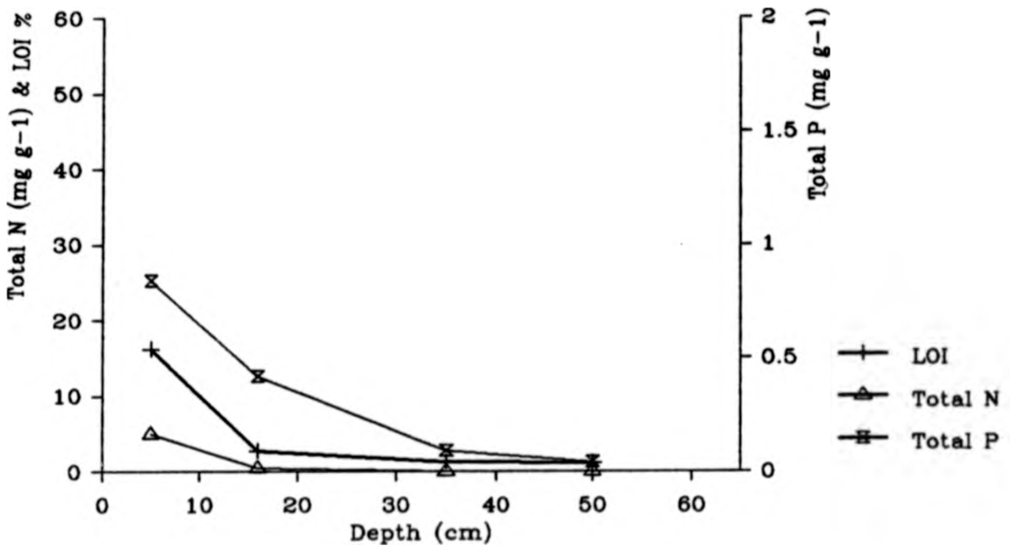


Fig. 3b. Gartfairn (plot 4, profile No. 4)



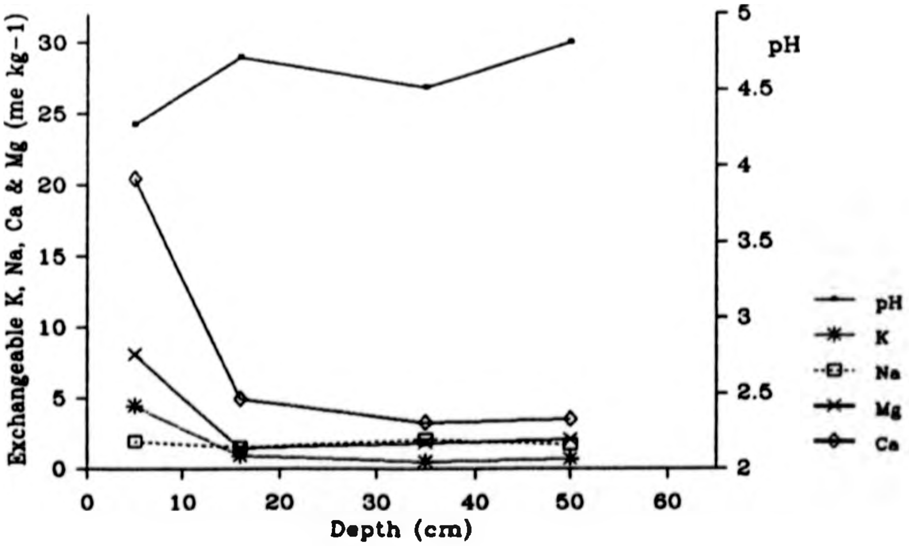
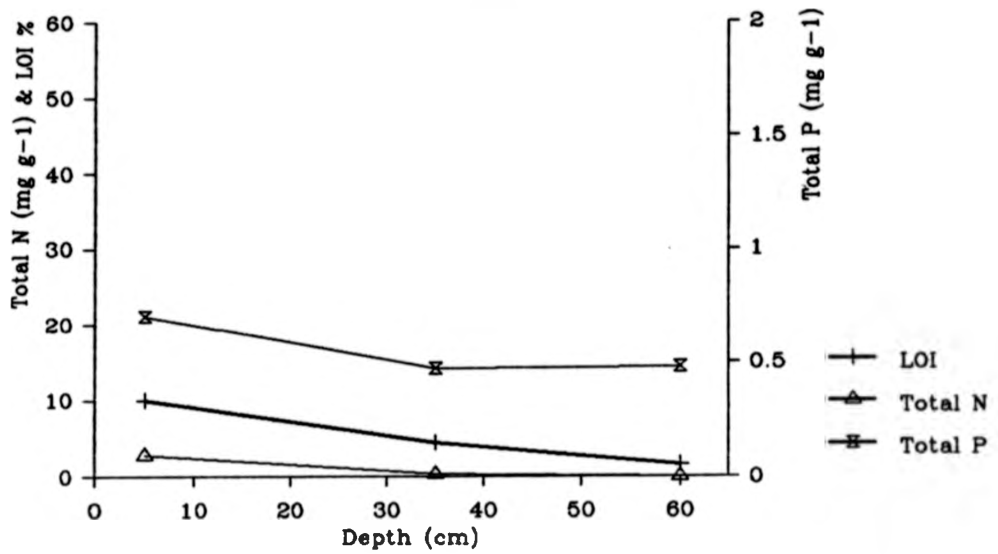
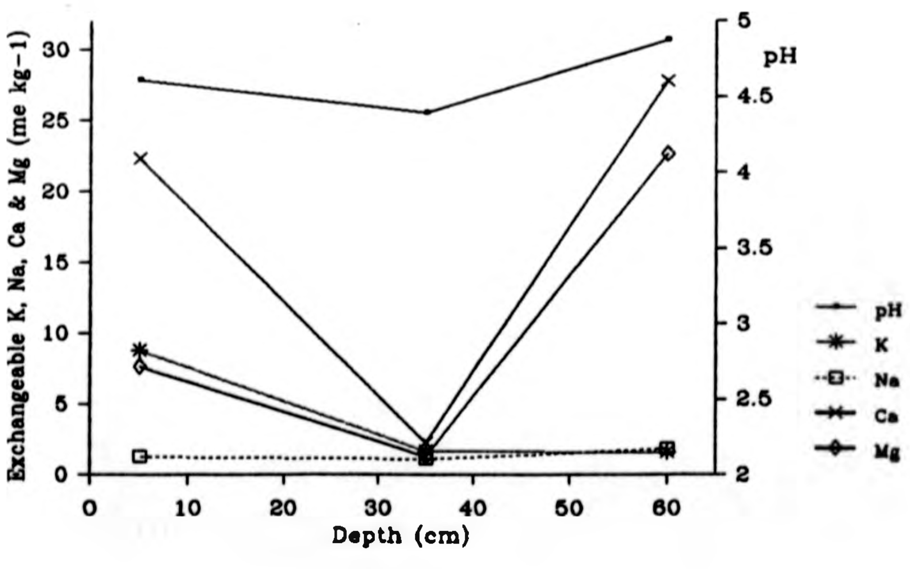


Fig. 3c. Methven (plot 7, profile No. 7)





Tables 4.1, 4.4 & 4.9 (4.2, 4.3 & 4.5-4.8 in appendix 1B) show analytical data (pH, loss-on-ignition, exchangeable cations and total nitrogen and phosphorus) for the profiles. Values are means (± S.E.) (_n_ = 3) and expressed on an oven dry (85 °C) basis where appropriate. (ND means not determined)

Table 4.1 Soil analytical data for profile No 1a at Ross.

Horizon	F&H	Ea-Bh	Bh	BC
Depth (cm)	2-10	18-25	30-40	55-65
pH in water	2.9±0.03	3.3±0.03	4.1±0.04	4.7±0.01
pH in CaCl2	ND	ND	ND	ND
L.O.I %	59.4±16.0	10.2±2.32	5.14±0.51	1.52±0.38
Exchangeable	cations (m-equiv/kg)			
K	16.3±5.01	0.88±0.12	0.71±0.03	0.41±0.10
Na	8.19 1.01	2.61 0.32	2.62 0.45	2.01 0.11
Ca	26.5 10.8	1.10 0.10	0.99 0.14	0.76 0.04
Mg	48.2 14.3	2.12 0.55	0.35 0.00	0.17 0.00
Total (mg g^{-1})				
N	11.6±2.21	1.91±0.67	0.27±0.04	0.00±0.00
P	0.84 0.01	0.44 0.04	0.30 0.01	0.35 0.03

Table 4.4 Soil analytical data for profile No 4 at Gartfairn

Horizon	F&H	Ah	Eb(g)	Eb(g)
Depth (cm)	1-9	12-20	30-40	45-55
pH in water	4.3±0.09	4.7±0.03	4.5±0.01	4.8±0.05
pH in CaCl2	3.8 0.09	4.2 0.04	4.2 0.04	4.3±0.04
L.O.I %	16.2±2.08	2.75±0.64	1.31±0.05	1.10 O
Exchangeable	cations (m-equiv/kg)			
K	4.49±0.41	0.91±0.21	0.49±0.15	0.69 O
Na	1.96 0.24	1.49 0.11	2.05 0.23	1.71 O
Ca	20.4 0.63	4.93 1.54	3.24 0.80	3.52 O
Mg	8.07 0.29	1.47 0.46	1.82 0.79	2.05 O
Total (mg g^{-1})				
N	4.99±0.90	0.49±0.22	0.00±0.00	0.00 O
P	0.84 0.08	0.42 0.06	0.09 0.03	0.04 O

O= One sample only

Table 4.9. Soil analytical data for profile No 9 at Methven.

Horizon	Ah	Bs	Cgf
Depth (cm)	2-8	30-40	55-65
pH in water	4.4±0.09	4.6±0.02	4.8±0.03
pH in CaCl2	3.9 0.08	4.1 0.02	4.3 0.04
L.O.I %	9.16±0.05	4.10±0.23	1.87±0.13
Exchangeable cations (m-equiv/kg)			
K	4.60±0.70	0.96±0.06	1.18±0.11
Na	1.74 0.19	1.58 0.03	2.03 0.40
Ca	9.59 5.35	2.75 0.22	14.2 7.04
Mg	3.82 1.23	2.18 0.24	12.6 6.63
Total (mg g^{-1})			
N	2.68±0.10	0.00±0.00	0.00±0.00
P	0.79 0.02	0.48 0.01	0.53 0.03

Surface-sample chemistry

pH, loss-on-ignition, nitrogen, potassium, sodium and magnesium differed significantly between sites and usually to a lesser extent between and within plots. (Table 5, appendix 1C). Total phosphorus and exchangeable calcium did not show any significant differences between sites but showed highly significant differences between and within plots.

Table 5. Total nitrogen and phosphorus (mg g^{-1}), exchangeable cations (m-equiv kg^{-1}), pH_{H2O} (log units) and loss-on-ignition (LOI) (%) in the top 10 cm of soil in three plots in each of three woodland sites. Values are means (n=9) (± S.E.) and except for pH are expressed on an oven dried (85 °C) basis. Variations between the sites (V.B.S.) and between plots (V.B.P.) for each item at levels of (NS, not significant; *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$) are shown.

Wood	Plot	N	P	K	Na	Ca	Mg	pH	LOI
Ross	1	17.9	1.13	19.4	8.93	79.9	69.2	2.9	83.2
		±0.87	0.06	0.98	0.91	8.02	5.08	0.0	5.00
	2	12.9	0.93	14.4	5.82	50.1	34.7	3.0	59.1
		±2.04	0.06	2.67	0.79	9.07	5.97	0.0	7.23
	3	13.5	0.54	10.6	3.84	31.9	34.6	3.0	61.0
		±1.78	0.06	1.56	0.48	3.44	3.69	0.0	8.17
Gart-fairn	4	7.34	0.89	4.05	2.66	16.9	10.2	4.0	20.6
		±0.63	0.06	0.26	0.10	4.29	0.97	0.1	1.71
	5	7.54	0.91	4.09	5.46	33.4	16.0	4.4	23.6
		±1.13	0.09	0.93	0.96	9.73	1.89	0.1	4.51
	6	12.8	1.47	6.41	3.10	25.9	12.3	4.0	35.2
		±1.53	0.18	0.88	0.46	6.01	1.48	0.1	5.28
Meth-ven	7	3.66	0.88	7.76	1.35	29.5	9.09	4.6	12.0
		±0.29	0.07	0.66	0.10	6.68	1.18	0.1	1.04
	8	2.95	0.96	6.50	1.35	23.7	8.04	4.6	9.71
		±0.37	0.07	0.63	0.11	4.21	0.76	0.1	0.81
	9	3.17	0.90	6.07	1.32	15.3	6.20	4.5	10.9
		±0.37	0.08	0.60	0.12	2.60	0.63	0.0	0.80
V.B.S		***	NS	**	*	NS	*	***	***
V.B.P		***	***	***	***	***	***	*	*

Ross had the most acidic top soil with an average pH_{H2O} of 3.0 and had the highest LOI and had the highest concentrations of soil nutrient elements except phosphorus. Gartfairn had a less acidic top soil (pH_{H2O}=4.1) and a mean for LOI of 26.5%. Methven had the least acidic top soil (pH_{H2O}=4.5) and the lowest LOI and nutrients of the three sites. Unfortunately no measurements were made of cation exchange capacity (CEC). It is likely that the upper parts of the Ross soils had the highest CEC because of the large amounts of organic matter there. Although the highest concentrations (on a mass basis) of exchangeable bases occur at Ross (Table 5), their proportions (percentage base saturation) of the exchange sites occupied will be less. The very low pH at Ross indicates that hydrogen ions occupy a high proportion of the exchange sites and hence fertility (in terms of percentage base saturation) at this site is likely to be the least for the three woodlands.

Using the bulk density measurements (Table 3) the soil chemical data were expressed on a volume basis (Table 6). Table 6 shows that the nitrogen in the top 10 cm soil was highest at Gartfairn although total nitrogen was also high in plot 2 at Ross. Phosphorus was least and magnesium highest at Ross. Phosphorus, potassium and calcium were the highest in Methven.

Table 6. Total nitrogen and phosphorus and exchangeable potassium, sodium, calcium and magnesium (kg ha^{-1}) of the top 10 cm of soil of three plots within each of the three woodland sites. Results are on an oven-dry (85 °C) basis.

Wood	Plot	N	P	K	Na	Ca	Mg
Ross	1	28.8	1.81	1.22	0.33	2.57	1.35
	2	46.5	3.35	2.01	0.48	3.61	1.52
	3	31.7	1.27	0.98	0.21	1.50	0.99
Gartfairn	4	49.5	6.00	1.07	0.41	2.28	0.84
	5	44.6	5.38	0.95	0.74	3.96	1.15
	6	80.2	9.20	1.57	0.45	3.25	0.94
Methven	7	35.8	8.61	2.97	0.30	5.78	1.08
	8	30.9	10.1	2.66	0.32	4.98	1.02
	9	27.4	7.78	2.05	0.26	2.65	0.65

2.23 DISCUSSION

The Ross Wood soil is developed on glacial drift (Tittensor & Steele 1971) overlying metamorphic schistose grits (MacDonald 1974). It was described by Mitchell (1973) as podzolic and very stony in places with light to medium loam and gleyed or peaty in hollows.

At Gartfairn the soil series termed Dryburn and Geanies by Gauld & Bell (1986) were observed. These are inside an alluvium association which is described as, poorly to very poorly drained, on some parts peaty, and originating from the river Endrick sediments. Dryburn soils which are gravelly and freely drained occur toward the north of this site (just at the border of plot 4). Geanies soils (being dominantly peaty on the top soil) are more abundant within my plots in this site. These soils overlie Lower Red Sandstone (MacDonald 1974; McKirdy 1986; Brown *et al* 1983,1984). The formation of gleyed soil and peat in this site is not due to soil texture (which is loamy sand or sandy) but to a high water table and partly impeded drainage channels (established as part of the previous managements). The lower parts of the Wood are seasonally flooded.

Methven Wood soils are categorised as Balrowin type, derived from Old Red Sandstone and further specified as till with partial water stress in the top layers (McCaulay Institute for Soil Research 1980 and Brown *et al* 1983). They are typical brown forest soils.

Nutrient availability in soils will be subject to both temporal (e.g. Gupta & Rorison 1975) and spatial heterogeneity. I have no information on the temporal changes but my data provide ample evidence of spatial heterogeneity.

2.3 *VEGETATION*

2.31 TREES

Oak (*Quercus sp.*) was the dominant tree in all plots in the three woodlands. Birch (*Betula sp.*) was also common in Gartfairn and frequent in Ross and Methven. At Ross there was one Rowan tree (*Sorbus aucuparia*) in each of plots 1 and 2 and a Beech sapling (*Fagus sylvatica*) in plot 1. Hazel (*Corylus avellana*) was frequent in Methven but did not occur within our plots (appendix 2A).

Materials and methods

All trees were measured for girth at breast height (1.30 m from the base), height (using a Haga gauge) and crown width from two directions (north-south and east-west). Above-ground tree biomass was calculated from the formula $W_T = F(HG)D$ (Cannell 1984) where W_T is biomass (t ha^{-1}), H is mean tree height (m), G is basal area at breast height (m^2 ha^{-1}), F is the form factor (0.58 for Oak, 0.60 for Birch and 0.72 for Rowan) and D (g dry weight/fresh volume) is mean specific gravity (0.60 for Oak, 0.55 for Birch and 0.61 for Rowan).

Results

The results of the tree measurments are summarized for each site in Table 7. (Data for individual trees are given in appendix 2B, for individual plots in appendix 2C). Height, basal area, above-ground biomass of Oak and Birch and density and crown cover of Birch differed significantly between the sites. Methven had the highest

Table 7 Average height, basal area, crown cover, biomass and numbers of Oak and Birch trees (≥5 cm dbh.) and the totals for the three woodland sites. The significant differences 'S.D.' (NS, not significant; *, p <0.05; **, p<0.01; ***, p <0.001) with values for the least significant difference 'L.S.D.' are given.

Feature	Ross	Gart-fairn	Meth-ven	S.D.	L.S.D.
Average height (m)					
Oak	11.5	13.9	16.0	*	3.1
Birch	7.6	15.1	12.9	***	2.7
Basal area (m^2ha^{-1})					
Oak	21.3	24.0	36.4	***	5.6
Birch	0.43	6.4	1.4	**	2.8
Crown cover (m^2ha^{-1})					
Oak	14000	11000	15000	NS	
Birch	350	3100	700	*	1600
Biomass t ha^{-1}					
Oak	85	120	200	***	30
Birch	1.1	31	6.0	***	11
Total	89	151	206	***	29
Density ha^{-1}					
Oak	307	263	250	NS	
Birch	30.0	147	30.0	NS	
Total	343	410	280	NS	

In column 1 the totals are bigger than the sums of the values for Oak and Birch because the values for one Rowan present in each of the plots 1 and 2 in Ross are also added.

values for Oak height, total crown cover, and biomass but had the lowest density of Oak. Gartfairn had the most Birch. Ross Wood had the least average height, basal area and biomass but highest density of Oak (Table 7).

There were 22 and 29 trees with more than two stems (>5 cm dbh.) at Gartfairn and Methven respectively. This abundance of multiple stem trees suggests a different or more recent coppice management from Ross where no multiple stem trees were recorded. It is possible that a last thinning had taken place in Ross whereas in the other two a clear cut was taken before abandonment.

Fig 4 shows the typical physiognomy of the three woodlands.

2.32 GROUND FLORA

The percentage cover of the ground flora was estimated from two 2 x 2 m random quadrats in each of the nine plots during May 1989 and further plant collections were made during subsequent field visits (appendix 2A). Names of vascular plant species follow Clapham *et al* (1987) and mosses Smith (1976).

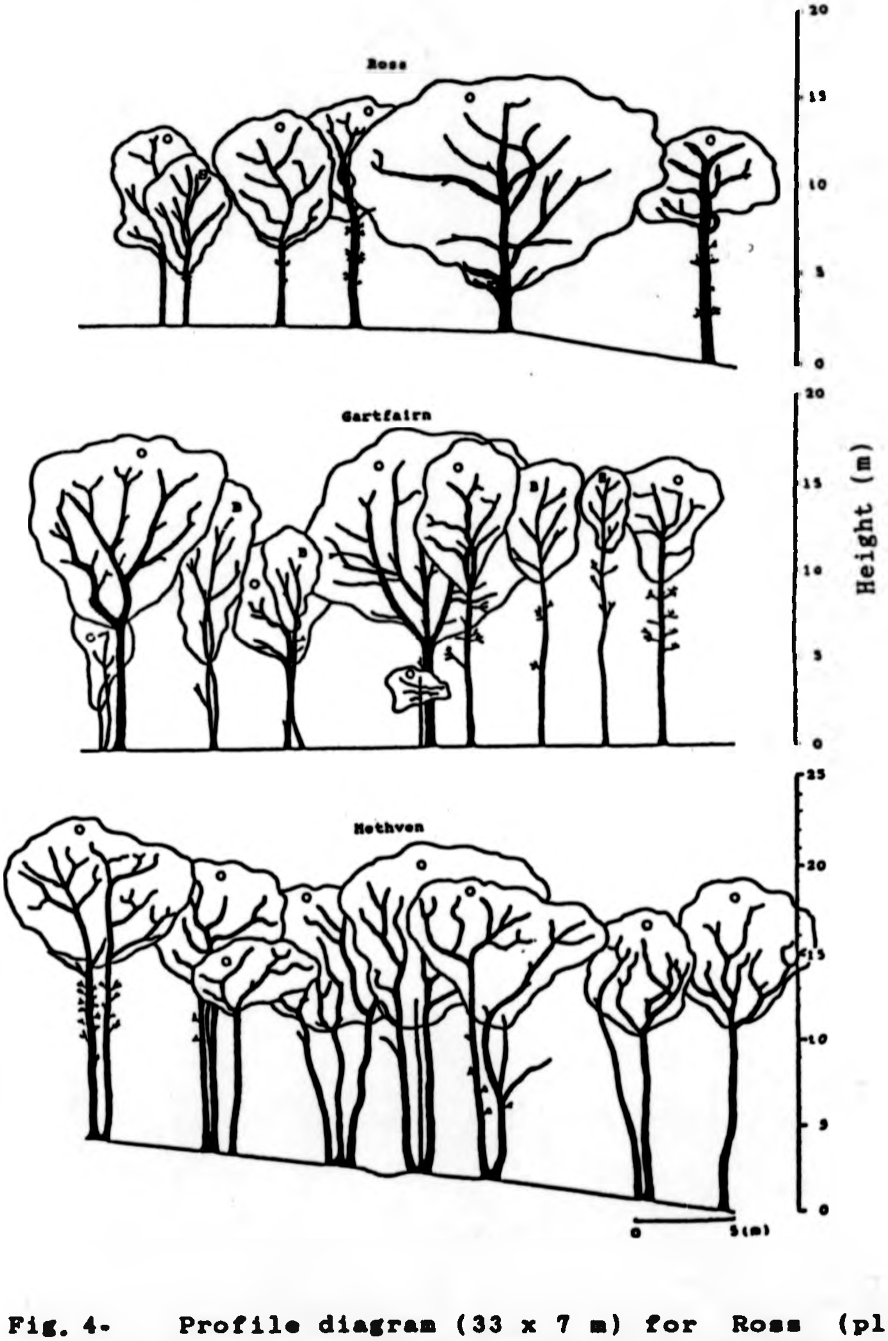


Fig. 4- Profile diagram (33 x 7 m) for Ross (plot 1), Gartfairn (plot 4) and Methven (plot 7). Symbols are: O, Oak; B, Birch.

CHAPTER 3

SMALL LITTERFALL

3.1 INTRODUCTION

Litterfall has long engaged the attention of ecologists and the classic work in Germany by Ebermayer (1876) (cited by Bray & Gorham 1964) early showed the importance of litterfall in the cycling of nutrients in forest ecosystems. Bray & Gorham (1964) and Ovington (1965) reviewed litter production studies throughout the world. More recent studies on temperate deciduous woodlands include Carlisle *et al* (1966a), Boerner (1984), Briggs *et al* (1989), Brown (1974), Lang & Forman (1978), Rawat & Singh (1988a), Rapp & Leornardi (1988), Reiners & Reiners (1970), Rochow (1975), Singh & Singh (1987) and Shure & Phillips (1987) but there have been no published studies in Scottish Oak woods.

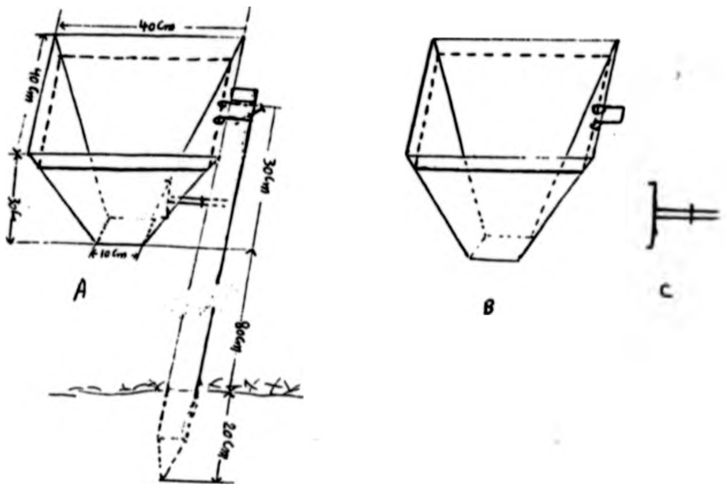
The term small litterfall has been used for all the litterfall components including wood for which the size has been variously defined is but always less than 10 cm diameter (Proctor 1983). I studied the annual amount and the seasonal pattern of dry weight and nutrient elements of small litterfall in the three contrasting Scottish oak woodland sites.

3.2 MATERIALS AND METHODS

Small litterfall was collected using a total of 162 litter traps in Ross, Gartfairn and Methven. In each of three plots (33.33 x 33.33 m) within each wood eighteen litter traps were placed (two traps at random in each of the nine sub-plots (11.11 x11.11 m). Following the principles given by Newbould (1967) and Chapman (1986) the litter traps were made of three parts (Fig 5): baskets, clips and poles. The baskets were made of aluminium mesh plate of 2 mm mesh size and were 30 cm deep with a square open area of 40 x 40 cm. They were fixed to the pole by clips so that the openings were about 1.1 m above the ground. The baskets were designed to use the least material (aluminium mesh) and to be carried easily in large numbers. The baskets could be easily unclipped from the poles to facilitate emptying the litterfall. Occasionally in a few exposed sites the clip was not strong enough to keep the baskets level and they were more firmly fixed to the pole with string. The traps were still usable after about eighteen months in the field.

The litterfall collections began on : 22 September 1987 at Ross; 17 October 1987 at Gartfairn; and 18 April 1988 at Methven. The litterfall collections were made every two to three weeks in October, November and December and every four weeks in the other months. Collections finished on 21 February 1989 at Ross and Gartfairn and on 18 May 1989 at Methven (see appendix 3A).

Fig 5. (A) the litter trap installed on its pole, (B) basket and (C) clip.



Immediately after collection the samples were air-dried and sorted into five fractions: Oak leaves, non-Oak leaves (usually Birch and occasionally Rowan), small wood (i.e. wood < 2 cm diameter and bark < 2 cm on the largest dimension), fruit (only acorns, their seeds and cupules) and miscellaneous.

After sorting the litterfall fractions were weighed after oven drying at 85 °C to constant weight. They were then bulked for each plot and ground to pass through a 1 mm mesh before chemical analysis. Chemical analysis was carried out for all fractions of which the weight per plot exceeded 0.5 g in each collection. 0.5 g oven-dried sub-samples of each fraction were digested in a mixture of 6 ml concentrated sulphuric acid and 3 ml hydrogen peroxide using a selenium catalyst (Allen *et al* 1974) and analyzed for nitrogen and phosphorus colorimetrically by an auto-analyser technique (Tecnicon Industrial Systems 1976). Several 0.5 g oven dried sub-samples were also digested in 15 ml concentrated nitric acid (Allen *et al* 1974). Potassium, sodium, calcium and magnesium were measured by atomic absorption using a Perkin Elmer 303 spectrophotometer using an air-acetylene flame except for calcium where a nitrous oxide-acetylene flame was used. There were no significant differences between the values measured for sulphuric and nitric acid digestions and the data presented here refer to the sulphuric acid digests only.

A nested analysis of variance was employed to evaluate the differences in the annual production between and within the woodlands.

3.3 RESULTS

Small litterfall mass

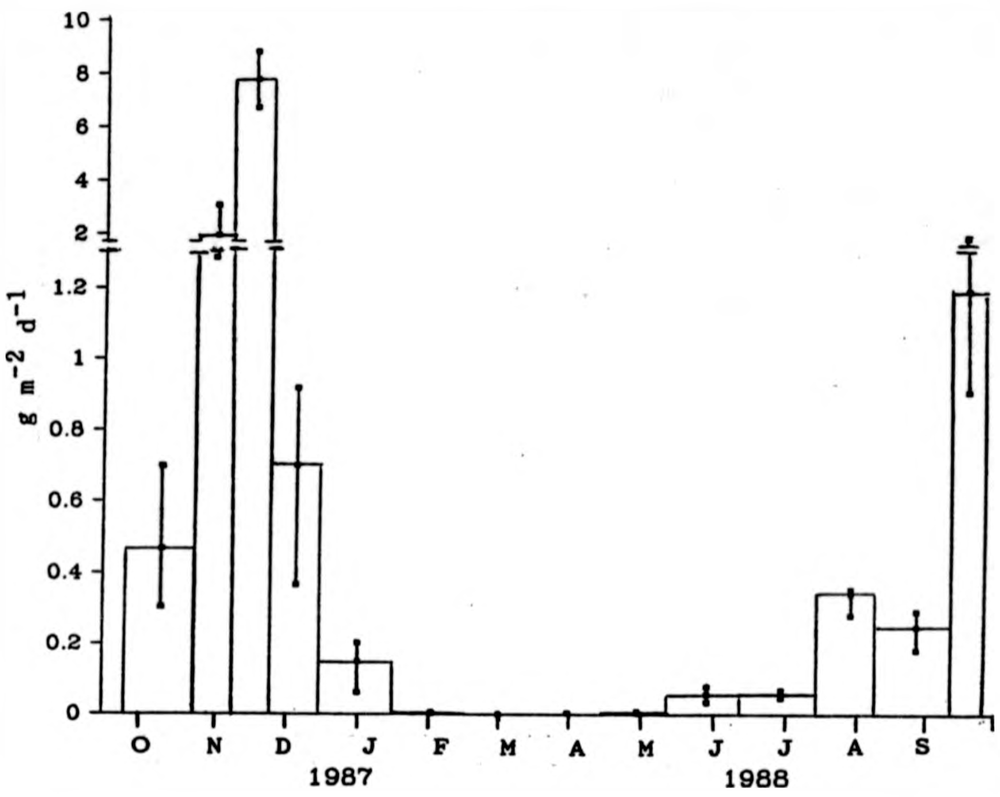
The small litterfall data are summarised in Figures 6 to 8. The temporal pattern of total small litterfall (TSL) and each of its fractions is very similar for the three woods although there were marked differences in quantities.

Oak leaf litter (Figs 6a, 7a and 8a) started to fall from mid-May forming a small peak in July to early August. It hastened from mid-September and most was shed in October to November with its peak in November. There was

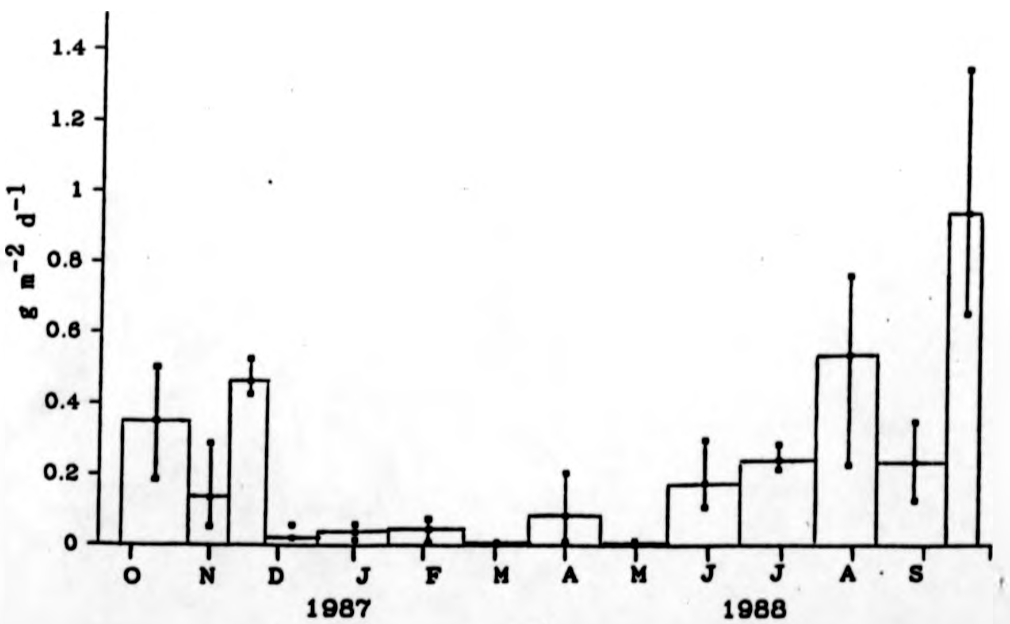
Fig. 6. Temporal changes in oven dried (85 °C) mass input ($g \cdot m^2 \, d^{-1}$) of: (a) oak leaves, (b) small wood, (c) acorns, (d) miscellaneous and (e) total small litterfall (TSL) in Ross.

Fig. 6.

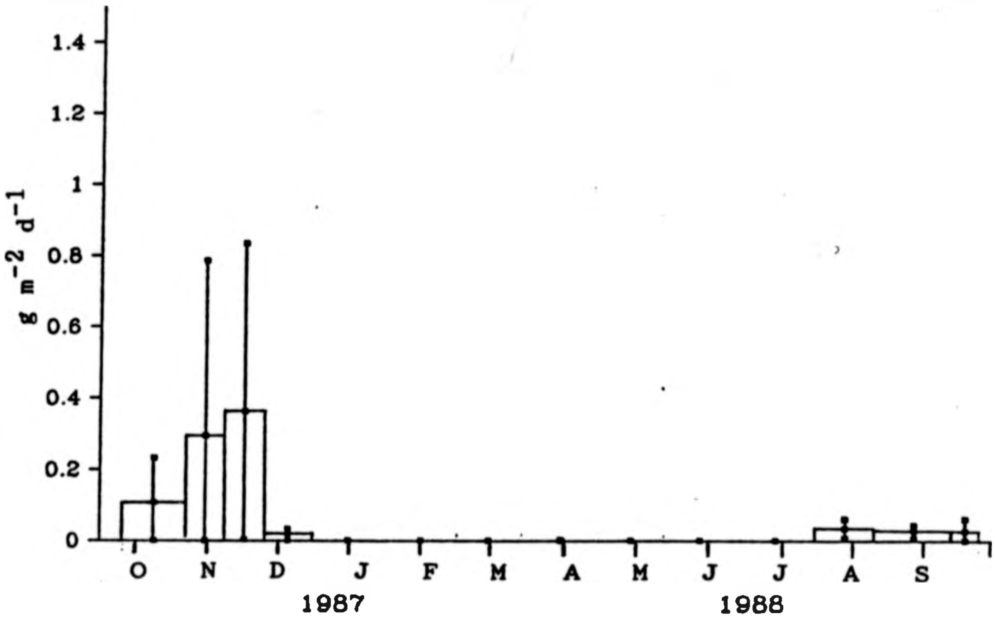
(a)



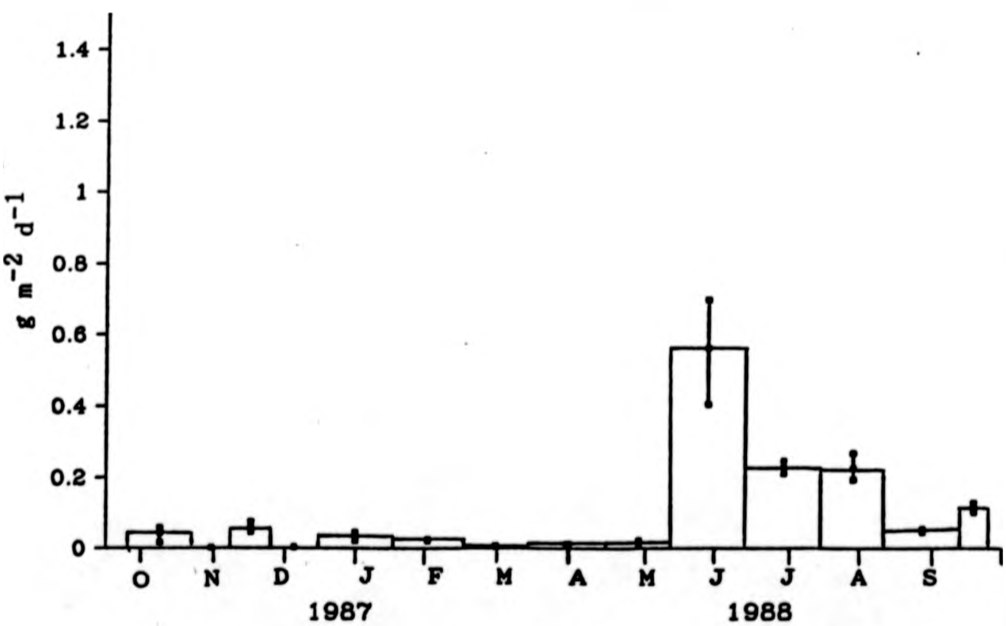
(b)



(c) Fig. 6. Continued.



(d)



(e) Fig. 6. Continued.

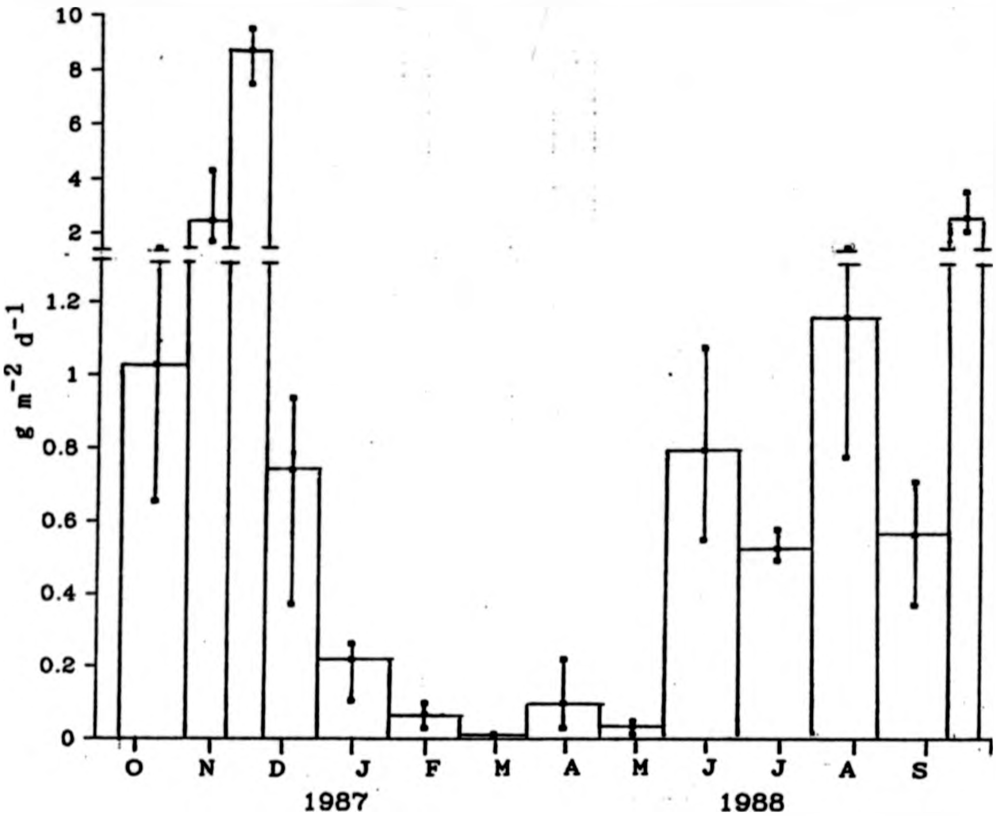
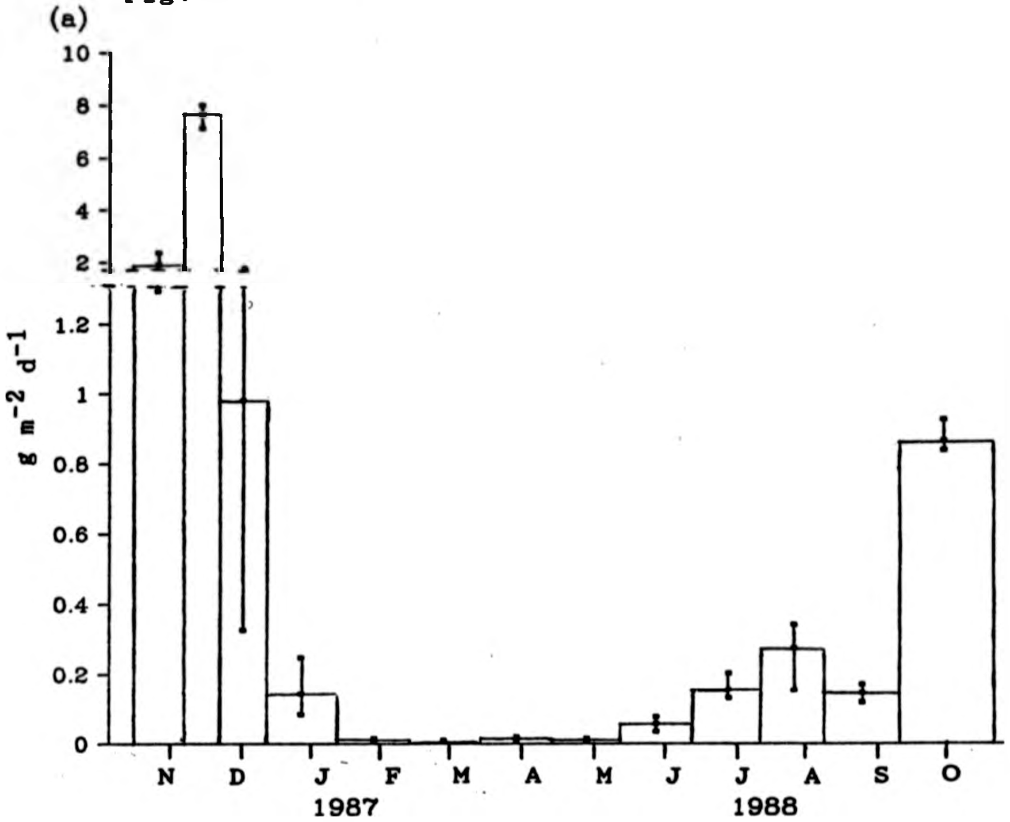
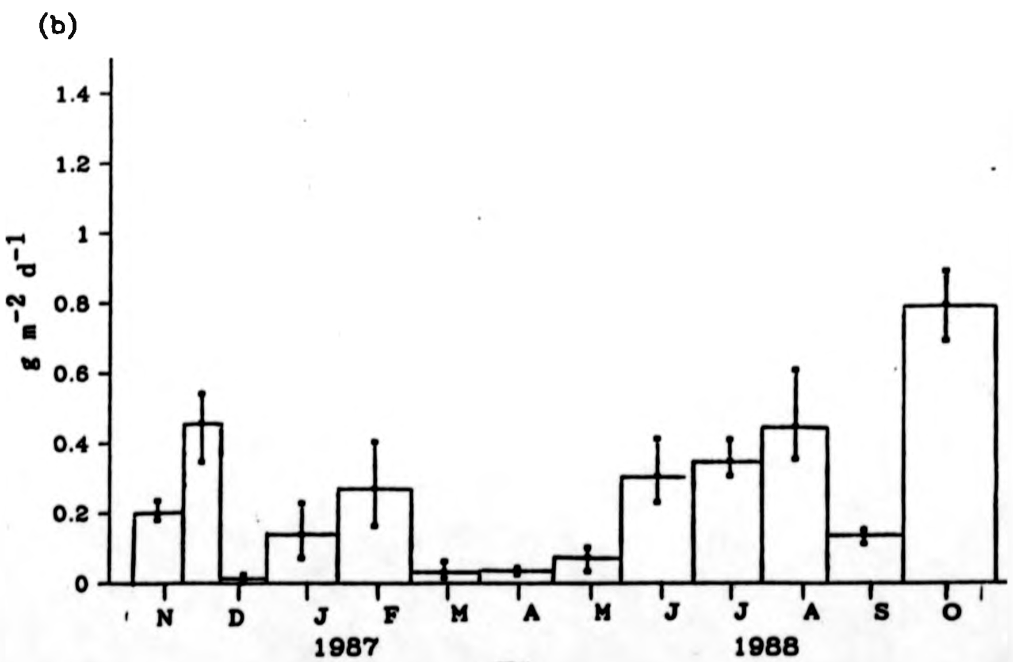


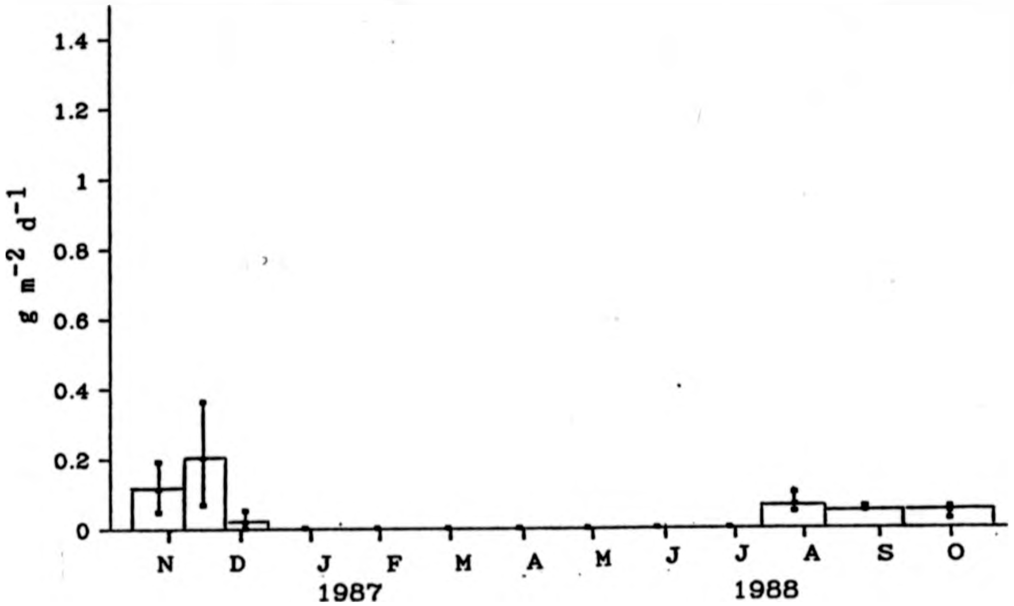
Fig. 7. Temporal changes in oven dried (85 °C) mass input (g m^2 d^{-1}) of: (a) oak leaves, (b) small wood, (c) acorns, (d) miscellaneous, (e) birch leaves and (f) total small litterfall (TSL) in Gartfairn.

Fig. 7.





(c) Fig. 7. Continued.



(d)

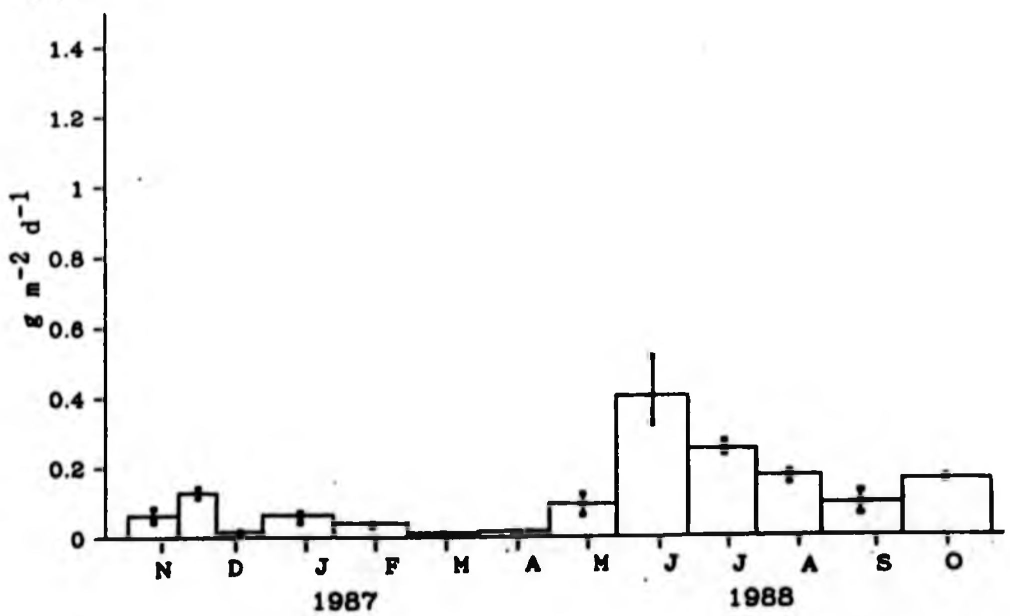


Fig. 7. Continued.

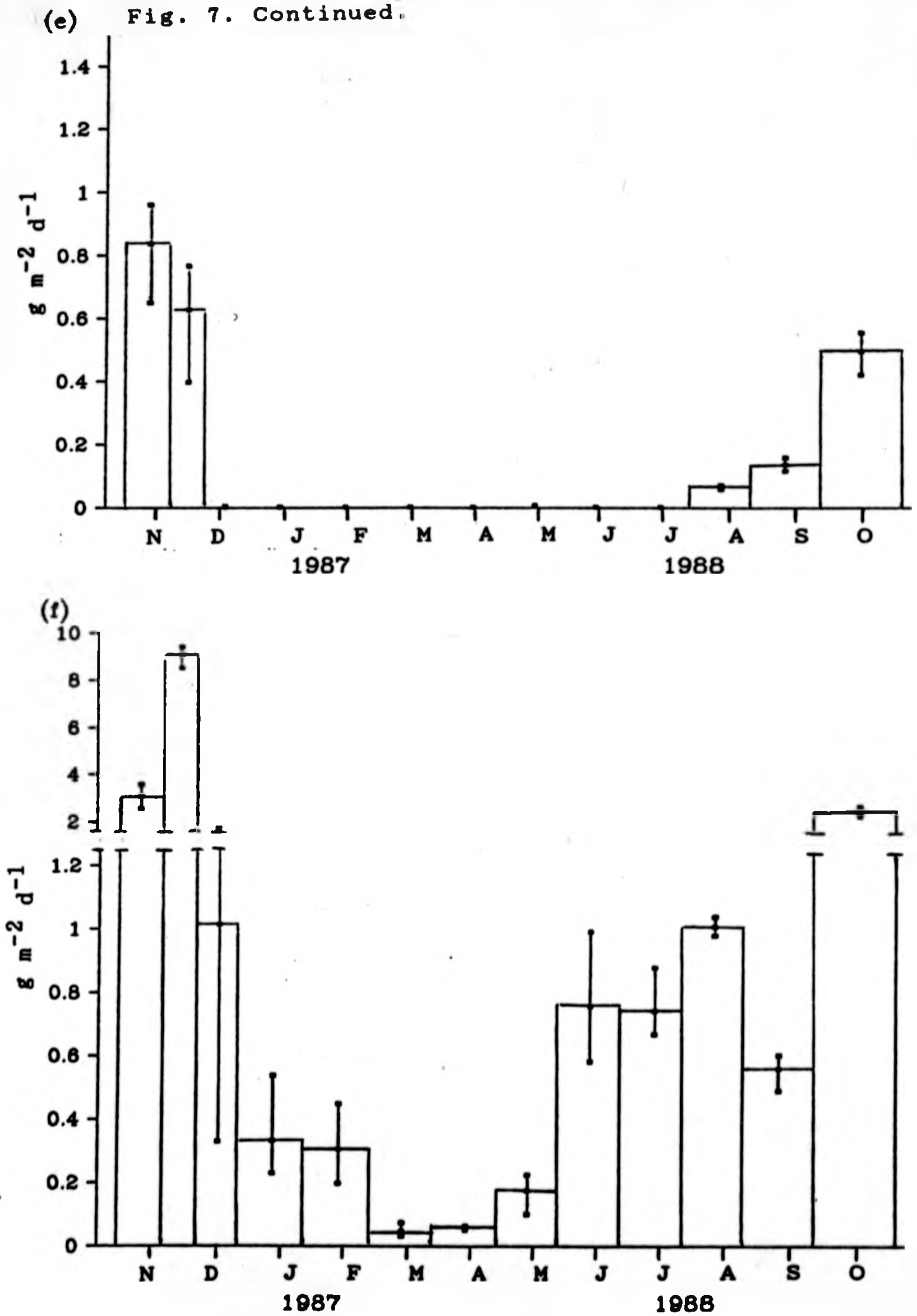
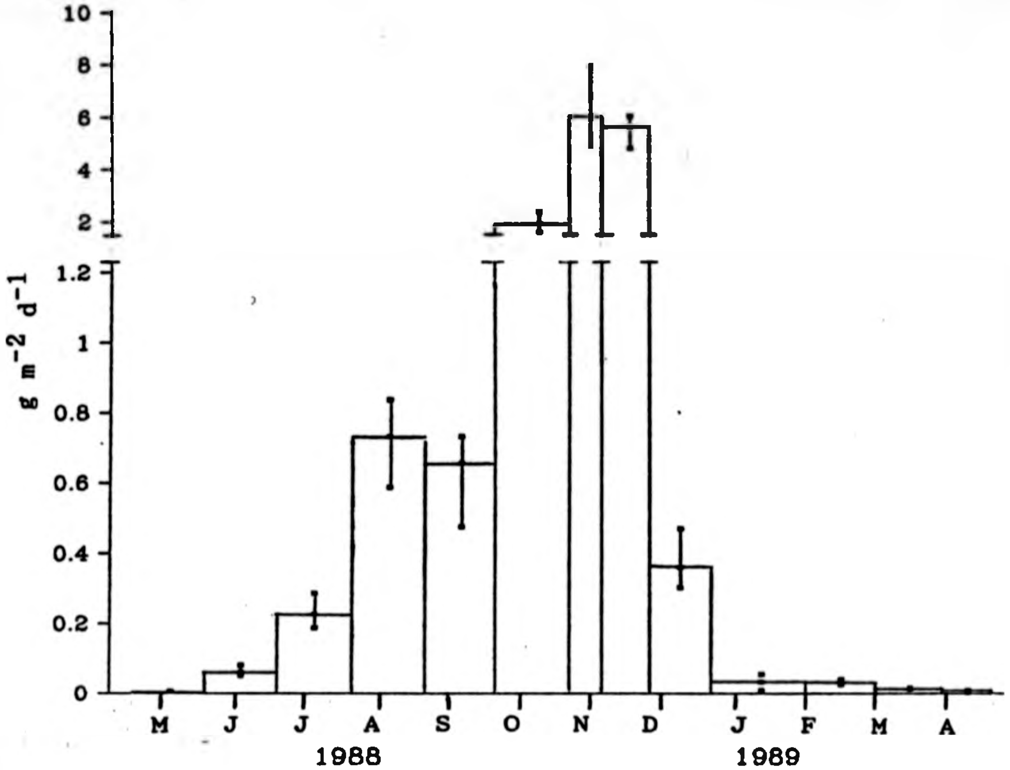


Fig. 8. Temporal changes in oven dried (85 °C) mass input (g m^2 d^{-1}) of: (a) oak leaves, (b) small wood, (c) acorns, (d) miscellaneous and (e) total small litterfall (TSL) in Methven.

Fig. 8.

(a)



(b)

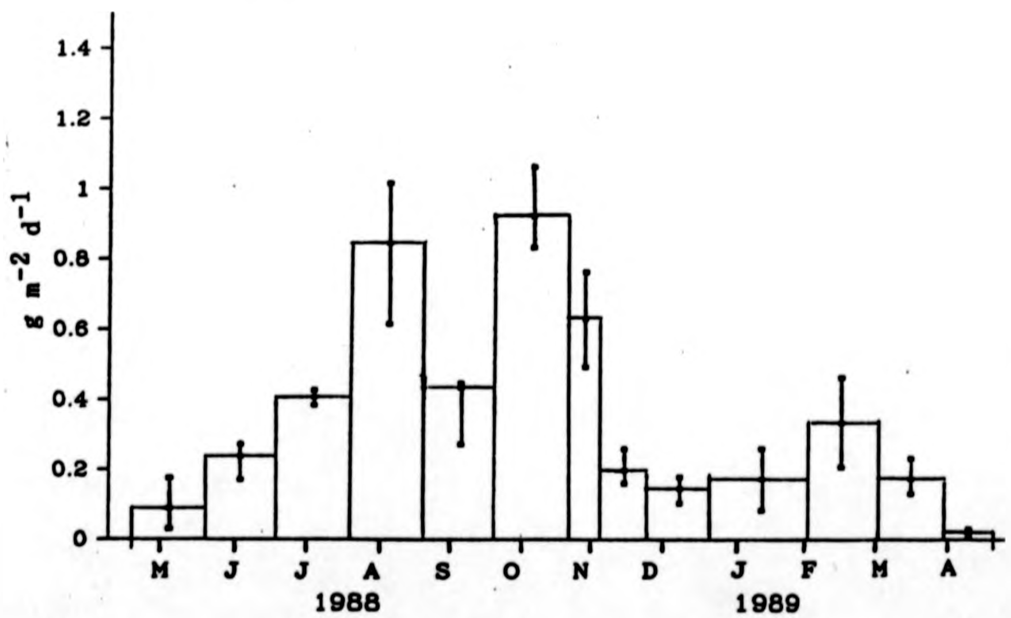
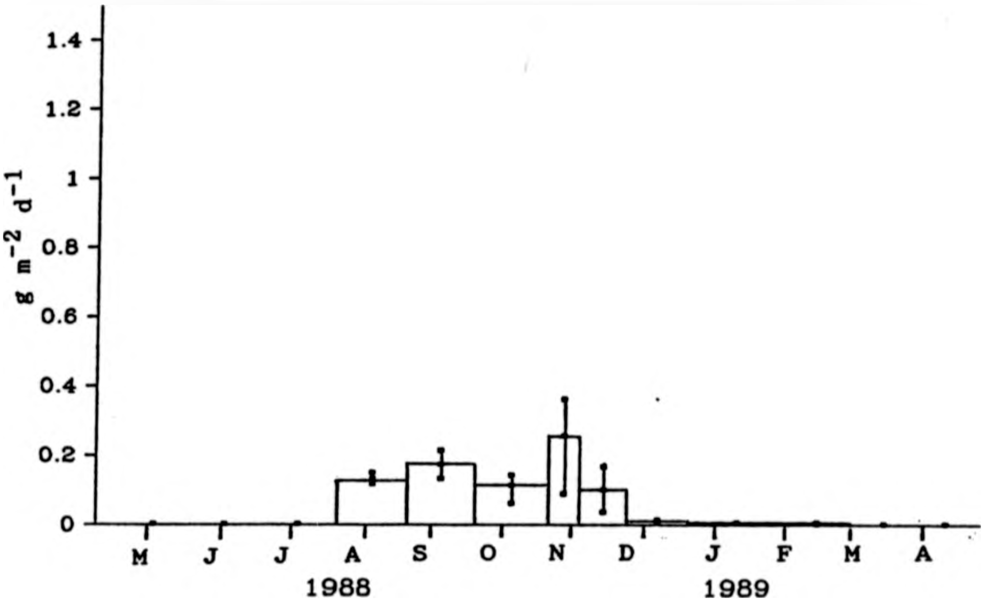
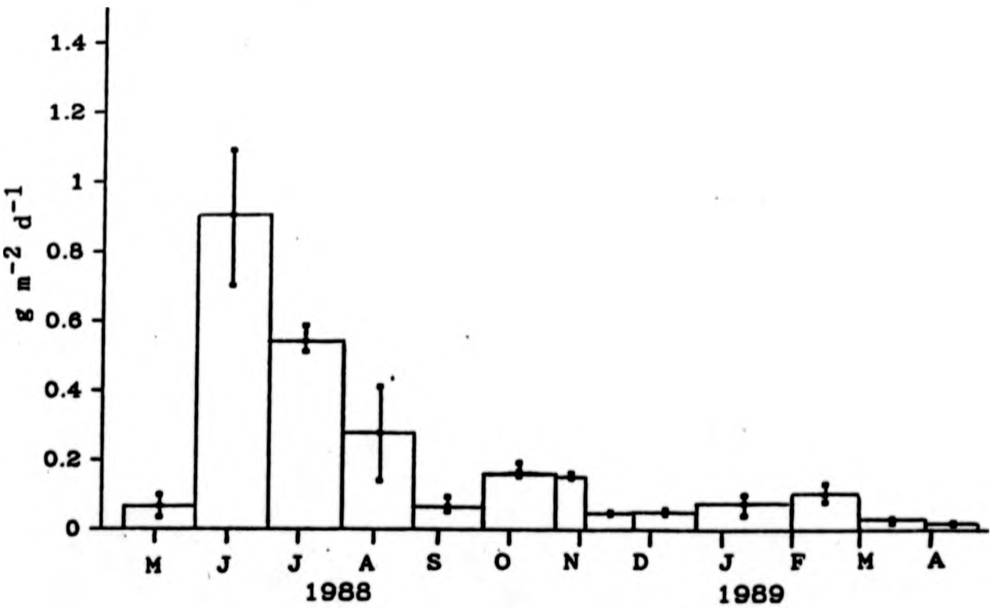


Fig. 8. Continued.

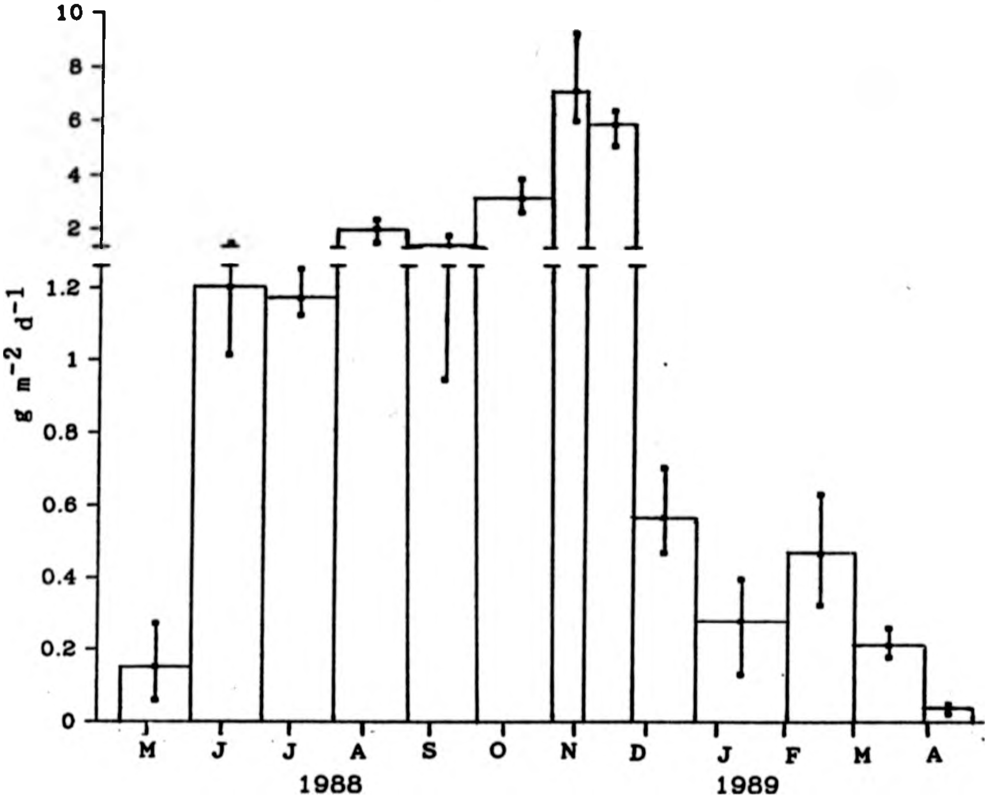
(c)



(d)



(e) Fig. 8. Continued.



very little or no leaf litterfall during mid-January to mid-May. Birch leaves were only an important fraction at Gartfairn (Fig 7e).

Small wood fall (Figs 6b, 7b and 8b) had a similar pattern to leaf litter but in late autumn and winter it was less than leaf litter and showed higher quantities in other seasons and a highest peak in October. It seems that the pattern of small wood litterfall is affected by autumn gales.

The production of acorns (Figs 6c, 7c and 8c) and related fragments started in mid-July, rose relatively sharply from October to a peak in November and had finished by mid-December.

The amount of miscellaneous litter (Figs 6d, 7d and 8d) rose up sharply to a peak (from mid-May to mid-June) and then gradually reduced. There was also a small peak from September to November. The miscellaneous fraction had a different composition through the year. In winter and early spring it was mostly composed of small fragments of wood and bark. In mid-March bud scales were included; catkin fragments became the major component during May to early June; then later in June to early August, frass. Later small pieces of leaves and dead insects became a component and then until mid January there was mostly a mixture of wood, bark, leaves and small wasp galls.

The pattern of the TSL (Figs 6e, 7f and 8e) was mostly affected by Oak leaves, with a lesser contribution from small wood. The miscellaneous fraction was a high proportion of the litterfall during May to early August.

The annual production data are summarized in Tables 8 and 9. Total litterfall, small wood and miscellaneous (significant) and also Oak leaves (not significant) were highest in Methven and lowest in Ross. Birch leaves were significantly highest in Gartfairn. Plot 7 in Methven had the highest and plot 3 in Ross had the lowest values among the plots. The confidence limits of values for Oak leaves and TSL (Table 8) are < 10% and indicate the sufficiency of the sampling although for some fractions the confidence limits are wider.

Table 8. The oven-dried weight (85 °C) of Oak leaf, non-Oak leaf, small wood, fruit, miscellaneous and total small litterfall (TSL) (kg ha^{-1} yr^{-1}) in three plots in each of three woodland sites. Values are means (n=18) (± 95% C.L.). Variations between woodlands (Var.B.W.) and between plots (Var.B.P.) for each item at levels of (NS, not significant; *, p<0.05; **, p<0.01; ***, p<0.001) are shown.

Wood	Plot	Oak (leaves)	Non-Oak (leaves)	Small wood	Fruits	Miscell-aneous	TSL
Ross	1	2700±215	66± 38	764±162	379±120	382±63	4291±435
	2	2238 169	28 19	874 130	22 16	442 66	3604 248
	3	1996 216	46 35	481 159	91 64	311 55	2926 341
Gart-fairn	4	2523±211	564±142	945±164	97± 52	414±27	4544±232
	5	2498 311	574 89	971 255	75 29	400 42	4518 534
	6	2435 295	403 78	899 190	159 82	470 45	4366 471
Meth-ven	7	3657±245	157± 75	1470±218	226± 91	877±142	6388±479
	8	2703 236	47 55	1122 238	216 88	660 61	4749 495
	9	2943 198	45 43	1212 193	114 51	653 51	4967 352
Var.B.W		NS	***	*	NS	**	*
Var.B.P		***	***	**	***	***	***

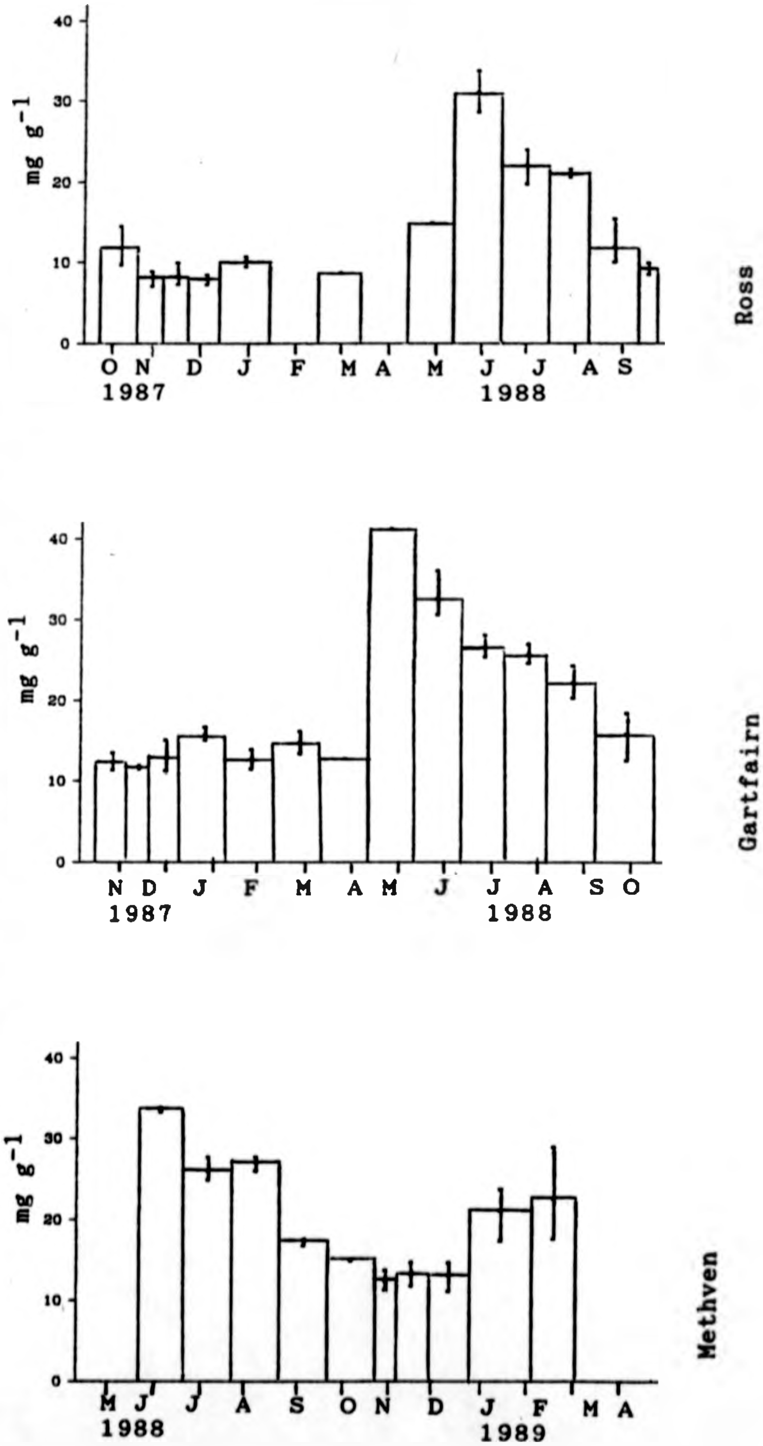


Fig. 9 (a). Nitrogen concentration in leaf litterfall.

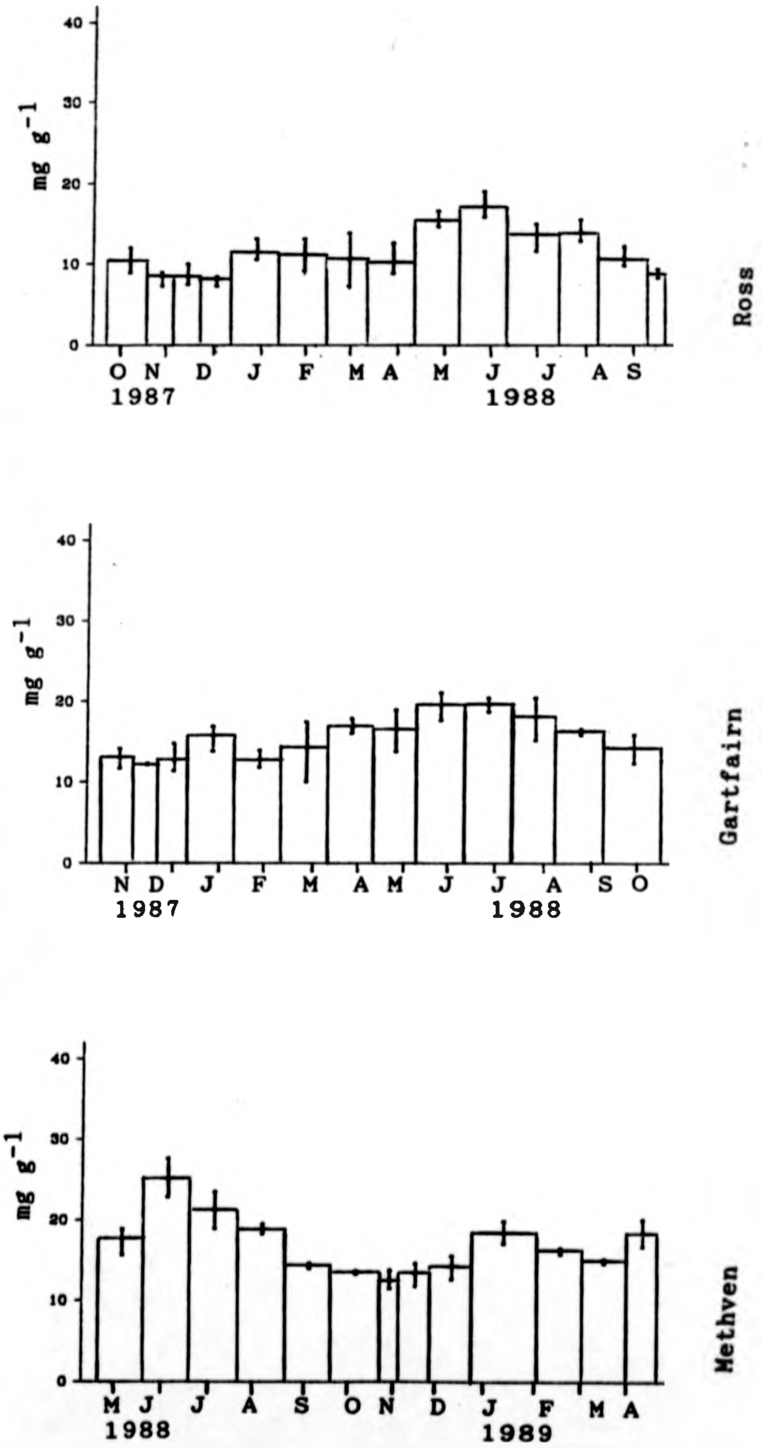


Fig. 9 (b). Nitrogen concentration in total small litter-fall (TSL).

Fig. 10 (a) Phosphorus concentration in leaf litterfall.

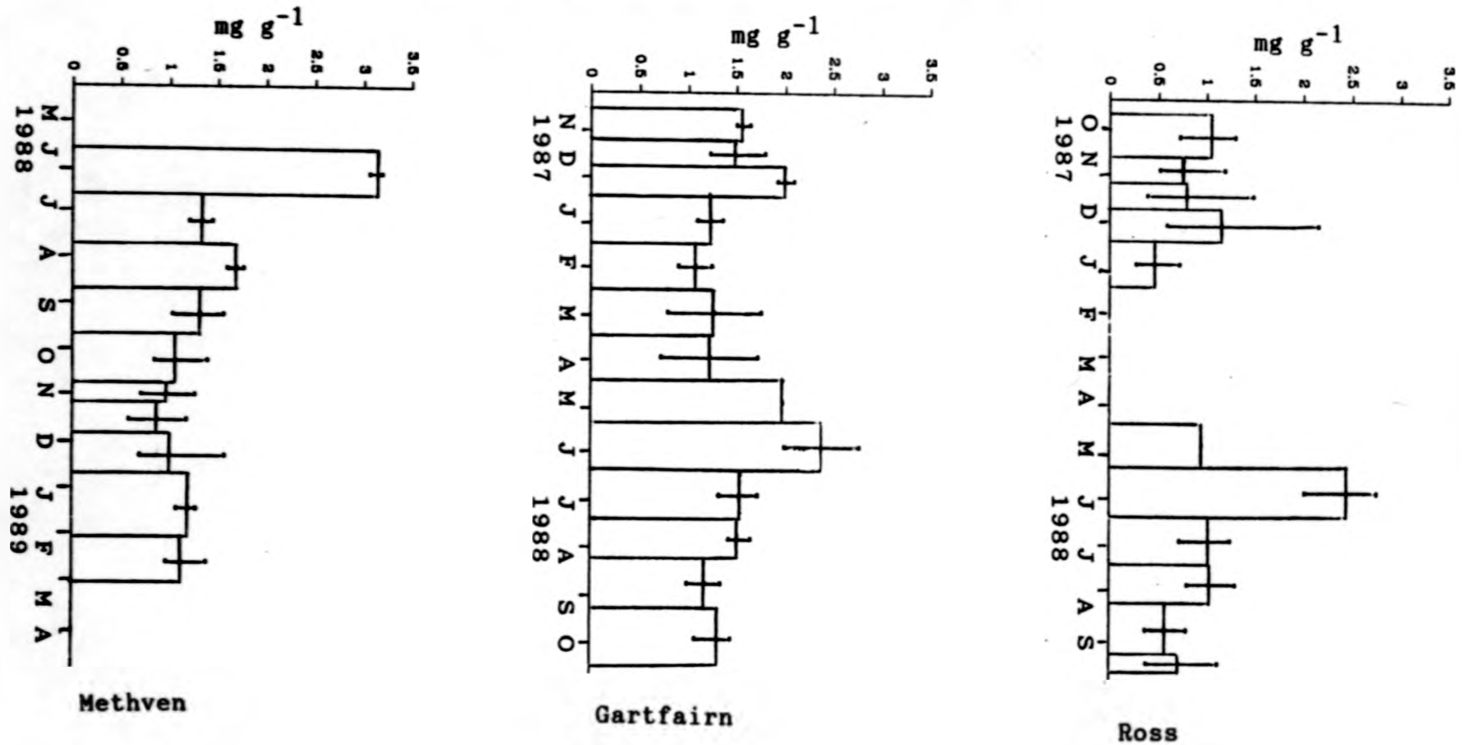
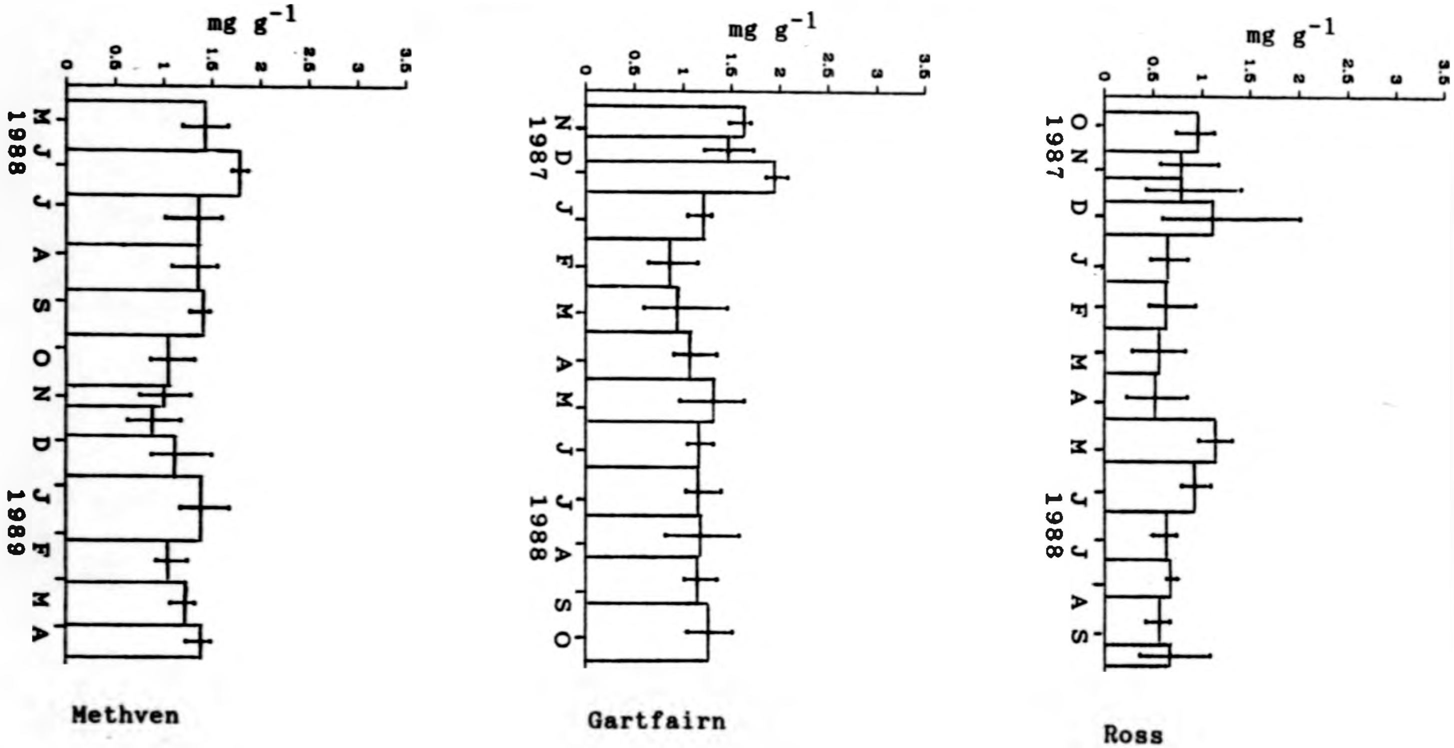


Fig. 10 (b). Phosphorus concentration in total small litterfall (TSL).



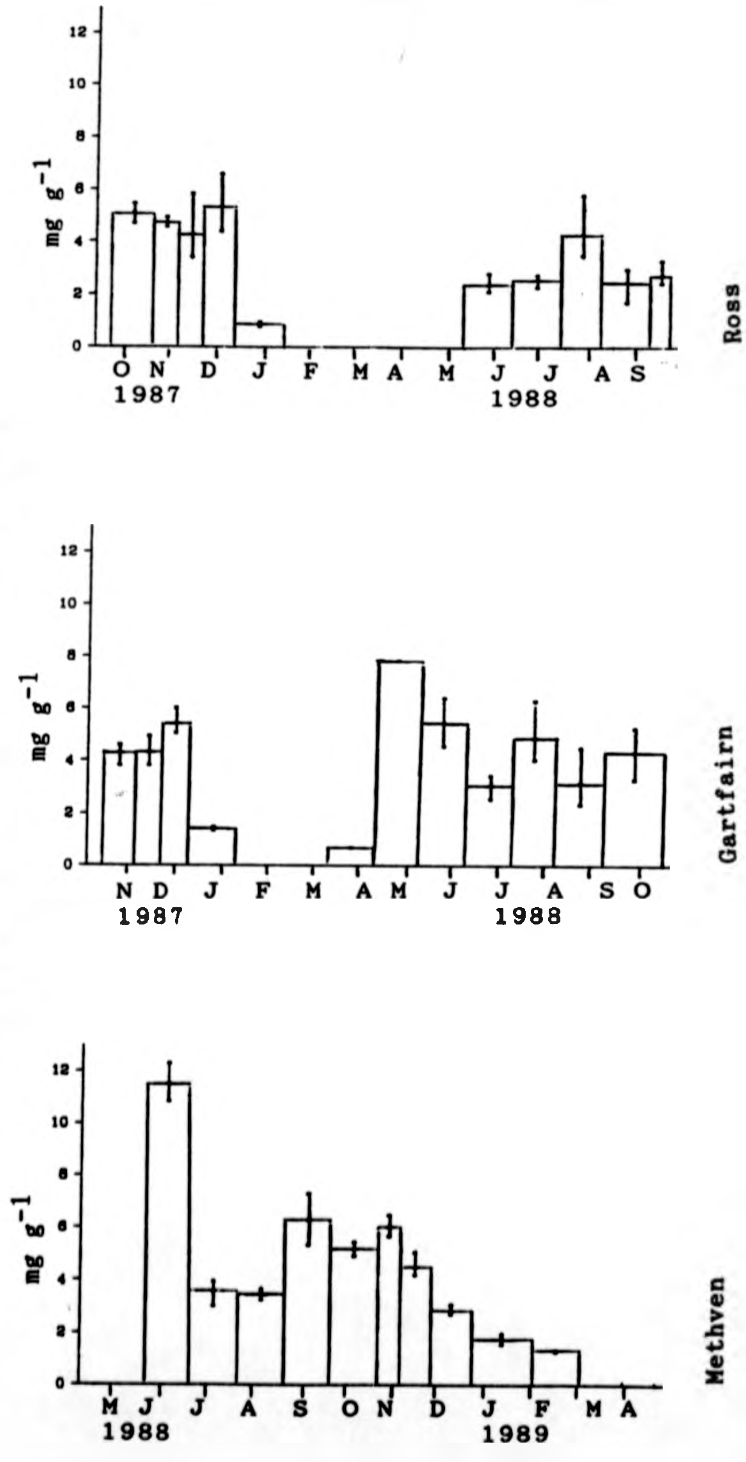


Fig. 11 (a) Potassium concentration in leaf litterfall.

Fig. 11 (b). Potassium concentration in total small litterfall (TSL).

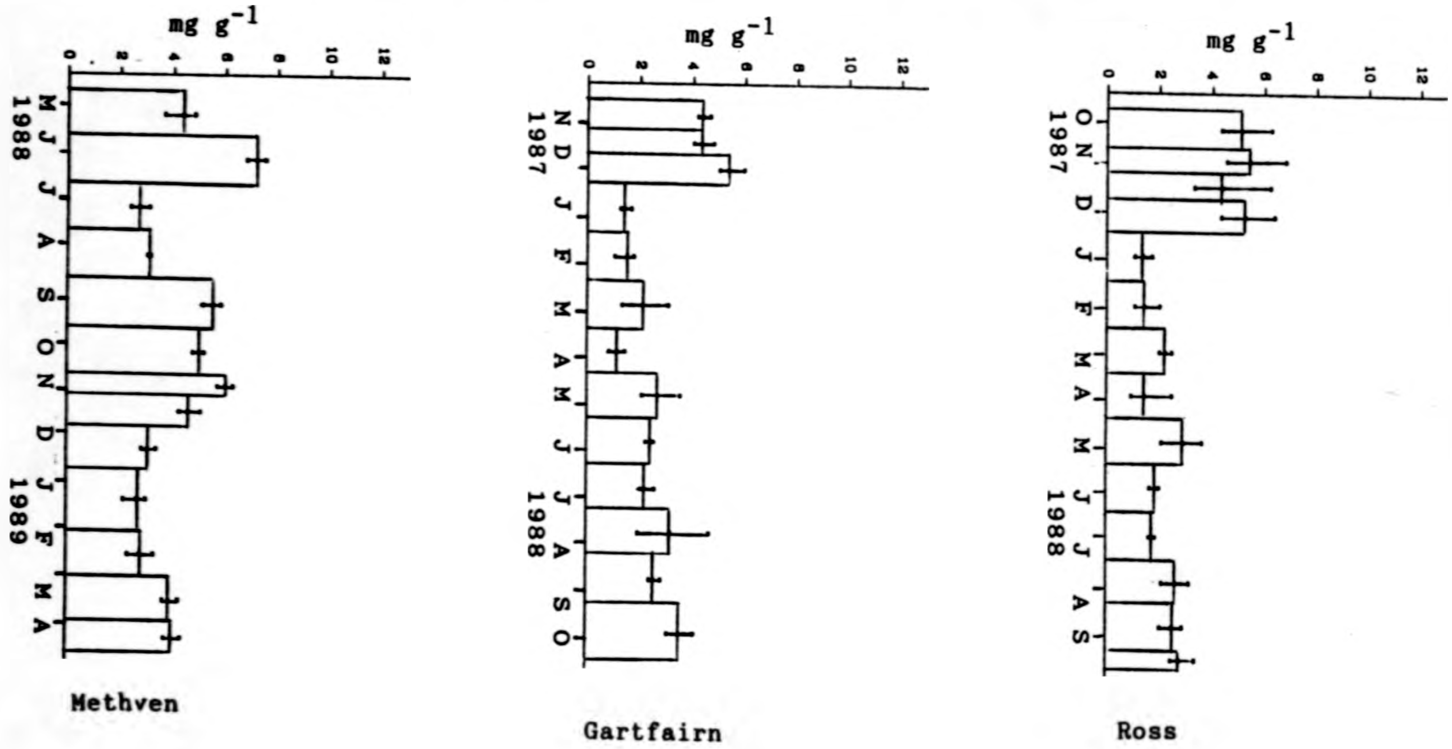
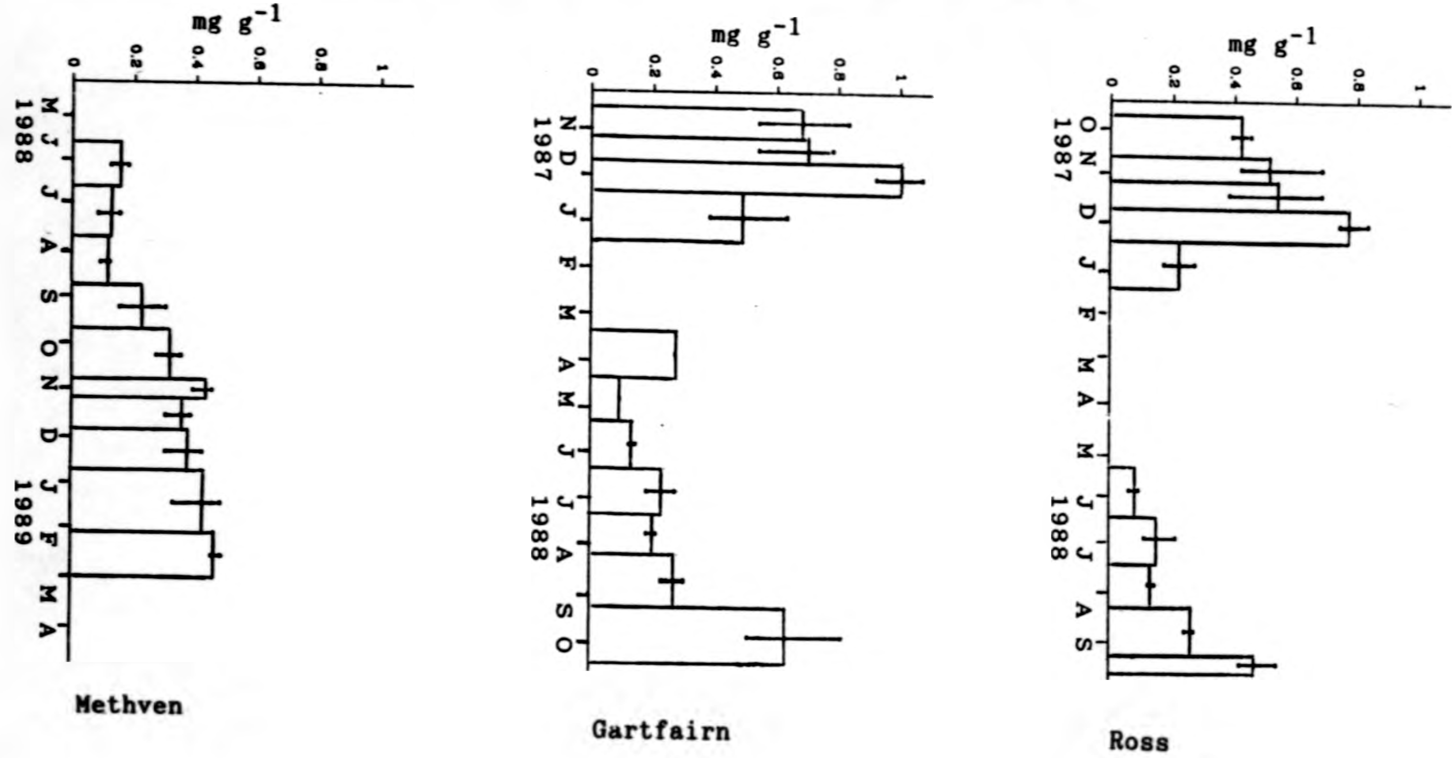


Fig. 12 (a) Sodium concentration in leaf litterfall.



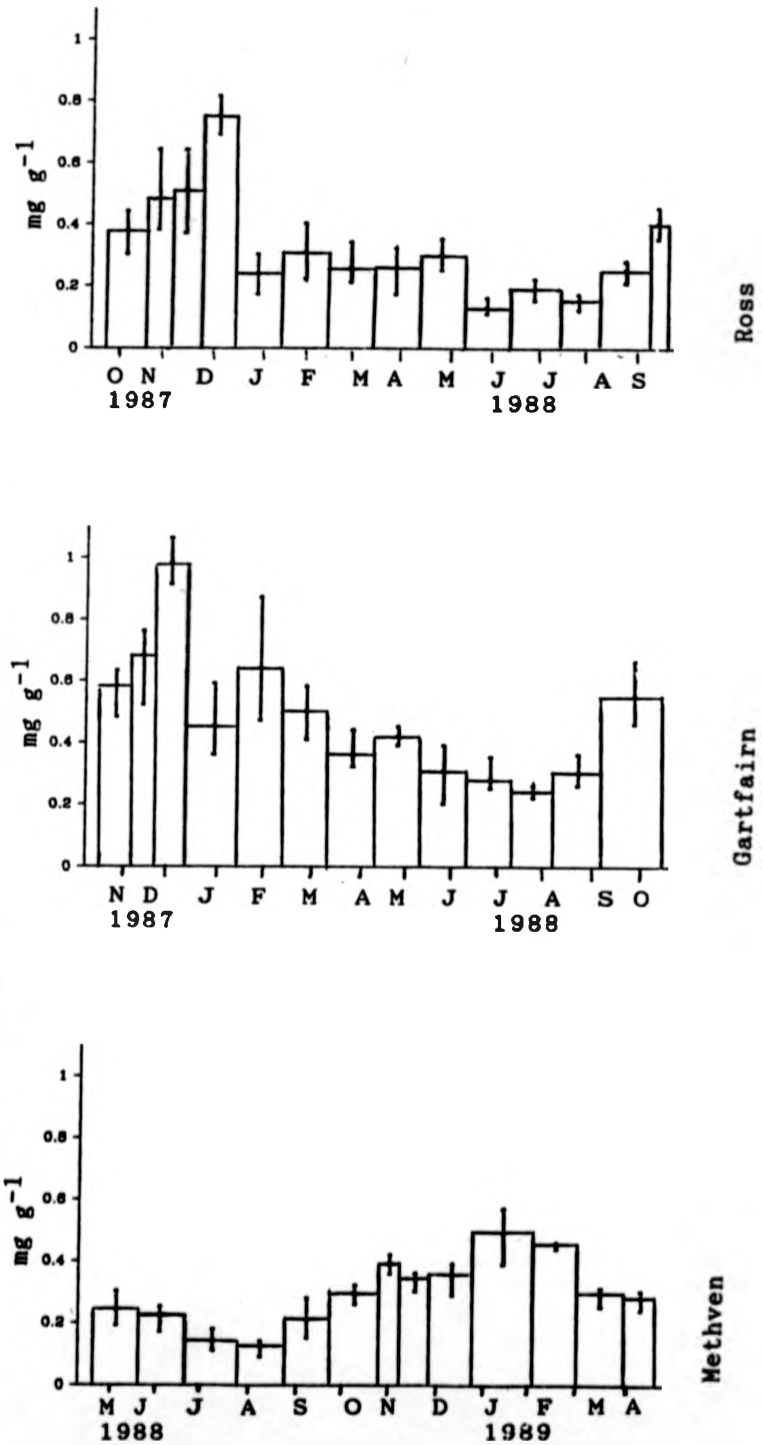


Fig. 12 (b). Sodium concentration in total small litter-fall (TSL).

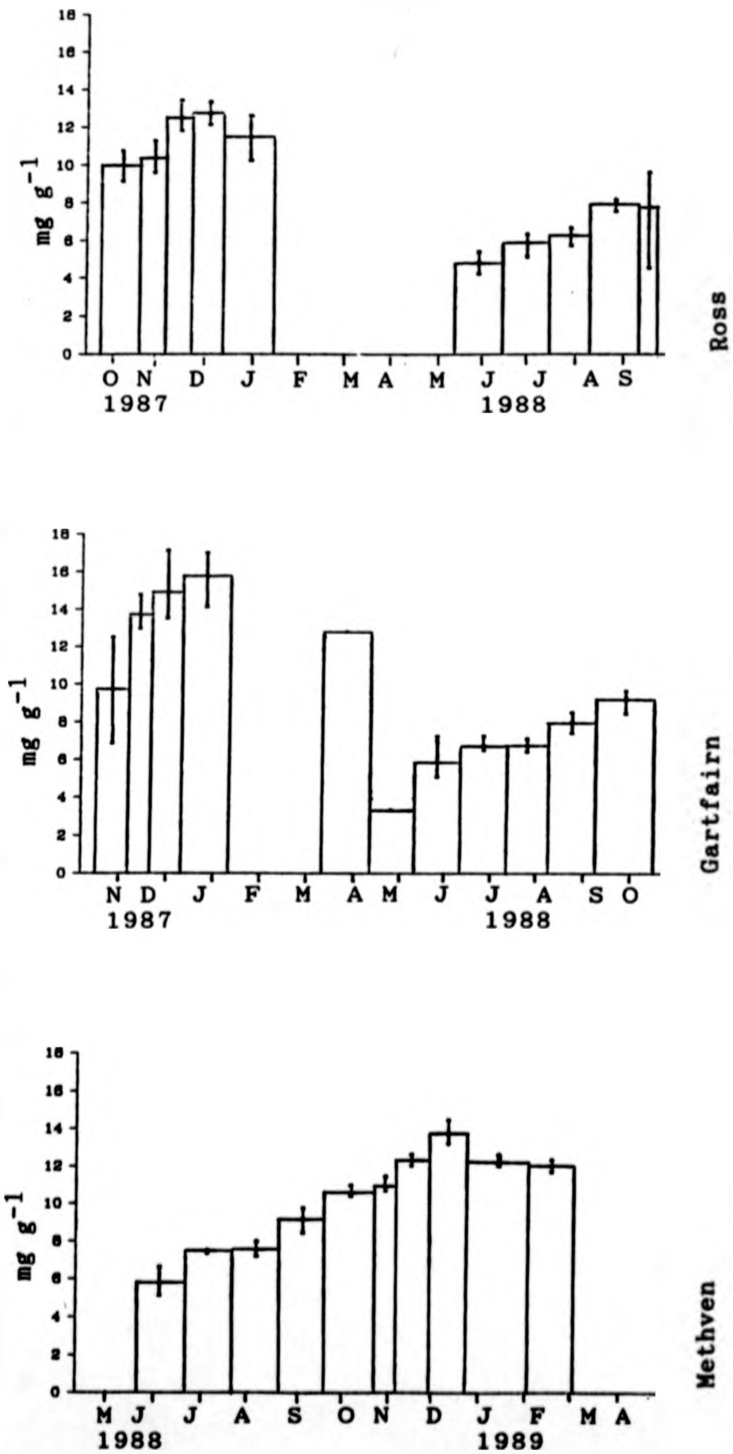


Fig. 13 (a) Calcium concentration in leaf litterfall.

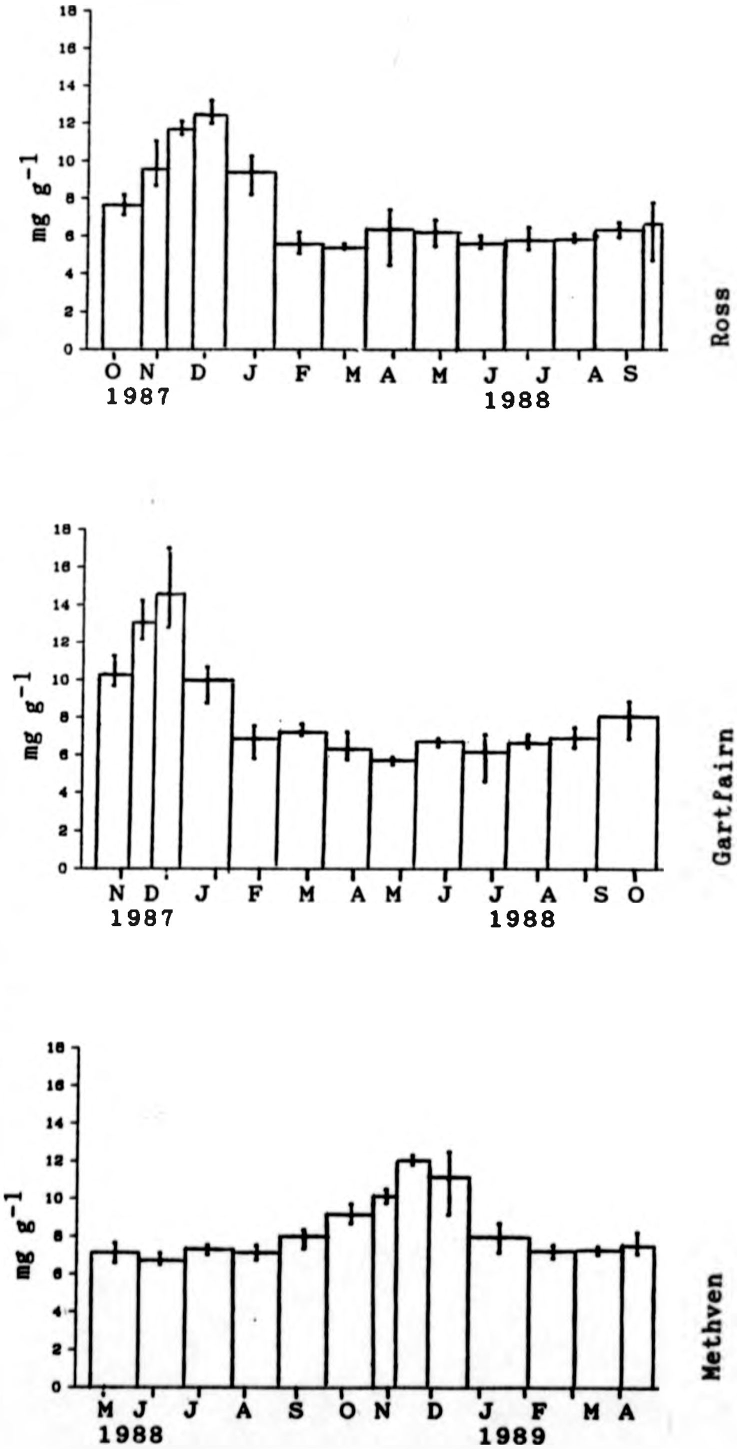


Fig. 13 (b). Calcium concentration in total small litter-fall (TSL).

Fig. 14 (a) Magnesium concentration in leaf litterfall.

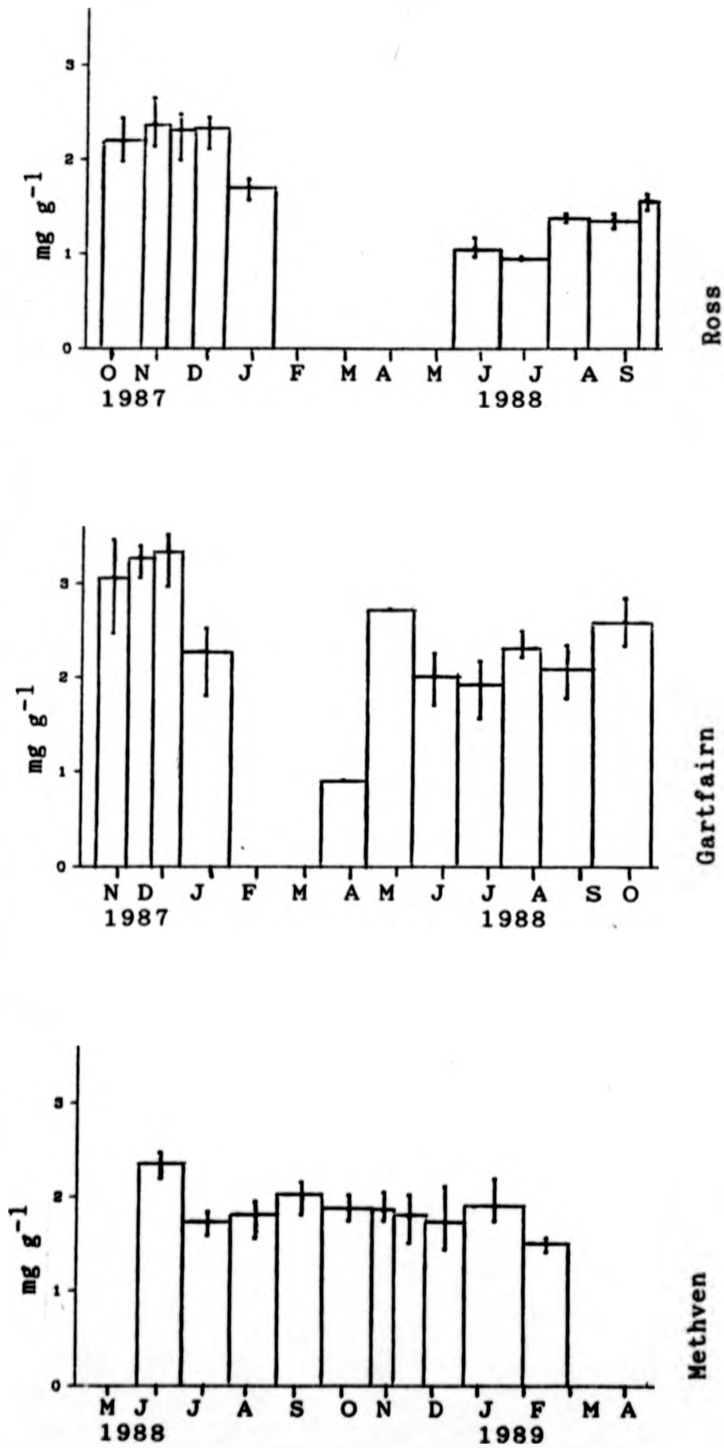


Fig. 14 (b). Magnesium concentration in total small litterfall (TSL).

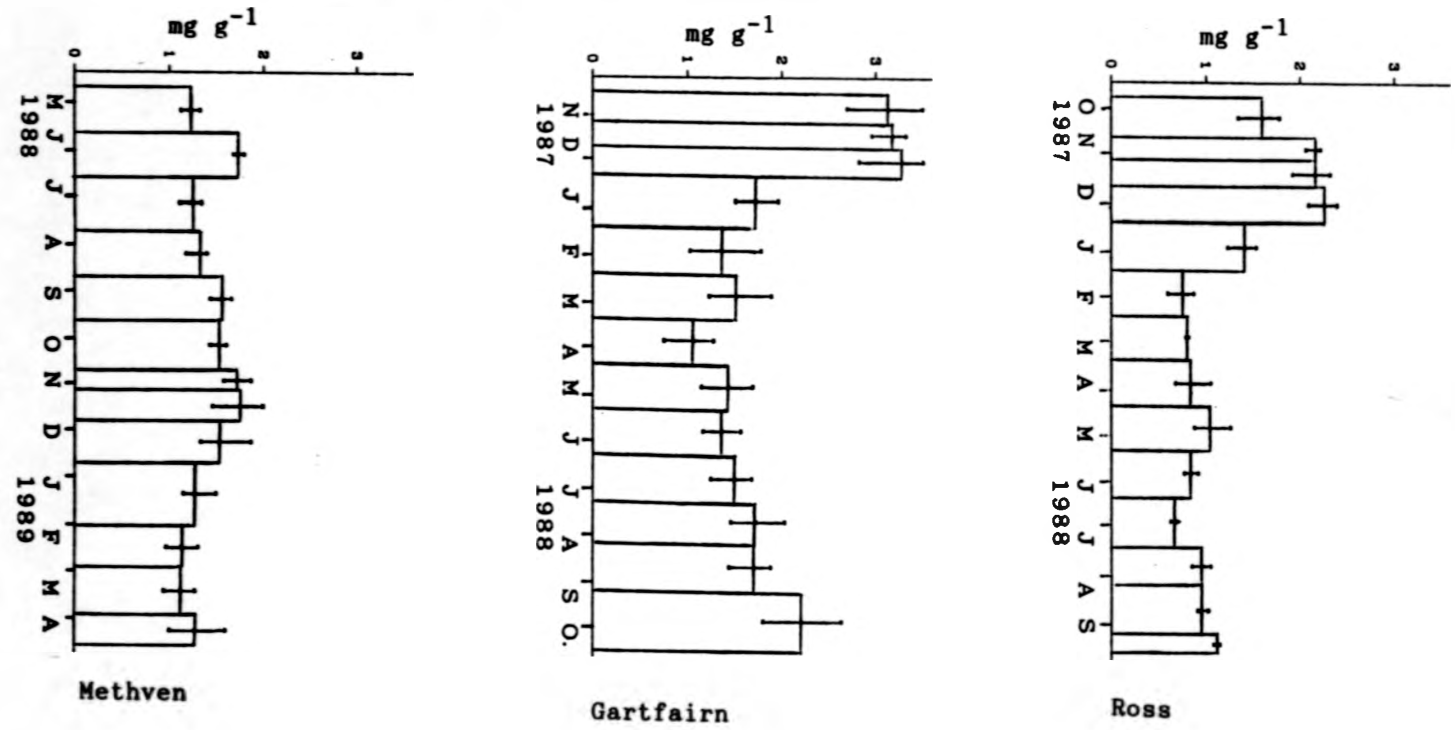


Table 9. Average annual production of Oak leaf, non-Oak leaf, small wood, fruit, miscellaneous and total small litterfall (TSL) (kg $ha^{-1}yr^{-1}$) in Ross, Gartfairn and Methven. Values are expressed on an oven dried (85 °C) basis.

Wood	Oak (leaves)	Non-Oak (leaves)	Small wood	Fruits	Miscell-aneous	TSL
Ross	2311	47	706	164	379	3607
Gartfairn	2485	514	938	110	428	4476
Methven	3101	83	1268	185	730	5368

Chemical elements

Concentrations of nitrogen, phosphorus, potassium, sodium, calcium and magnesium are described in Figures 9 to 14 for Oak leaves (a) and TSL (b). The values for all the individual fractions are in appendix 3B.

The following patterns of nutrient concentrations in Oak leaves were observed (Figs 9a-14a): nitrogen and phosphorus were highest in May - June and reached low values by October-November; potassium concentrations fluctuated and were rather high in mid-October to November; sodium, calcium and magnesium concentrations were low in May and continued to rise until the end of the leaf fall season (December to January). The patterns of nutrient concentrations in TSL (Figs 9b-14b) for all of the elements are dominated by Oak leaves nutrients (Figs 9a-14a) with a reduced fluctuation caused by contributions of the other fragments.

The following differences in nutrient concentrations of Oak leaves were observed between the woodlands: nitrogen concentrations for June and November were both slightly higher in Methven and lower in Ross although the highest peak in Gartfairn (based on one sample of a very small amount of freshly fallen leaves) was in mid-April to early May; phosphorus was higher in Methven in mid-May to mid-June than the other two woodlands, and it remained rather high only in Gartfairn in mid-October to December; potassium, in mid-May to mid-June, was highest in Methven and lowest in Ross, and in October-November was lower in Gartfairn than Ross and Methven; sodium, in mid-December to early January, was highest in Gartfairn and lowest in Methven; calcium concentrations in June were lower in Ross and in December were highest in Gartfairn; magnesium was generally higher in Gartfairn than other woods through the year.

Differences in TSL nutrient concentrations between woodlands for all of the elements are dominated by values for the Oak leaves except for small variations in phosphorus. Phosphorus concentrations of TSL (Fig 10b) were highest: during May and June in both Ross and Methven, and during November to January in Gartfairn, and were lowest: during October to November in Methven, April in Ross and February in Gartfairn.

Nitrogen, phosphorus, potassium, sodium, calcium and magnesium input (mg m^{-1} d^{-1}) are shown in Figs 15 to 20 for Oak leaves (a) and TSL (b). The input of all the elements, both for Oak leaves and TSL was least during March to early May when it gradually rose, and then in October sharp rises occurred and it remained high until

Table 10 a. Nitrogen, phosphorus, potassium, sodium, calcium and magnesium input (kg ha^{-1} yr^{-1}) by Oak leaves in each of the three plots in each of the three sites. The mean ± SE (n=3) for each site is shown.

Wood	Plot	N	P	K	Na	Ca	Mg
Ross	1	22.90	3.69	14.29	1.33	31.45	6.21
	2	24.15	1.34	7.88	0.84	24.27	4.25
	3	17.36	0.91	7.30	1.23	22.09	4.49
Mean		21.47	1.98	9.82	1.13	25.94	4.98
± SE		2.09	0.86	2.24	0.15	2.83	0.62
	4	32.34	3.64	11.45	1.74	31.37	7.31
	5	29.14	3.75	9.44	1.23	26.67	7.40
	6	33.79	3.16	9.52	1.67	27.36	6.82
Mean		31.76	3.52	10.14	1.55	28.47	7.18
± SE		1.37	0.18	0.66	0.16	1.47	0.18
	7	58.23	4.82	18.34	1.13	39.94	6.67
	8	39.60	2.14	13.03	0.96	29.99	4.43
	9	42.12	2.93	15.02	0.95	32.03	5.94
Mean		46.65	3.30	15.46	1.01	33.99	5.68
± SE		5.84	0.80	1.55	0.06	3.03	0.66

Table 10 b. Nitrogen, phosphorus, potassium, sodium, calcium and magnesium input (kg ha^{-1} yr^{-1}) by Birch leaves in each of the three plots in each of the three sites. The mean ± SE (n=3) for each site is shown.

Wood	Plot	N	P	K	Na	Ca	Mg
Ross	1	0.87	0.07	0.28	0.02	0.54	0.28
	2	0.40	0.04	0.09	0.01	0.29	0.08
	3	0.39	0.03	0.17	0.01	0.44	0.22
Mean		0.55	0.05	0.18	0.01	0.42	0.19
± SE		0.16	0.01	0.06	0.00	0.07	0.06
	4	8.99	1.11	2.18	0.35	7.57	1.63
	5	7.01	1.07	1.70	0.25	5.64	2.00
	6	6.25	0.98	1.38	0.34	4.52	1.53
Mean		7.42	1.05	1.75	0.31	5.91	1.72
± SE		0.82	0.04	0.23	0.03	0.89	0.14
	7	2.48	0.30	1.04	0.06	1.84	0.45
	8	0.80	0.07	0.34	0.03	0.76	0.16
	9	0.69	0.09	0.23	0.01	0.45	0.11
Mean		1.32	0.15	0.54	0.03	1.02	0.24

Table 11. Nitrogen, phosphorus, potassium, sodium, calcium and magnesium input (kg ha $^{-1}$ yr $^{-1}$) by total small litterfall (TSL) in each of the three plots in each of the three sites. The mean ± SE (n=3) for each site is shown.

Wood	Plot	N	P	K	Na	Ca	Mg
Ross	1	38.85	4.94	21.49	1.71	39.73	7.46
	2	40.72	2.29	10.74	1.06	31.41	5.29
	3	26.86	1.45	9.73	1.46	26.97	5.19
Mean		35.48	2.89	13.99	1.41	32.70	5.98
± SE		4.34	1.05	3.76	0.19	3.74	0.74
Gartfairn	4	63.25	6.07	17.55	2.61	48.54	10.63
	5	56.26	5.93	14.42	1.96	40.67	11.39
	6	63.40	5.78	15.88	2.62	41.08	10.88
Mean		60.97	5.93	15.95	2.40	43.43	10.97
± SE		2.36	0.08	0.90	0.22	2.56	0.22
Methven	7	100.09	8.40	29.31	1.63	57.58	9.70
	8	73.79	4.54	22.13	1.46	44.34	6.59
	9	72.23	5.57	23.40	1.42	45.54	8.37
Mean		82.04	6.17	24.95	1.50	49.15	8.22
± SE		9.04	1.15	2.21	0.06	4.23	0.90

early to mid January. The peak of the input was in November in Ross and Gartfairn (1987) and late October to early November in Methven (1988). The peaks for all the elements were highest in Gartfairn and lowest in Methven except for potassium which was highest in Methven.

The annual input of nutrient elements (N, P, K, Na, Ca and Mg) to the soil for the plots and the sites are shown in Tables: 10 a for Oak leaves, 10 b for Birch leaves, and 11 for TSL. The input of all nutrients by Oak leaves and TSL were highest in Methven and lowest in Ross except for sodium and magnesium for which the values were higher at Gartfairn. The inputs of nutrients by birch leaves were much higher in Gartfairn and were lowest in Ross. In agreement with other studies (e.g Carlisle *et al* 1966a), for all the nutrients most of the annual input,

Fig. 15 (a). Nitrogen input by leaf litterfall.

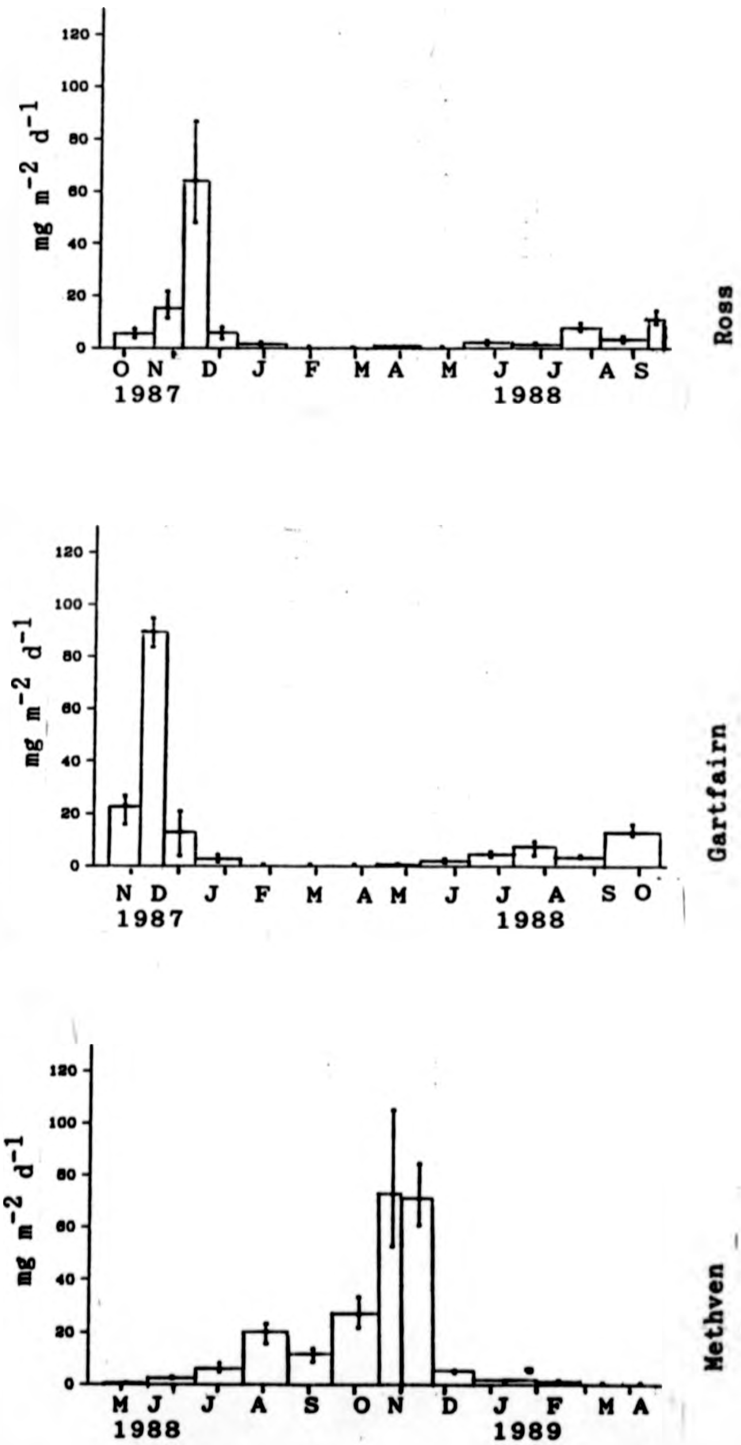


Fig. 15 (b). Nitrogen input by total small litterfall (TSL).

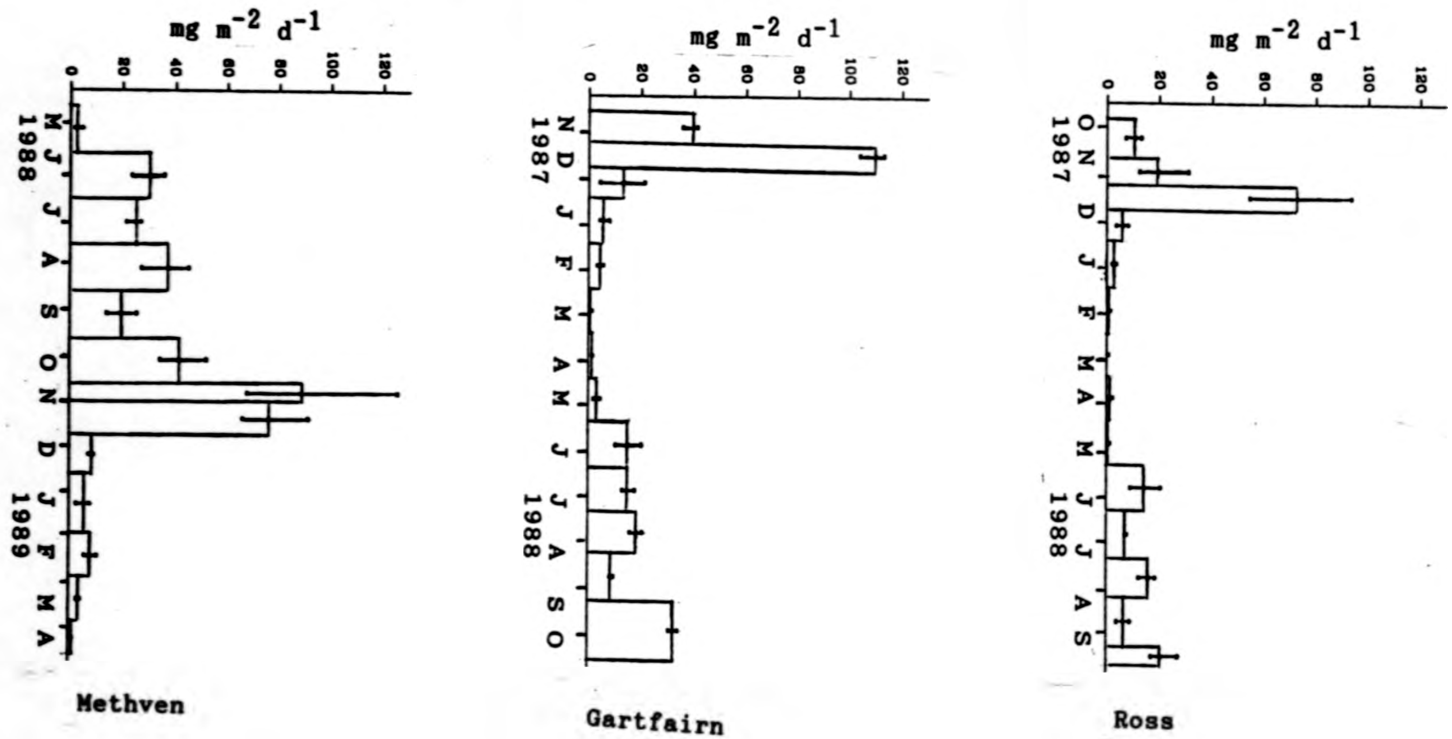


Fig. 16 (a). Phosphorus input by leaf litterfall.

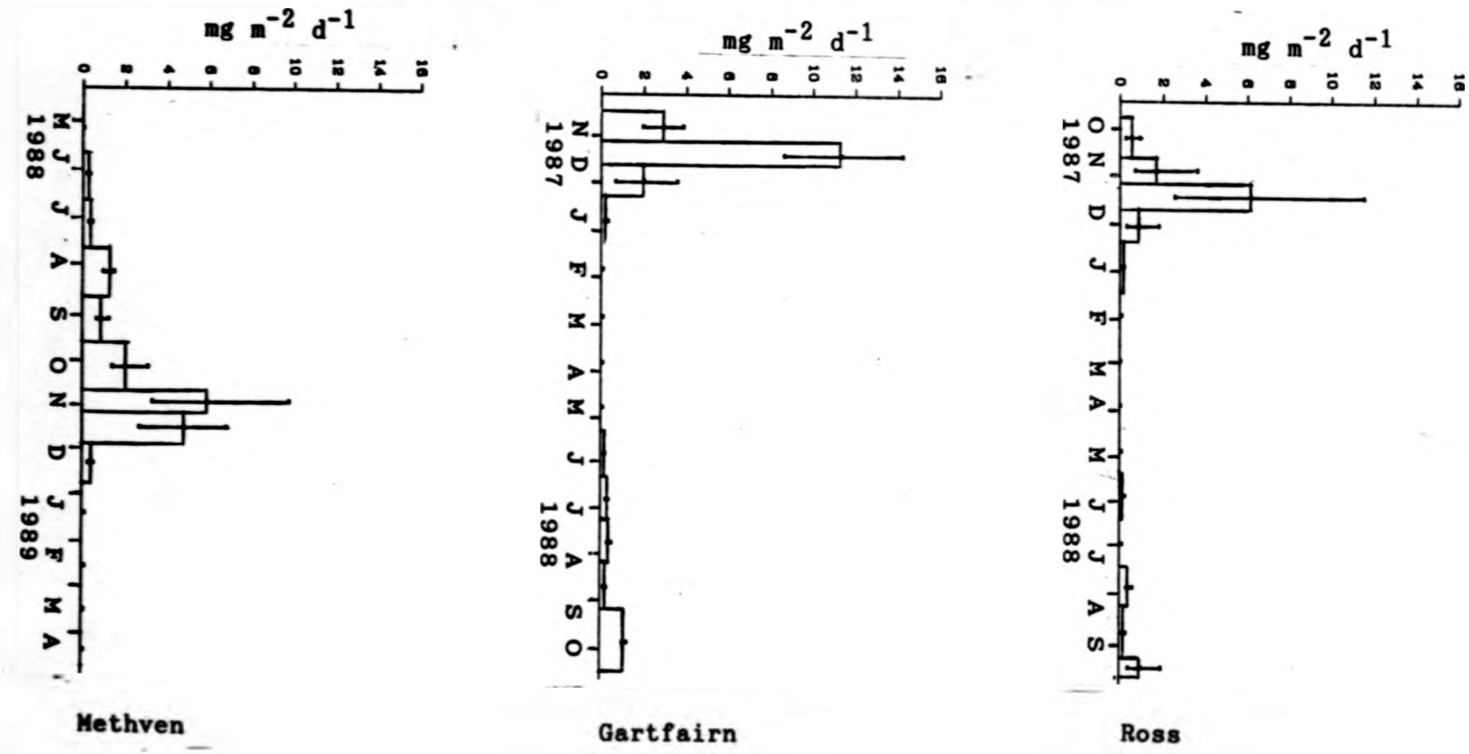
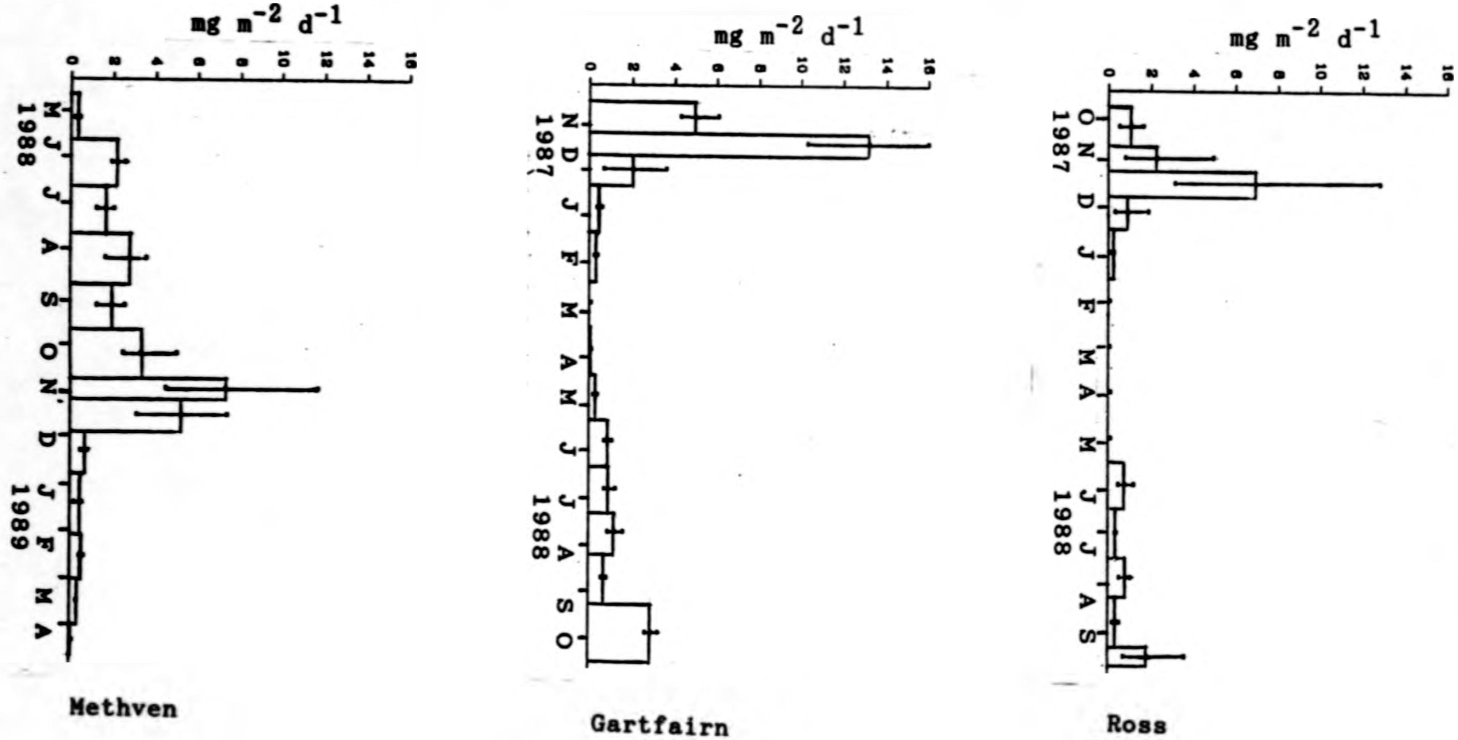


Fig. 16 (b). Phosphorus input by total small litterfall (TSL).



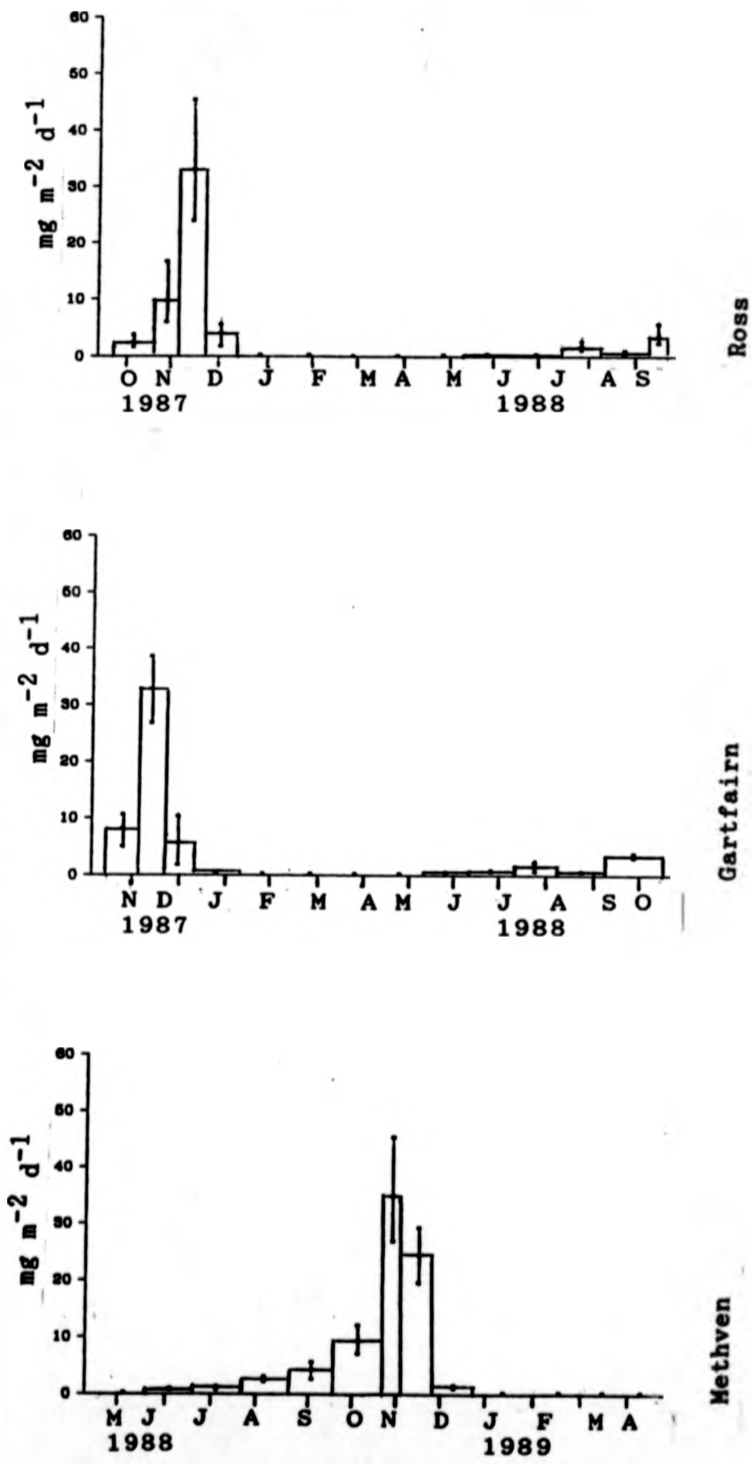


Fig. 17 (a). Potassium input by leaf litterfall.

Fig. 17 (b). Potassium input by total small litterfall (TSL).

Fig. 18 (a). Sodium input by leaf litterfall.

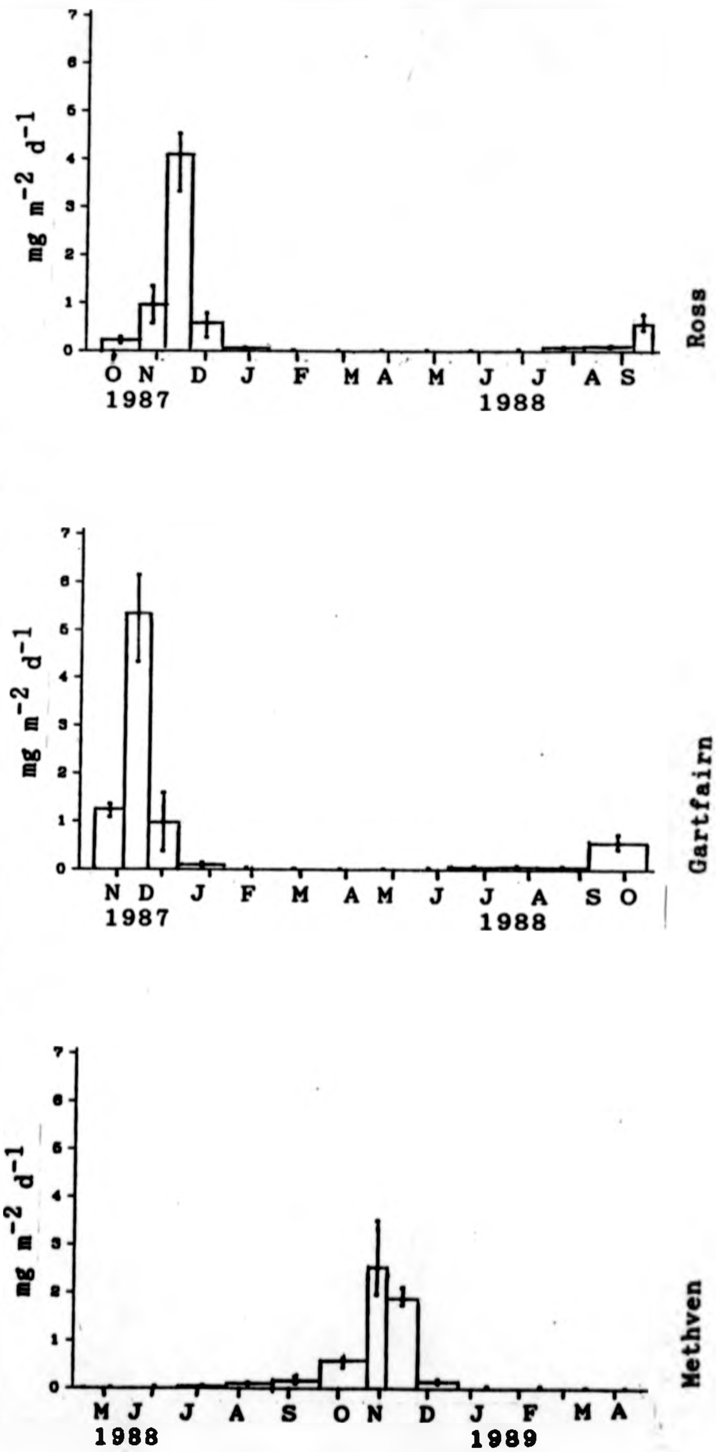
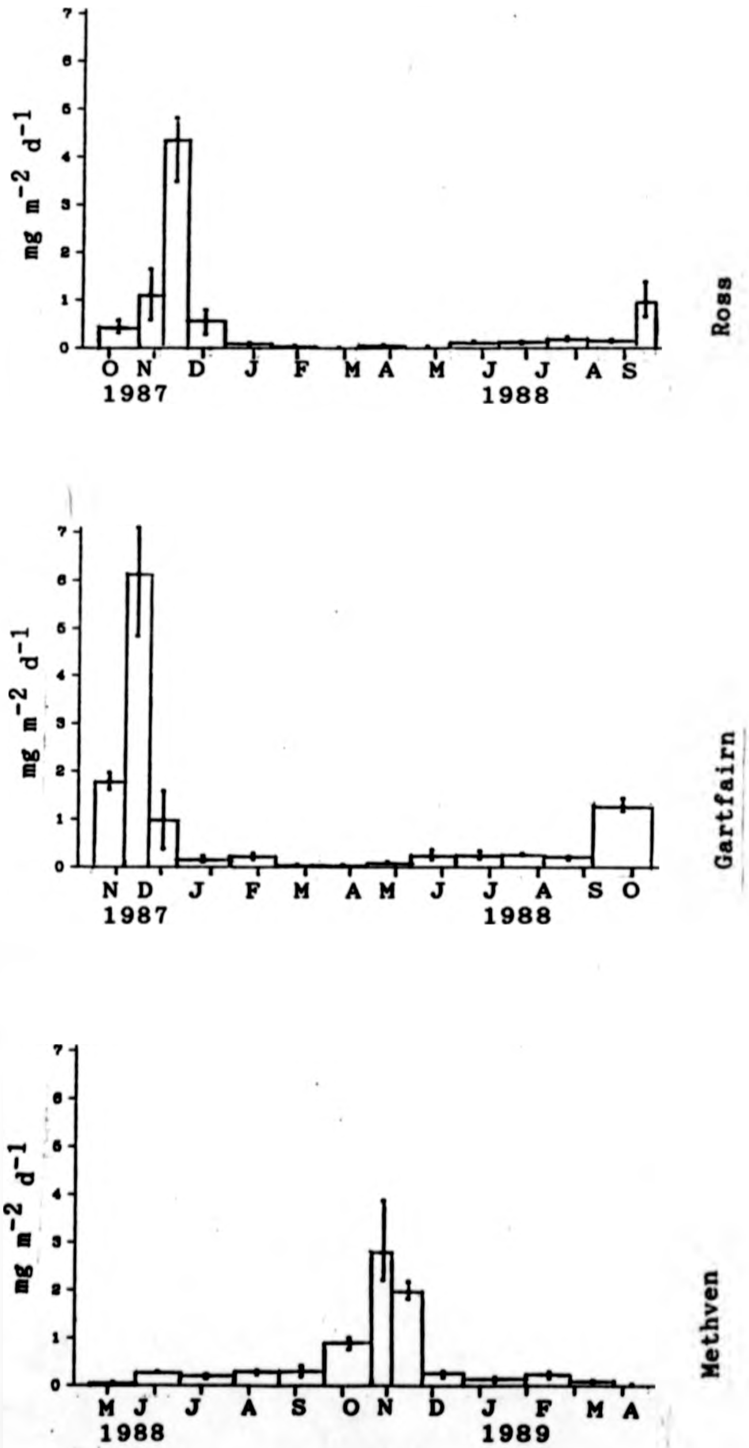


Fig. 18 (b). Sodium input by total small litterfall (TSL).



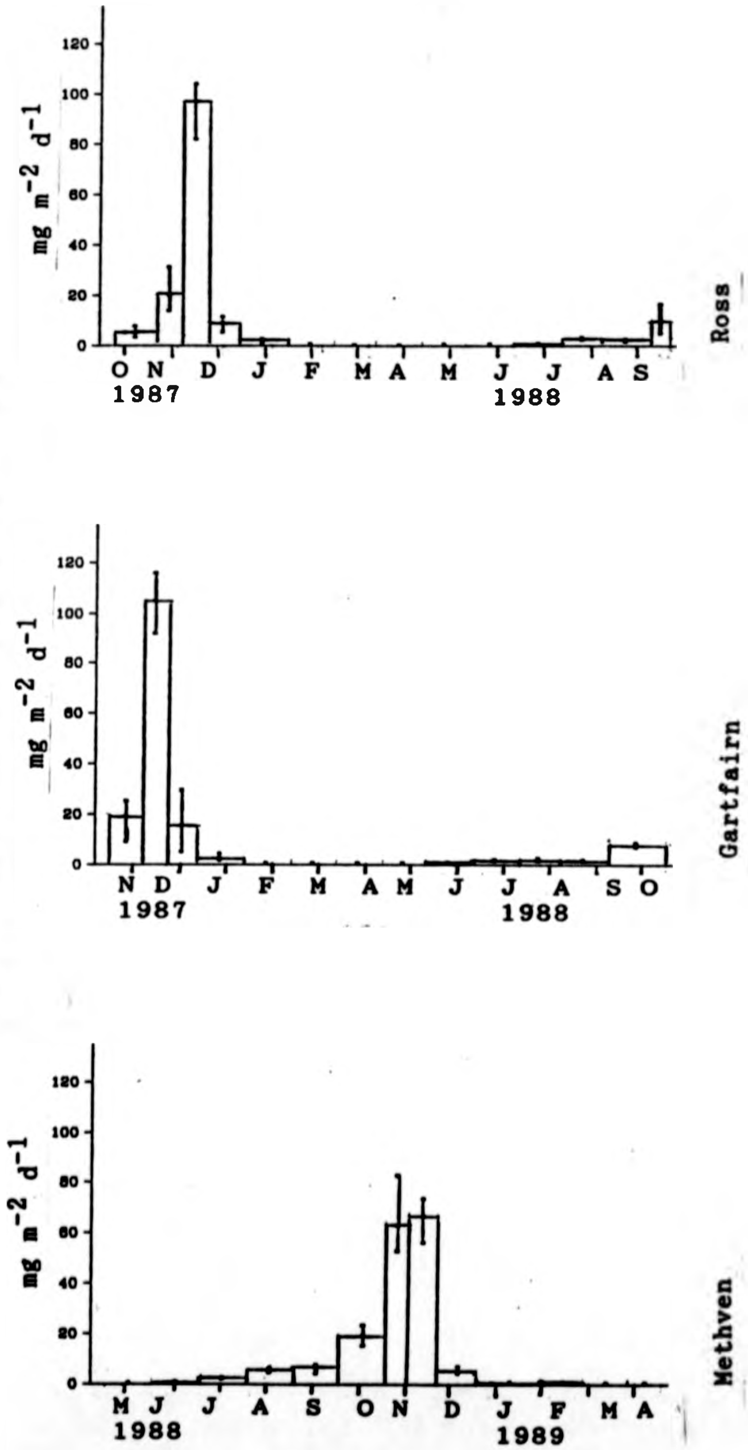
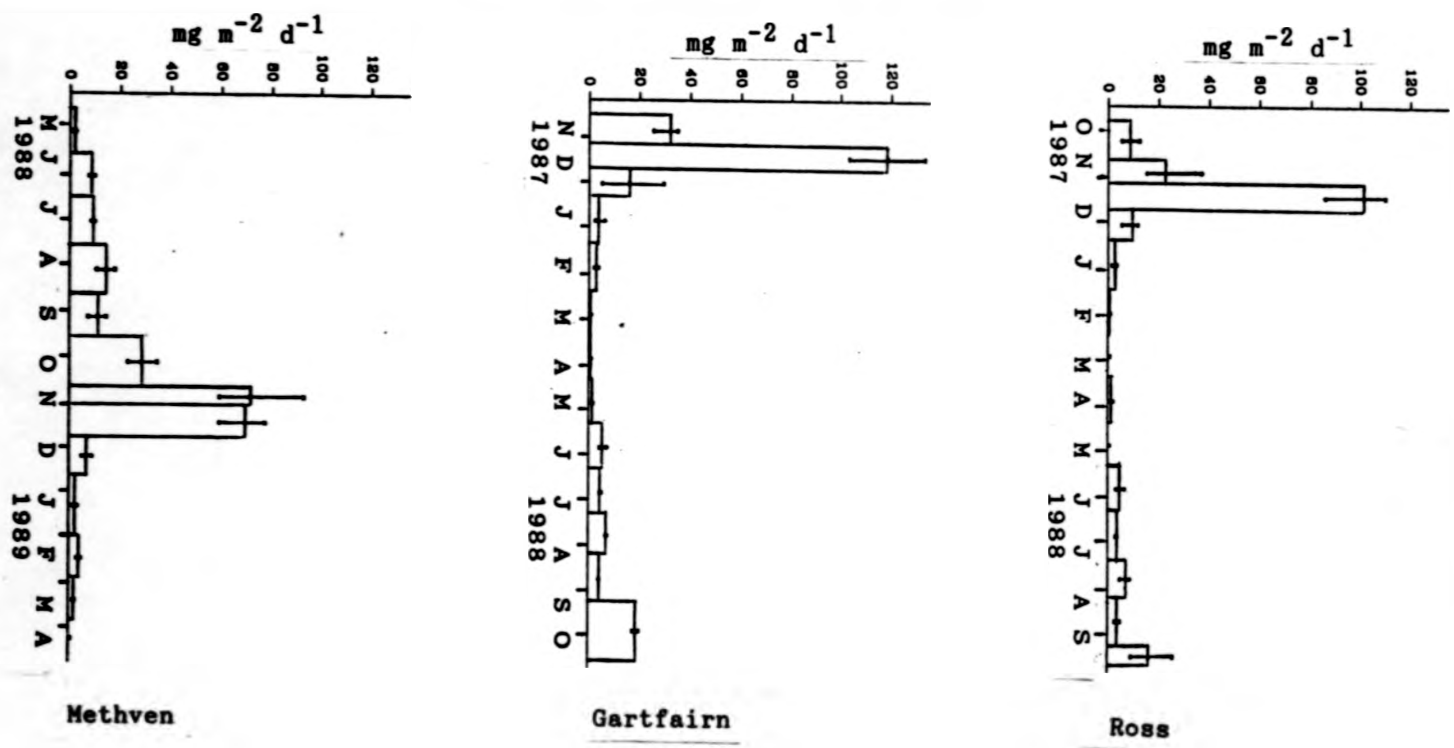


Fig. 19 (a). Calcium input by leaf litterfall.

Fig. 19 (b). Calcium input by total small litterfall (TSL).



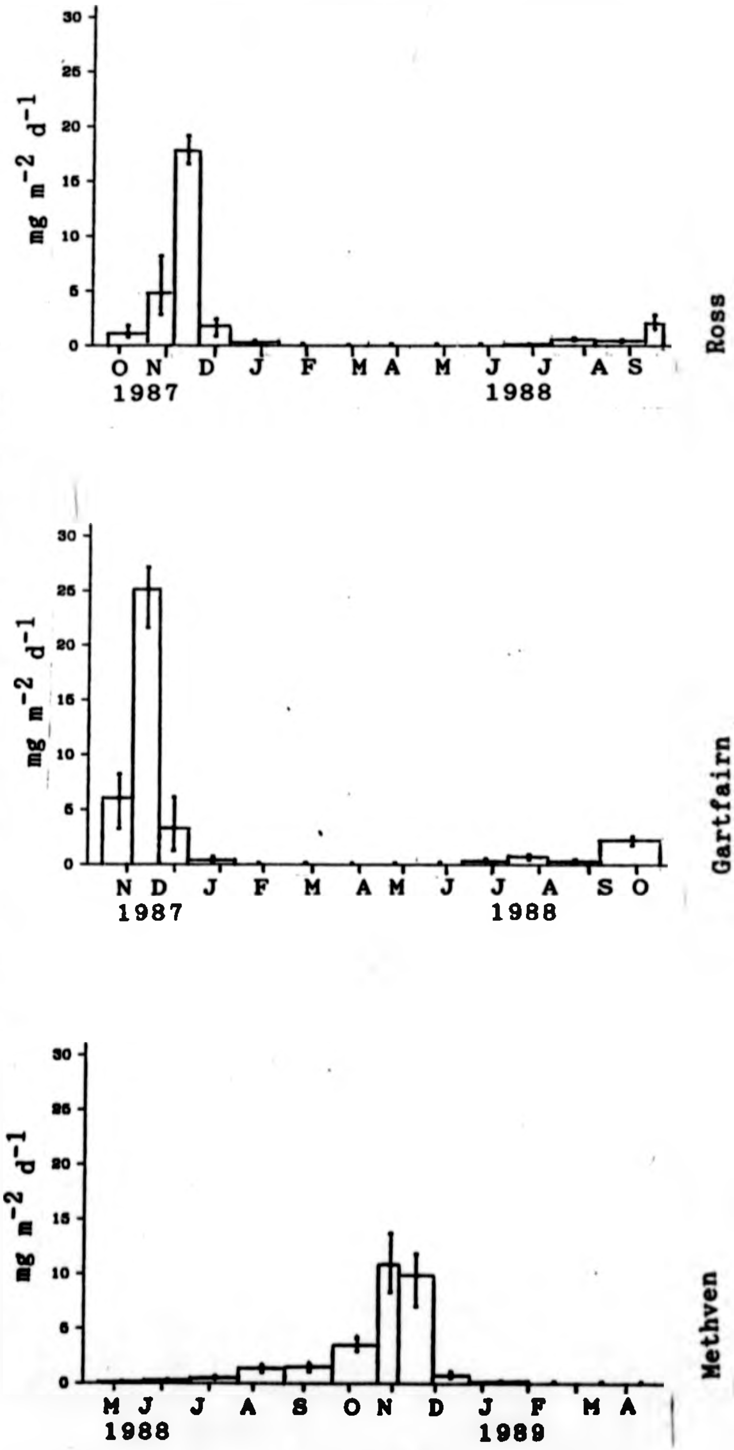
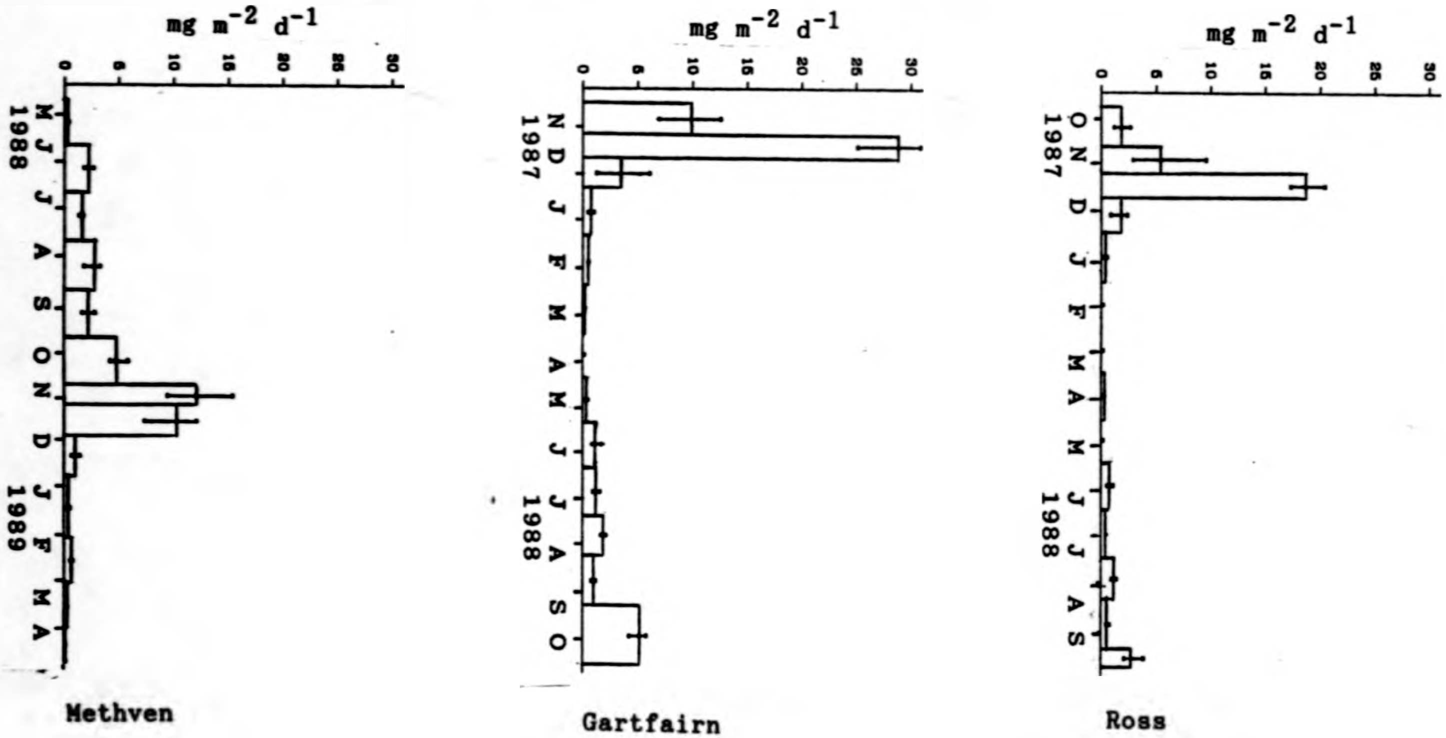


Fig. 20 (a). Magnesium input by leaf litterfall.

Fig. 20 (b). Magnesium input by total small litterfall (TSL).



by litterfall occurred during the autumn (Figs 15-20 a) but the amount of nutrient input, by leaves and other litterfall fractions, during other seasons (Figs 15-20 b) were of importance. Fall of nutrient-rich bud scales and catkins during spring and early summer, and later frass and dead insects could be of importance in the cycling of the nutrients (Ovington 1963; Brown 1974).

3.4 DISCUSSION

Litterfall study period

The wide variations in litterfall from month to month show that one year is the minimum period for a litterfall study. I have no information on variation in litterfall from year to year. To evaluate year to year variations a study period of at least three years is recommended (Newbould, 1967 and Chapman, 1986). Briggs *et al* (1989) in an Oak forest in northeastern Kansas (USA) found highly significant differences in annual litterfall during 1981-1986. They correlated the annual production (negatively) with the precipitation. Carlisle *et al* (1966a) found less autumn litterfall in a heavy *Tortrix* activity year than other years. The litterfall data reported by some workers showed highly significant differences between the years of their study period (eg. Stohlgren, 1988; Rapp & Leornardi, 1988; Bray & Gorham, 1964) while in others these variations were not significant (eg. Cameron & Spencer, 1989 and Weber, 1987).

Litterfall mass

The high proportion of leaves in total small litterfall (e.g. Gosz *et al* 1972; Brown 1974; Carlisle *et al* 1966a; Lang & Forman 1978; Rawat & Singh 1988a; Singh *et al* 1984, and this study) in different temperate Oak forests results in high litterfall during autumn (October to December). However there was substantial leaf fall in other seasons (Figs 6a-8a) with the pattern in agreement with the review by Longman & Coutts (1974). The contribution of wood fall which is mostly heavy in October is important (Carlisle *et al* 1966a; Brown 1974). The abscission of apparently healthy (up to 75 cm long) leafy branches is characteristic of Oak in autumn (Longman & Coutts 1974). This was the case in my study and in the autumn and early winter small wood reached a peak earlier than the peak for leaf fall. Autumn gales have been reported to cause this (Bray & Gorham 1964; Gosz *et al* 1972; Longman & Coutts 1974; Carlisle *et al* 1966a). The retention of leaves during this time would increase the wind resistance and the likelihood that the branches would be shed. Variation in temperature has also been reported to be responsible for temporal and spatial variation in the pattern of leaf fall in deciduous woodland (Monk 1949, cited by Bray & Gorham 1964) which could be a reason for the differences in litterfall pattern in Methven compared Ross and Gartfairn. In none of the sites was there a heavy acorn production. It has been reported that in mast years this can reach 5000 kg ha^{-1} yr^{-1} (Longman & Coutts

1974). The confidence limits for the sampling of acorns (and to some extent of small wood) were high (Table 8) a feature that has been noticed elsewhere (Briggs *et al* 1989). The reasons for this are: a, sporadic occurrences of acorns especially in low production years; b, consumption of acorns on trees and in traps (a squirrel was once seen inside the traps and in several other cases peelings of consumed acorns were found; c, the velocity by which the acorns (also wood) fall to the ground is much higher than leaves which come down slowly and gliding and have a more even distribution on the forest floor. A number of fascinating accounts of the fate of acorns and the variety of animals and birds responsible for their depletion have been reported (Shaw 1974). The composition of the miscellaneous fraction was a reflection of the phenology of the trees (Longman & Coutts 1974).

As a whole the masses for leaf and total litterfall produced in the three sites falls within the values in the literature (Table 16) for temperate regions. Differences in the amounts of litterfall have been correlated with: latitude, altitude and precipitation (Lonsdale 1988), soil physical properties (Ovington 1965), and also to basal area (Crosby 1961; Bonnevie-Svendsen & Gjems 1957) (both cited in Bray & Gorham 1964). In my study regressing different fractions of small litterfall against soil nutrients, soil pH, basal area and above ground biomass (using mean or total values, as appropriate, for plots, i.e. *n*=9) the following significant correlations for leaf and TSL masses (kg ha^{-1} yr^{-1}) with soil pH and above ground biomass (t ha^{-1}) (Chapter 2) were achieved.

Leaf mass = 863 + 510 soil pH	r=0.73	P=0.026
TSL = 615 +995 soil pH	r=0.76	P=0.017
TSL=2498+13.4 above ground biomass	r=0.75	P=0.020

Nutrient fluxes

Tree litterfall accounts for one of a number of fluxes of nutrients within the woodland ecosystem. Other above-ground fluxes are the inputs by the ground flora litterfall, throughfall, stem flow, and large woodfall. Below-ground there is uptake and release by growing plants and micro-organisms including the fluxes involved in the turnover of fine and large roots. Inputs to the whole ecosystem will occur through precipitation (including particulate matter) and weathering of the parent material; losses will occur in the drainage water. At Gartfairn there may be extra fluxes associated with the fall and rise of water levels in Loch Lomond. In the three woodlands studied information is available only for small litterfall which is however likely to be a major pathway. Its relative importance will vary from site and from element to element. The most easily comparable study where a range of fluxes have been estimated is that in the *Quercus petrea* woodland in North Lancashire (Carlisle, Brown & White 1967). They found (for a 225 m^2 plot) for the above-ground fluxes they measured (Table 12) that tree fine litterfall accounted for : 68.6% of the nitrogen;

47.5% of the phosphorus; 28.6% of the potassium; 3.4% of the sodium; 54.3% of the calcium; and 24.1% of the magnesium. It is clear that there will be substantial differences in the fine litterfall proportion of the total nutrient flux in the three woodlands studied. For example the lower rainfall at Methven will tend to reduce the amount of the nutrients moving in throughfall but this may be partially offset by atmospheric pollutants from the nearby large town of Perth. Without detailed studies of all the nutrient fluxes, the quantification of element movement in fine litterfall is frequently relied on (as in this study) as an index for ecosystem comparison.

Table 12. Dry weight mass and nutrient contents (kg ha^{-1}) of some of the component fluxes in Bogle Crag Wood at North Lancashire from Carlisle *et al* (1967)

	Dry weight	N	P	K	Na	Ca	Mg
Tree litter	5196	48.7	2.81	15.3	3.36	32.1	4.86
Pteridium litter	1470	12.9	0.89	6.9	0.74	4.0	1.26
Throughfall	—	9.3	0.92	29.7	89.4	21.0	13.2
Stemflow	—	0.13	0.01	1.56	5.91	2.01	0.71
Total	6666	71.0	4.63	53.5	99.4	59.1	20.0

Litterfall nutrients

The mass of nutrients added to the forest floor in the tree litterfall was within the range of the values for other temperate woodlands (Table 15). Notably, nitrogen in the Ross litterfall was near the lowest end of the range.

Nutrient-use efficiency

Vitousek (1982) has compared element concentrations in total small litterfall from a wide range of sites and has used this as an index of nutrient-use efficiency. This comparison is made for Ross, Gartfairn and Methven for nitrogen, phosphorus and calcium in TSL (Table 13) . Data for other elements in TSL are not given since potassium and sodium move largely in throughfall, and magnesium is intermediate and variable between sites.

Table 13. The mass of total small litterfall and its content of nitrogen, phosphorus and calcium (kg $ha^{-1}yr^{-1}$) in Ross, Gartfairn and Methven woods. Values in parentheses are the quotients litterfall mass / element content and are an index of nutrient use efficiency (Vitousek 1982).

Site	Litterfall mass	N	P	Ca
Ross	3600	35.5 (101)	2.89 (1250)	32.7 (110)
Gartfairn	4480	61 (73.4)	5.93 (755)	43.4 (103)
Methven	5370	82 (65.5)	6.17 (870)	49.2 (109)

The data in Table 13 gives evidence that at Ross the nitrogen and phosphorus are used more efficiently. This is what would be expected from soil analyses (Table 6) since the podzolic soils, such as those which occur at Ross, are likely to have low supplies of nitrogen and phosphorus.

One mechanism by which nutrients might be used more efficiently is that there may be a reabsorption of nutrients from leaves into stems prior to leaf abscission (eg.

Staaf 1982). A greater reabsorption has been demonstrated for trees on nutrient-poor soils compared with those better supplied with nutrients (eg. Boerner 1984; Stachureski & Zimka 1975). Such reabsorption is best quantified by using methods such as those of Boerner (1984) who sampled fresh leaves from similar positions on trees at several dates during the growing season and in freshly fallen litter over the autumnal period of litterfall. In my study no fresh leaf analyses were made but some indication of the extent of nitrogen and phosphorus reabsorption is given by comparing their concentrations in leaves shed during the growing season with those in leaves shed in autumn (Fig 9a -10a and Table 14). The autumn leaves have much lower concentrations of nitrogen and phosphorus and those from Ross have much lower proportions of nitrogen (when compared with the summer values) than the leaves from Gartfairn and Methven.

Table 14. Mean nitrogen, phosphorus and concentration (mg g^{-1}) in leaf litterfall in summer and winter in the three sites. The proportions of the concentrations (winter / summer) are given in parentheses.

Site	N		P	
	Jul	Nov	Jun	Nov
Ross	30.93	7.82	2.53	0.74
	(0.25)		(0.29)	
Gartfairn	26.36	12.24	2.37	1.54
	(0.46)		(0.65)	
Methven	25.82	12.27	3.13	0.95
	(0.48)		(0.30)	

Table 15. The leaf and Total small litterfall (TSL) mass and the annual input of nutrient elements (kg $ha^{-1} yr^{-1}$) reported for some forests of the world including this study.

Vegetation	Place		Mass	N	P	K	Na	Ca	Mg	Author
Quercus alba	Missouri									Rochow (1975)
	USA	TSL	3490	47.9	3.2	6.4	—	70.3	4.9	
Deciduous forests	Minnesota									Reiners & Reiners
Oak forest	USA	TSL	4574	43.8	5.4	—	—	49.6	10.0	(1970)
Fen forest		"	4115	45.0	6.5	—	—	87.0	11.5	
Swamp forest		"	4881	42.0	6.2	—	—	90.6	12.0	
	Minnesota									Ovington (1963).
White pine	USA	Leaf	2965	24	2.3	2.6	—	27.9	4.4	
Aspen		"	2101	15.6	2.0	2.6	—	27.3	4.4	
	Appalachian									Shure & Phillips.
Mixed hardwood	mountains USA	"	3651	—	—	—	—	—	—	(1987)
	New York USA									Whittaker &
Oak-pine		TSL	4060	—	—	—	—	—	—	Woodwell
	Tennessee USA									(cit. Barbour
Hardwood		TSL	3200	—	—	—	—	—	—	<u>et</u> <u>al</u>. 1980)
Softwood		TSL	2670	—	—	—	—	—	—	
	Flint Hills									Briggs <u>et</u> <u>al</u>
Mixed oak	Kansas, USA	Leaf	2190-3560							(1989)
		TSL	2910-4550							
	New Jersey									Lang & Forman
Mixed oak	USA	Leaf	4780	55	4.4	17.0	—	52.0	6.2	(1978)
" "		TSL	6200	100	6.6	23.0	—	65.0	7.1	
	Tennessee USA									Harris <u>et</u> <u>al</u>
Hardwood		TSL	4000-4500	—	—	—	—	—	—	(1973)*.
	Missouri USA									Rochow (1975).
Qercus alba		TSL	3500	—	—	—	—	—	—	
	Houston USA									Cameron & Spencer
Sapium sebiferum		Leaf	3900	41.0	3.12	23.1	2.73	87.8	19.5	(1989).
	Hubbard Brook									Goss <u>et</u> <u>al</u> (1972).
Mixed forest	New Hampshire	Leaf	2800	29.9	1.9	12.6	0.25	23.3	3.8	
" "	USA	TSL	4709	52.0	3.6	17.4	0.39	38.7	5.3	
	Florida, USA									Lugo <u>et</u> <u>al</u> (1978)*
Hardwood		TSL	10700	—	—	—	—	—	—	
	California USA									Stohlgren (1988a).
Giant sequoia		Leaf	3162	—	—	—	—	—	—	
- fir stand		TSL	6364	—	—	—	—	—	—	
Fir - pine		Leaf	1890	—	—	—	—	—	—	
forest		TSL	4355	—	—	—	—	—	—	
Pinus banksiana	Middle Ottawa									Weber (1987).
Stand 1	Canada	TSL	3986	23.2	2.81	4.37	—	18.5	3.1	
" 2		"	4182	20.0	1.99	3.27	—	14.2	2.5	
" 3		"	2431	14.8	1.58	2.72	—	15.9	3.4	
" 4		"	2400	11.5	1.27	1.65	—	12.3	1.5	
	Russia									Mina (cit. Barbour
Oak		TSL	3500	—	—	—	—	—	—	<u>et</u> <u>al</u>. 1980).

*; (cit. Anderson & Swift 1983).

Table 15. continued.

Vegetation	Place		Mass	N	P	K	Na	Ca	Mg	Author
Oak forest	Bogle Crag Lancashire	Leaf	2126	21.1	0.92	6.3	—	16.8	2.7	Brown (1974).
"	England	TSL	3857	41.1	2.19	10.5	—	23.8	3.9	
Oak forest	Heathop England	Leaf	3251	39.5	2.26	17.2	—	57.0	8.6	Stachell (cit. Brown 1974).
"		TSL	5736	72.6	4.34	25.2	—	76.8	12.1	
Oak	Doven England	Leaf	3127	—	—	—	—	—	—	Ovington (1963).
Birch	Holme fen wood England	Leaf	3431	—	—	—	—	—	—	
Quercus ilex	France	TSL	1900-3500	—	—	—	—	—	—	Rapp (cit. Singh & Singh 1987).
Quercus ilex	Monte Minardo Italy	Leaf	3690	38	3	15	—	41	5	Rapp & Leornardi (1988).
		TSL	5900	57	5	24	—	74	9	
Scot pine	Devilla, Fife Scotland	Leaf	3334	—	—	—	—	—	—	Cousens (1988).
" "		TSL	3400-5000	—	—	—	—	—	—	
Hardwood	Holland	TSL	3100	—	—	—	—	—	—	Witkamp & Drift (1961).
Mixed oak	Virelles Belgium	TSL	5600-5300	—	—	—	—	—	—	Duvigneaud & Denaeyer-De Smet (1970)*
Mixed Oak & Oak	For several temperate	TSL	1750-2400	—	—	—	—	—	—	Singh & Singh (1987).
Beech forest	South Sweden	Leaf	3570	—	—	—	—	—	—	Nihlgard (1972).
		TSL	5700	69	5	14.4	2.2	31.7	4.3	
Spruce "		TSL	5600	58	4.8	10.7	2.0	19.8	3.1	
conifers	Average for temperate	TSL	4377	—	—	—	—	—	—	Cole & Rapp (1981) (cit. Weber 1987).
Oak	Temperate for Europe	TSL	8100-1400	—	—	—	—	—	—	Bray & Gorham (1964).
Hardwoods		TSL	2800	—	—	—	—	—	—	
Hardwood and softwood		TSL	5000-3600	—	—	—	—	—	—	
Oak woods	Himalaya	Leaf	4750	79	5	—	—	—	—	Singh *et al* (1984).
		TSL	6130	93	6	—	—	—	—	
Pine forest		Leaf	4660	44	4	—	—	—	—	
		TSL	6710	64	5	—	—	—	—	
Mixed oak	Himalaya	TSL	3200	—	—	—	—	—	—	Mehra *et al* (cit. Singh & Singh 1987).
Oak	Himalaya	TSL	2900	—	—	—	—	—	—	Rawat. (cit. Singh & Singh 1987).
Mixed oak		TSL	3000	72.2	5.4	32.3	—	89.2	—	
" "		"	3900	70.0	5.8	31.9	—	91.6	—	
Oak-conifer	Himalaya	TSL	2800	60.4	4.4	28.5	—	86.3	—	Pandey & Singh (cit. Singh & Singh 1987).

*; (cit. Anderson & Swift 1983).

Table 15. continued.

Vegetation	Place		Mass	N	P	K	Na	Ca	Mg	Author
Quercus leucortrichophora	Central and western Himalaya	Leaf	4610	65	4.1	22.1	1.7	69	_	Rawat & Singh (1988 a & b).
		TSL	5800	76	4.4	23.6	1.8	84	_	
Q. floribonda		Leaf	3750	72	3.0	11.3	0.5	64	_	
		TSL	4780	83	3.2	12.8	0.6	73	_	
Q. lanuginosa		Leaf	5900	101	3.8	19.7	1.8	105	_	
		TSL	7810	125	4.3	22.6	2.2	129	_	
Oak woods	This study									
Ross		Leaf	2358	22	2.0	10.0	1.1	26.4	5.17	
		TSL	3607	35	2.9	14.0	1.4	32.7	5.98	
Gartfairn		Leaf	2999	39	4.6	11.9	1.9	34.4	8.90	
		TSL	4476	61	5.9	16.0	2.4	43.4	11.0	
Methven		Leaf	3184	48	3.5	16.0	1.0	35.0	5.92	
		TSL	5368	82	6.2	25.0	1.5	49.2	8.22	

*; (cit. Anderson & Swift 1983).

CHAPTER 4

LARGE WOOD LITTERFALL

4.1 INTRODUCTION

In many forests a large part of the carbon and nutrient pool in the forest floor is stored in large wood (Bray & Gorham 1964; MacMillan 1988). The fall of large wood litter is both temporally and spatially erratic. Few studies have dealt with large wood production (e.g.Proctor *et al* 1983; Gosz *et al* 1973; Carlisle *et al* 1966a; Stohlgren 1988a; MacMillan 1988; Yoneda 1986). In this study annual large wood production was measured for three woodlands.

4.2 MATERIALS AND METHODS

Wood (>2 cm diameter) including bark (> 2cm along the largest dimension) were sampled within two 5 x 5 m randomly chosen quadrats in each plot. The quadrats were marked with string and cleared of existing large wood on 13 March 1988, 14 March 1988 and 18 April 1988 for Ross, Gartfairn and Methven respectively. Collections were subsequently made from these plots at three to four monthly intervals on the dates shown in Table 16.

All wood inside each quadrat was weighed fresh in the field using a spring balance (10 g accuracy), one subsample for each of the quadrats were taken using a saw (when required), carried in a sealed plastic bag (in order to avoid the error of moisture loss), and immediately weighed (0.01 g accuracy) in the laboratory to enable a conversion to oven dry (85 °C) weight to be made. Both sub-samples for each plot were ground separately to pass a 2 mm mesh and then bulked in proportions of the whole weight for each of the quadrats. Chemical analyses were carried out from bulked samples for each plot on each sampling period. Total nitrogen, phosphorus, potassium, sodium, magnesium and calcium were analysed following the procedures described for small litterfall (chapter 3). A nested analysis of variance was employed to compare differences in dry weights, nutrient concentrations and their inputs between and within the sites.

4.3 RESULTS

Dry mass

Large wood litterfall (LWF) oven-dried (85 °C) weights for four sampling periods and the total annual LWF mass (kg ha^{-1}) for each of the quadrats are shown in Table 16. The annual woody litterfall did not differ significantly between and within sites (P levels of 0.126 and 0.07 respectively), the mean value of 1505 kg ha^{-1} yr^{-1} was highest for Methven and least (349 kg ha^{-1} yr^{-1}) for Gartfairn. The highest plot value was 2736 kg ha^{-1} yr^{-1} for plot 9 compared with the lowest of 207 kg ha^{-1} yr^{-1} for plot 3.

Table 16. Large wood litter fall oven-dried (85 °C) weights (kg ha^{-1}), from two 25 m^2 quadrats (column 3), in each of the three plots (column 2), in each of the sites (column 1), during four samplings (columns 4-7). Column 8 is the annual total. Rows 1 and 2 in each section shows related dates and periods (days) for each collection.

1	2	3	4	5	6	7	8
Site	Plot No.	Qad. No.	Sampling 1	2	3	4	Total* annual
Collection date			14/7/88	12/10/88	01/2/89	10/5/89	
Duration (days)			123	89	111	98	
	1	1	14	132	156	139	362
Ross		2	159	330	104	120	644
	2	1	29	534	79	155	708
		2	48	135	364	209	637
	3	1	2	120	14	93	176
		2	30	141	51	34	237
Mean							460
Collection date			13/7/88	13/10/88	31/1/89	25/5/89	
Duration (days)			121	91	109	114	
	4	1	30	230	175	1014	826
Gart-		2	5	39	50	59	117
fairn	5	1	30	165	94	375	434
		2	16	88	19	36	137
	6	1	6	87	16	292	222
		2	90	140	54	191	358
Mean							349
Collection Date			19/7/88	20/10/88	30/1/89	22/4/89	
Duration (days)			92	92	101	81	
	7	1	130	112	75	85	401
Meth-		2	551	550	228	331	1656
ven	8	1	172	326	214	154	864
		2	86	218	93	241	635
	9	1	32	563	1118	214	1924
		2	51	65	3331	102	3548
Mean							1505

* The fourth sample extended the collections for more than one year. The annual totals were calculated by prto-portionally reducing the litter fall mass of the forth sample so that results are for exactly one year.

Nutrient concentrations

The mean ± SE ($\underline{n}$=4) values of concentrations (mg g^{-1}) on an oven dried basis (85 °C) for the total nitrogen, phosphorus, potassium, sodium, magnesium and calcium of large wood litterfall for each of the three plots in each of the three sites are presented in Table 17 and the corresponding mean values ± SE (n=12) for the sites are shown in Table 18. Only nitrogen concentrations differed significantly between plots, showing the highest value (9.03) in plot 5 and the lowest (3.67) in plot 4 (Table

Table 17. Mean concentrations (mg g^{-1}) ± SE (n=4) of the total nitrogen, phosphorus, potassium, sodium, magnesium and calcium of large wood litterfall for each of the three plots in each of the three woodland sites. The levels of variation between plots (V.B.P.) (***, P<0.001; and NS, not significant) are shown.

Wood	Plot	N	P	K	Na	Mg	Ca
Ross	1	5.46	0.27	0.50	0.21	0.63	6.03
		±0.62	0.07	0.08	0.05	0.07	0.50
	2	6.55	0.35	0.58	0.13	0.56	5.59
		±0.89	0.05	0.06	0.05	0.08	0.55
	3	4.22	0.46	0.43	0.16	0.56	5.00
		±0.30	0.14	0.03	0.05	0.05	0.55
Gart-fairn	4	3.68	0.43	1.73	0.15	0.98	7.66
		±0.41	0.04	0.91	0.02	0.05	1.06
	5	9.03	0.58	0.72	0.18	0.76	7.45
		±1.07	0.08	0.07	0.05	0.11	0.76
	6	4.99	0.44	0.64	0.28	1.03	6.27
		±1.02	0.07	0.09	0.08	0.19	0.82
Meth-ven	7	6.50	0.50	0.87	0.18	0.74	7.87
		±0.47	0.06	0.16	0.07	0.09	0.45
	8	6.03	0.49	0.93	0.17	0.72	7.89
		±0.37	0.05	0.25	0.07	0.10	1.13
	9	5.65	0.54	1.24	0.19	0.89	9.04
		±0.86	0.07	0.27	0.04	0.18	1.55
V.B.P.		***	NS	NS	NS	NS	NS

18). Magnesium and calcium concentrations differed significantly between the sites and their values were highest in Gartfairn and Methven respectively and both were lowest in Ross. The average nitrogen, phosphorus, potassium, sodium, magnesium and calcium concentration values for

Table 18. Mean concentrations (mg g^{-1}) ± SE (n=12) of nitrogen, phosphorus, potassium, sodium, magnesium and calcium of large wood litterfall in each of the three woodland sites. The levels of variation between the sites (V.B.S.) (*, P<0.05; **, P<0.01; and NS, not significant) are shown.

Wood Plot	N	P	K	Na	Mg	Ca
Ross	5.41 ±0.44	0.36 0.06	0.51 0.04	0.17 0.03	0.58 0.04	5.54 0.31
Gartfairn	5.90 ±0.83	0.48 0.04	1.03 0.32	0.20 0.03	0.92 0.08	7.12 0.50
Methven	6.06 ±0.33	0.51 0.03	1.01 0.13	0.18 0.03	0.78 0.07	8.27 0.62
V.B.S.	NS	NS	NS	NS	*	**

Table 19. Mean concentrations (mg g^{-1}) ± SE (n=9) of nitrogen, phosphorus, potassium, sodium, magnesium and calcium of large wood litterfall in each of the four sampling periods in the three sites. The levels of variation between the periods (V.B.Pe.) (***, P<0.001; **, P<0.01; and NS, not significant) are shown.

Sampling periods	N	P	K	Na	Mg	Ca
1: Mar-Apr 1988 to mid-Jul	6.38 ±0.84	0.46 0.05	0.80 0.06	0.12 0.02	0.87 0.08	8.02 0.92
2: Mid-Jul to mid-Oct	5.55 ±0.46	0.53 0.07	0.78 0.10	0.09 0.01	0.86 0.09	7.19 0.78
3: Mid-Oct to late-Jan 1989	5.93 ±0.80	0.52 0.03	0.71 0.17	0.21 0.02	0.80 0.08	6.63 0.34
4: Late-Jan to Apr-May	5.30 ±0.47	0.29 0.02	1.11 0.44	0.31 0.03	0.52 0.05	6.07 0.34
V.B.Pe.	NS	**	NS	***	**	NS

the four sampling periods (pooled for the three sites) are presented in Table 19. Phosphorus, sodium and magnesium concentrations differed significantly between sampling periods for which the reason is not clear. Phosphorus concentration was higher during samplings 2 and 3 (mid-July to late January) and lower in sampling 4 (late-January to April-May). Sodium was higher in sampling 4 and lower in sampling 2 (mid-July to mid-October). Magnesium and also calcium (not significantly) were highest in sampling 1 (March-April to mid-July) and lowest in sampling 4.

Table 20. Nitrogen, phosphorus, potassium, sodium, magnesium and calcium input (kg $ha^{-1} yr^{-1}$) by large wood litterfall for each of the nine plots. The mean ± SE (n=3) for each of the sites and the levels of variation between the sites (V.B.S.) (*, P<0.05; and NS, not significant) are shown.

Wood	Plot	N	P	K	Na	Mg	Ca
Ross	1	2.61	0.12	0.26	0.09	0.33	2.87
	2	3.84	0.27	0.35	0.06	0.36	3.42
	3	0.80	0.14	0.09	0.03	0.12	1.00
Mean		2.42	0.18	0.23	0.06	0.27	2.43
±SE		0.88	0.04	0.07	0.02	0.08	0.73
Gart-fairn	4	1.58	0.19	1.13	0.08	0.45	3.22
	5	2.37	0.15	0.20	0.05	0.22	2.23
	6	1.46	0.12	0.18	0.08	0.26	1.79
Mean		1.80	0.15	0.50	0.07	0.31	2.41
±SE		0.28	0.02	0.31	0.01	0.07	0.42
Meth-ven	7	6.51	0.51	0.94	0.15	0.78	8.33
	8	4.43	0.37	0.70	0.13	0.53	5.55
	9	11.20	1.44	5.02	0.43	2.03	17.97
Mean		7.38	0.77	2.22	0.24	1.11	10.62
±SE		2.00	0.34	1.40	0.10	0.47	3.76
V.B.S.		*	NS	NS	NS	NS	P=0.064

Nutrient inputs

The annual input of nitrogen, phosphorus, potassium, magnesium and calcium (kg ha^{-1} yr^{-1}) for each of the three plots in each of the sites and the averages for the sites are represented in Table 20. The input of nitrogen (significantly), calcium (at the level of P=0.064) and the rest of the elements (although not significantly) were highest at Methven. Nitrogen, phosphorus, and calcium input were least at Gartfairn, potassium, sodium and magnesium least at Ross.

4.4 DISCUSSION

There was a wide variation between quadrats and consequently a lack of statistically significant differences between plots and sites. The size and number of quadrats was clearly inadequate. The definition of large wood has varied. In Carlisle *et al* (1966a) it refers to the branches longer than 16 inches while Proctor *et al* (1983) used the term large wood for wood >2 cm diameter and Stohlgren (1988a) categorised the large wood by 2.5-15.2 cm in diameter in his work. The large wood fall recorded in the present study falls within the range (352-1648 kg ha^{-1}) reported in literature (Bray & Gorham 1964; Carlisle 1966a; Stohlgren 1988). The proportion of annual mass and the nutrient input by large wood (Table 21) to the total litterfall is less than 10% except for Methven.

Table 21. Percentages of annual input of mass and nutrients by large wood fall to the total litterfall.

Site	Mass	N	P	K	Na	Ca	Mg
Ross	9.1	6.4	5.8	1.6	4.1	6.9	4.3
Gartfairn	7.2	9.0	2.4	3.0	2.8	5.2	2.7
Methven	21.8	8.3	11.1	8.2	13.8	17.8	11.9

CHAPTER 5

LITTER LAYER

5.1 INTRODUCTION

The variations in the mass of the litter layer as a response to variation in latitude, altitude, environmental factors, and vegetation type have received much attention (e.g. Williams & Gray 1974; Singh & Gupta 1977). More litter is accumulated on the forest floor with increasing altitude and latitude, and in coniferous forests compared with deciduous woodlands. In woodlands with low-nutrient soils the nutrient pool in the litter layer is very important (Carlisle *et al* 1966a). In this study the mass of the litter layer, and the concentrations and its stocks of nutrients were compared for the three Oak woodlands.

Litter layers and decomposition constants

The quotient (k) of litterfall input /litter layer mass has often been calculated to give an index of decomposition. This is attempted in the present paper but it is important to be aware of the derivations and limitations of k.

Jenny *et al*. (1949) and Olson (1963) suggested that in a steady-state ecosystem with continuous litter input the ratio of the annual input of dead organic matter (I) to the mean annual mass of dead organic matter (Xss) gives an index of the rate of decomposition i.e. $k = I/X_{ss}$ (1) where k is the annual fractional weight loss and the reciprocal of k is turnover time (year) for the mass of dead organic matter. In the case of deciduous forests with pulsed litterfall, Jenny *et al* (1949) and Olson (1963) recommend the calculation of $k^{/}$ from the equation $k^{/}=L/T$ (2). In this case L is the annual input of litter; and T is sum of the minimum (late summer) values for litter layer (A) plus L. It was felt that in the present case the litterfall input was sufficiently discrete to justify the use of equation (2) for comparison between the forests. Olson (1963) has suggested that where litterfall is not discrete the calculation of k may involve a hybrid calculation (with elements of equations 1 and 2) between extremes of evergreen forest with continuous litter input and deciduous forest with a highly discrete input.

An important limitation to the use of k concerns the assumptions in its derivation of a steady state. The woods at Ross, Gartfairn and Methven, though probably as little disturbed as any Scottish Oakwood, have nevertheless been managed in the past. Secondly the mean annual litterfall and mean minimum litter layer mass can only be accurately measured by using a rigorous sampling programme at regular intervals over many years (Swift *et al* 1979). In the present study a major drawback is that the estimates could only be made for one year.

The paper by Olson (1963) includes all dead soil organic matter in the litter layer assessment. This concept of litter has limited usefulness because there are below-ground inputs which are very difficult to measure (and which were not quantified in my study). In this thesis I follow the more useful approach of Swift *et al*

(1979) which confines attention to the above-ground litterfall and litter layer material which has the same size categories as the litterfall and originates from it. I used the suffix $_L$ to designate 'k ' values so calculated. Thus defined 'k_L' values describe the decomposition of only a component part of the total organic matter in the system and relate only to the early stage of decomposition. They do not take into account stages beyond the point where detritus is no longer recognisable as plant litter. The k_L value used here thus ignores the decomposition of soil organic matter including humus. k_L is readily measured and comparative data are available for many sites. Some of the limitations of the k_L index have been outlined. Swift *et al* (1979) regard k_L as 'an indication of the broad magnitude of the organic turnover in ecosystems and its use is best confined to comparisons of a very general kind. Within these limitation it can nevertheless be recommended as a useful ecosystem constant'. It was felt that in the present study the contrast between soil types was so great that k_L values would be useful comparative indices of organic matter and inorganic nutrient turnover. (k_L values can be calculated not only for the mass of litterfall and litter layer but also for the nutrients they contain and hence give an indication of relative rate of nutrient turnover).

Olson has suggested the value k derived from k' ($k= -\ln(1-k')$) is a better means of comparison between systems when time intervals are of the order of a year. Accordingly both k_L and k'_L are given in Tables 33 and 34 and comparisons described in the text refer to k_L rather than k'_L values.

5.2 MATERIALS AND METHODS

The small litter layer was collected within six randomly placed (50 x 50 cm^2) quadrats within each of the three plots in each of the sites on four sampling dates (Table 22). A sharp knife was used to cut litter that crossed the edge of the quadrat. Immediately after collection the samples were sorted into leaves (no separation was made for species), small wood, fruits (which mostly were acorn cupules). The litter layer (the L horizon in soil profiles. see chapter 2) included all recognisable plant fragments (excluding roots) defined in the same way as small litterfall (page 32) except that fragments less than 2 mm along the longest dimension were rejected. Such fragments account for a very small proportion of the litter layer and were too difficult to separate from soil organic matter (in the F and H horizons). No material from the F and H horizons was included in litter layer collections. The litter layer collected in the above manner thus excludes a 'miscellaneous' fraction which was included with the litterfall estimates (p. 32). The sorted fractions were oven-dried (85 °C), weighed and bulked for each plot at each sampling. They were then ground and chemically analysed for nitrogen, phosphorus, potassium, sodium, calcium and magnesium following the procedures described for small litterfall (chapter 3). One-gram oven dried sub-samples of the bulked samples were also ashed (at 375 °C for 24 hours) to calculate the percentage of ash.

Calculations of k_L for litter and their nutrient content were made using the formula (2) described earlier where L is the annual input of the litter and A is the layer minimum value (mid-June for Ross and Methven; early-August for Gartfairn) (Fig. 21 and Appendix 5). The values for litter input include litterfall contributions for all species (Tables 10 a, 10 b, and 11).

Table 22. The dates for four sampling occasions of the litter layer in each of the three plots within each of the three woodland sites.

Wood	Plot	Sampling occasions 1	2	3	4
Ross	1	2/8/1988	27/11/1988	4/4/1989	16/6/1989
	2	31/7/1988	" " "	" " "	" " "
	3	2/8/1988	" " "	" " "	" " "
Gart-fairn	4	10/8/1988	29/11/1988	5/4/1989	17/6/1989
	5	" " "	" " "	" " "	" " "
	6	" " "	" " "	" " "	" " "
Meth-ven	7	4/8/1988	24/11/1988	29/3/1989	15/6/1989
	8	" " "	" " "	" " "	" " "
	9	" " "	" " "	" " "	" " "

5.3 RESULTS

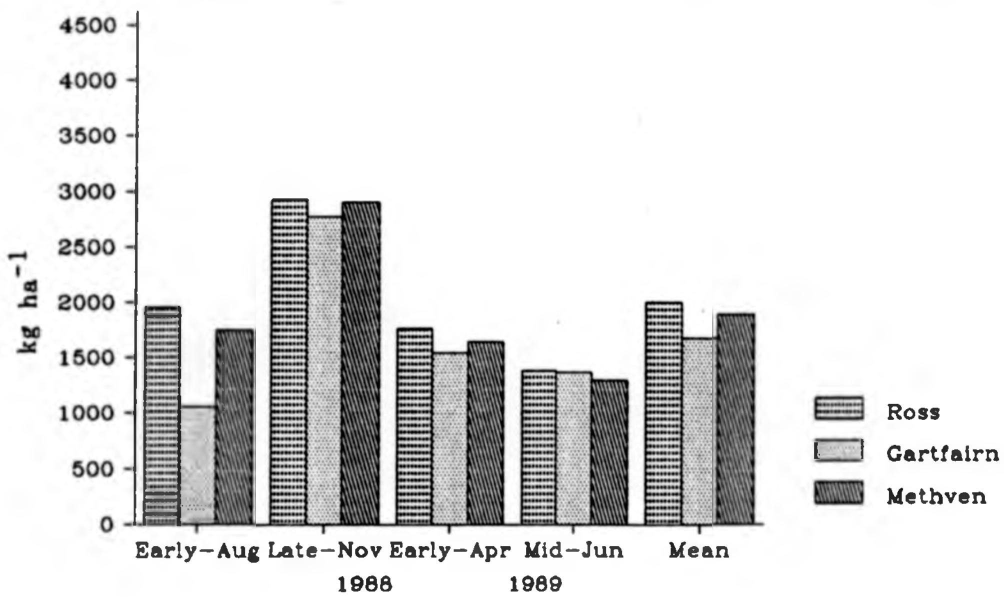
Litter mass

The mean values (Table 23) for leaf litter layer were highest in Ross, and for small wood were highest in Methven, whilst Gartfairn had the lowest values of both leaves and small wood. These differences fell short of statistical significance however (P=0.095 for leaves, P=0.118 for small wood). The mean values for fruit and total litter layer were highest in Methven and lowest in Ross for fruit and in Gartfairn for total litter (see also Fig. 21). These differences (Table 23) were statistically significant (P=0.002 for fruit and P=0.048 for total litter). The masses of leaf and total litter layer were highest in late November and lowest in mid-June 1988 for Gartfairn and in early August 1989 for Ross and Methven. Mass of fruit was highest on all sites in early August and lowest in mid-June and small wood mass showed irregular fluctuations with sampling dates (Fig. 21, appendix 4). Except for fruit (in Ross) and small wood (in Ross and Methven) the differences in mass between sampling dates for each site were statistically significant (Table 23). The mean ± SE ($\underline{n}$=6) of the mass values for each component of the litter layer for each plot and the mean ± SE ($\underline{n}$=18) for each site on each sampling date are given in appendix 4.

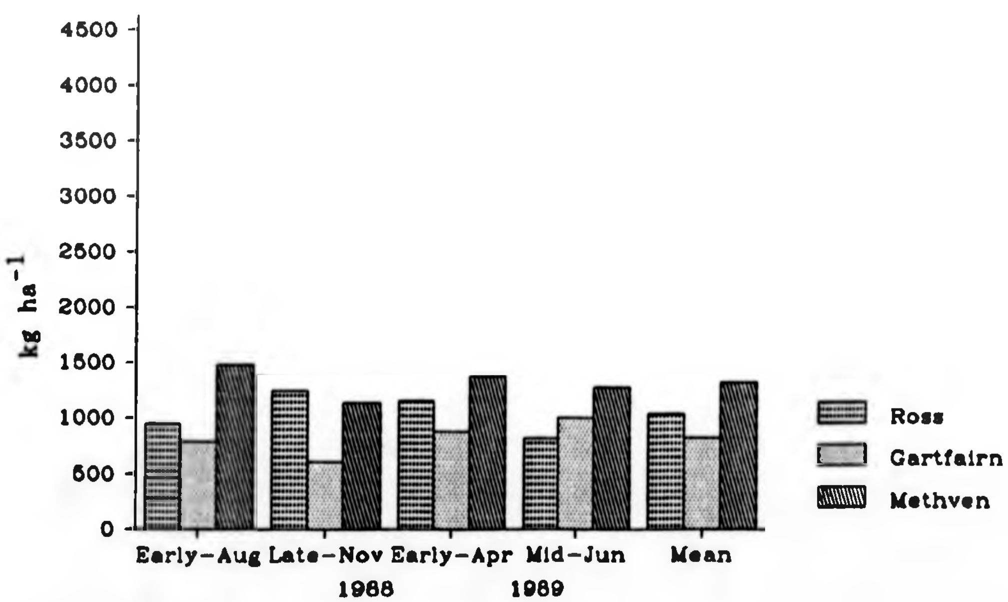
Chemical concentrations

Mean concentrations for nitrogen, phosphorus, potassium, calcium, magnesium and the percentage of ash for the litter layer fractions are given in Tables 24 to 27. All element concentrations and ash percentage for leaf (Table 24), small wood (Table 25), and total litter layer (Table 27) showed statistically significant differences between the sites. For fruits only the percentage ash was statistically significant between the sites (Table 26).

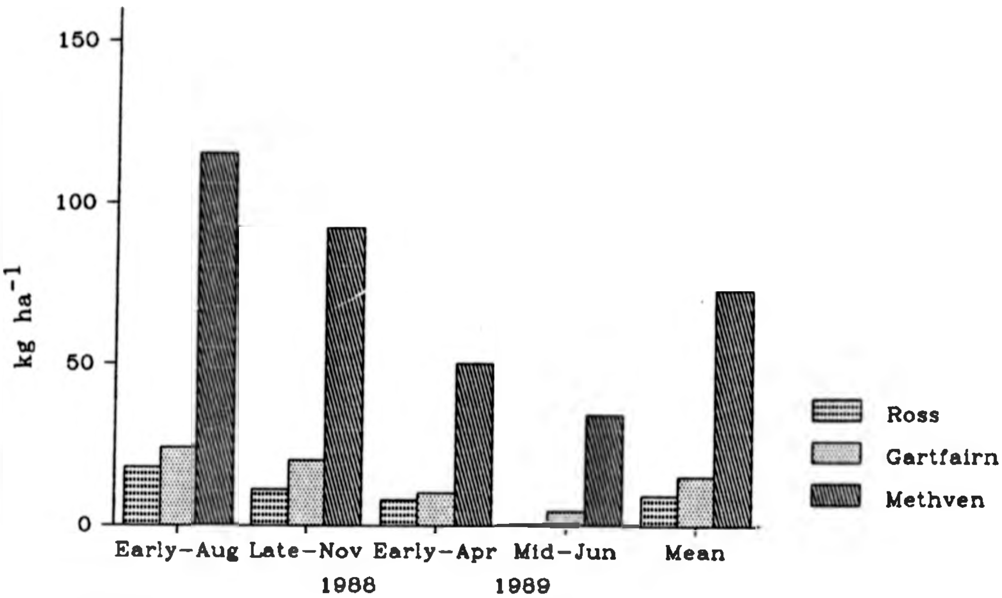
Figure 21. Mean of mass values for (a) leaf, (b) small wood, (c) fruit and (d) total litter layer in Ross, Gartfairn and Methven in each of the four sample dates and the mean values for sample dates in each site. *; notice the different scale.



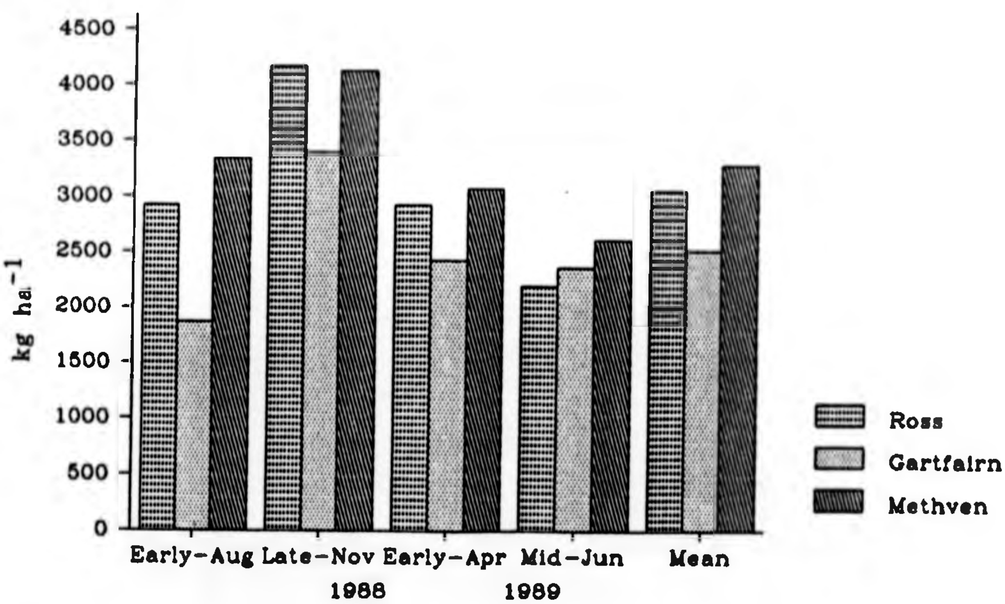
(a) Leaf



(b) Small wood



(c) Fruit *



(d) Total

Table 23. The mean ± SE (n=24, for four sample dates of six 50 x 50 cm^2 samples in each plot) oven dried (85 °C) weights (kg ha^{-1}) of leaf, small wood (<2 cm diameter) and fruit in the litter layer and their total for each of the three plots in each of the three woodland sites. The overall annual means ± SE for each site (n=72) and the variation levels (***, P<0.001; **, P<0.01; *, P<0.05; and NS, not significant) for between sampling dates in each sites (V.B.Sa.), between plots (V.B.P) and between sites (V.B.S.) are shown.

Site	Plot	Leaf	Small wood	Fruit	Total
Ross	1	2219±135	1072± 78	17± 4	3308±176
	2	1875 149	1171 137	2 1	3047 242
	3	1923 137	872 83	9 4	2804 182
Mean		2005 82	1038 60	9 2	3053 118
V.B.Sa.		**	NS	NS	**
Gart-fairn	4	1705 148	803 77	15 4	2522 167
	5	1529 146	568 74	13 4	2110 170
	6	1813 166	1076 101	17 5	2906 162
Mean		1682 89	816 54	15 3	2513 102
V.B.Sa.		***	*	*	***
Meth-ven	7	1991 144	1107 110	51 10	3149 171
	8	1773 150	1666 126	95 15	3534 185
	9	1923 214	1173 85	72 21	3168 250
Mean		1896 99	1315 68	73 9	3284 118
V.B.Sa.		***	NS	**	***
V.B.P.		NS	**	*	*
V.B.S.		NS	NS	**	*

All of the elements and ash were lowest for Ross. Nitrogen was equally high in Gartfairn and Methven for the total litter layer (Table 27). Nitrogen, calcium and ash in leaf (Table 24) and small wood (Table 25), ash in fruits (Table 26) and calcium and ash in total litter (Table 27) were highest in Methven. Phosphorus, magnesium and sodium in leaf (Table 24), small wood (Table 25) and total litter layer (Table 27) were highest in Gartfairn. For sampling dates the differences in concentrations, of potassium, sodium, calcium, magnesium and ash percentage in leaf litter (Table 24), sodium in small wood (Table

25) and total litter layer (Table 27) and magnesium in total litter (Table 27), were statistically significant and were usually highest in early August and lowest in early April in all the sites.

Table 24. The mean ± SE (n=3) concentrations of nitrogen, phosphorus, potassium, sodium, calcium and magnesium (mg g^{-1}) and ash (%) in the leaf litter layer in Ross, Gartfairn and Methven on four sample occasions (Table 1). The overall annual means ± SE (n=12) for each of the sites and the variation levels (***, P<0.001; **, P<0.01; *, P<0.05; and NS, not significant) for between site x sampling (V.B.S.Sa) and sites independent of sampling (V.B.S.) are shown.

Wood	Sampling		N	P	K	Na	Ca	Mg	Ash
Ross	1		17.8	1.09	1.85	0.11	10.8	1.64	4.33
		±	1.28	0.09	0.09	0.01	0.35	0.11	0.09
	2		10.6	0.72	1.92	0.23	12.6	1.89	4.23
		±	0.43	0.11	0.06	0.04	0.60	0.00	0.03
	3		12.2	0.70	1.15	0.49	8.93	1.52	4.10
		±	0.58	0.11	0.06	0.04	0.25	0.09	0.12
	4		14.6	0.97	1.46	0.13	10.1	1.54	4.50
		±	0.35	0.12	0.08	0.01	0.46	0.13	0.15
Mean			13.8	0.87	1.59	0.24	10.6	1.65	4.29
		±	0.88	0.07	0.10	0.05	0.44	0.06	0.06
Gart-fairn	1		18.9	1.34	2.76	0.14	16.4	2.64	5.57
		±	0.65	0.01	0.03	0.01	0.92	0.11	0.32
	2		13.2	1.00	2.38	0.29	13.3	3.02	4.37
		±	1.05	0.06	0.29	0.04	0.77	0.13	0.33
	3		15.3	1.13	1.65	0.76	9.41	2.30	4.50
		±	0.50	0.02	0.08	0.02	1.23	0.05	0.32
	4		17.8	1.35	1.88	0.23	11.7	2.20	5.00
		±	0.61	0.05	0.13	0.03	0.89	0.05	0.40
Mean			16.3	1.21	2.17	0.35	12.7	2.54	4.86
		±	0.74	0.05	0.14	0.07	0.87	0.11	0.20
Meth-ven	1		19.1	1.22	3.62	0.12	16.0	2.67	8.17
		±	0.84	0.11	0.50	0.01	0.35	0.18	0.29
	2		14.7	0.91	3.64	0.26	14.3	2.40	7.17
		±	0.26	0.08	0.23	0.02	0.84	0.07	0.29
	3		14.5	0.86	1.79	0.42	12.3	1.72	7.20
		±	1.34	0.09	0.04	0.03	0.13	0.11	0.35
	4		18.0	1.15	2.51	0.33	11.4	1.64	6.27
		±	5.25	0.10	0.22	0.02	1.58	0.09	0.27
Mean			16.6	1.03	2.89	0.28	13.5	2.11	7.20
		±	0.71	0.06	0.27	0.03	0.66	0.14	0.24
V.B.S.Sa.			NS	NS	*	***	*	**	*
V.B.S.			***	***	***	***	***	***	***

Table 25. The mean±SE ($\underline{n}$=3) concentrations of nitrogen, phosphorus, potassium, sodium, calcium and magnesium (mg g^{-1}) and ash (%) in the small wood litter layer in Ross, Gartfairn and Methven on four sample occasions (Table 22). The overall annual means ± SE ($\underline{n}$=12) for each of the sites and the variation levels (***, P<0.001; *, P<0.05; and NS, not significant) for between site x sampling (V.B.S.Sa) and sites independent of sampling (V.B.S.) are shown.

Wood	Sampling	N	P	K	Na	Ca	Mg	Ash
Ross	1	7.56	0.46	1.05	0.12	6.25	1.04	1.90
		± 0.74	0.01	0.06	0.00	0.52	0.08	0.12
	2	6.36	0.46	1.52	0.16	6.25	0.93	1.97
		± 0.36	0.06	0.23	0.02	0.17	0.02	0.15
	3	7.45	0.40	0.93	0.41	5.74	0.69	1.87
		± 0.16	0.02	0.16	0.04	0.47	0.03	0.14
	4	7.73	0.46	0.96	0.29	5.26	0.67	1.93
		± 0.12	0.02	0.15	0.03	0.33	0.03	0.38
Mean		7.27	0.44	1.11	0.24	5.88	0.83	1.92
		± 0.24	0.02	0.10	0.04	0.21	0.05	0.10
Gart-fairn	1	10.0	0.59	1.69	0.15	7.61	1.59	2.40
		± 0.13	0.06	0.09	0.01	0.46	0.06	0.06
	2	9.79	0.66	1.95	0.24	6.97	1.48	2.17
		± 0.59	0.04	0.29	0.04	0.33	0.07	0.09
	3	9.00	0.62	1.31	0.60	6.16	1.24	2.20
		± 0.73	0.05	0.23	0.06	0.05	0.09	0.15
	4	9.65	0.64	1.26	0.43	5.92	1.06	2.03
		± 0.25	0.04	0.17	0.04	0.12	0.06	0.09
Mean		9.61	0.63	1.55	0.35	6.66	1.34	2.20
		± 0.24	0.02	0.12	0.06	0.24	0.07	0.06
Meth-ven	1	10.8	0.60	1.97	0.10	8.72	1.27	3.27
		± 0.65	0.06	0.18	0.02	0.68	0.08	0.26
	2	9.90	0.56	2.95	0.20	7.89	1.18	2.63
		± 0.07	0.03	0.35	0.03	0.24	0.10	0.20
	3	9.34	0.58	2.09	0.37	6.41	0.83	2.60
		± 0.44	0.02	0.01	0.04	0.41	0.05	0.06
	4	11.1	0.66	2.13	0.38	7.37	0.85	2.63
		± 0.49	0.03	0.03	0.01	0.50	0.08	0.24
Mean		10.3	0.60	2.28	0.26	7.60	1.03	2.78
		± 0.29	0.02	0.14	0.04	0.33	0.07	0.12
V.B.S.Sa.		NS	NS	NS	*	NS	NS	NS
V.B.S.		***	***	***	***	***	***	***

Table 26. The mean±SE ($\underline{n}$=3) concentrations of nitrogen, phosphorus, potassium, sodium, calcium and magnesium (mg g^{-1}) and ash (%) in the fruit litter layer in Ross, Gartfairn and Methven on four sample occasions (Table 22). The overall annual means ± SE ($\underline{n}$=12) for each of the sites and the variation levels (***, P<0.001; and NS, not significant) for between site x sampling (V.B.S.Sa) and sites independent of sampling (V.B.S.) are shown.

Wood	Sampling		N	P	K	Na	Ca	Mg	Ash
Ross	1		11.9	0.72	3.28	0.14	5.41	1.10	2.27
		±	1.90	0.09	2.10	0.07	1.32	0.15	0.19
	2		11.5	0.79	5.03	0.15	4.31	1.03	2.37
		±	1.87	0.14	2.01	0.06	1.52	0.16	0.03
	3		11.4	0.68	3.14	0.23	5.31	1.00	2.20
		±	1.92	0.11	2.17	0.03	1.31	0.17	0.15
	4		11.6	0.73	3.82	0.17	5.01	1.04	2.27
		±	1.82	0.09	1.91	0.06	1.29	0.16	0.09
Mean			11.6	0.73	3.82	0.17	5.01	1.04	2.28
		±	0.80	0.05	0.90	0.03	0.60	0.07	0.06
Gart-fairn	1		11.2	0.88	3.69	0.13	6.98	2.03	2.70
		±	0.65	0.09	0.94	0.02	0.00	0.05	0.35
	2		11.0	0.82	4.32	0.24	6.83	2.19	3.13
		±	0.17	0.06	1.53	0.01	0.48	0.01	0.09
	3		10.4	0.68	1.12	0.59	5.74	1.63	2.70
		±	1.80	0.07	0.10	0.10	0.47	0.05	0.35
	4		12.2	0.81	1.77	0.28	7.04	1.79	2.70
		±	2.20	0.14	0.62	0.10	0.26	0.09	0.35
Mean			11.2	0.79	2.73	0.31	6.65	1.91	2.81
		±	0.65	0.05	0.57	0.06	0.22	0.07	0.14
Meth-ven	1		11.0	0.65	2.15	0.31	8.55	1.68	3.87
		±	0.44	0.06	0.20	0.22	1.02	0.04	0.22
	2		12.1	0.71	4.87	0.15	8.00	1.62	4.30
		±	0.83	0.06	0.36	0.03	0.46	0.07	0.56
	3		10.4	0.69	2.08	0.43	6.16	1.23	3.93
		±	0.46	0.03	0.40	0.04	1.26	0.08	0.24
	4		12.5	0.75	1.87	0.34	9.85	1.11	3.97
		±	1.14	0.07	0.31	0.02	2.73	0.08	0.27
Mean			11.5	0.70	2.74	0.31	8.14	1.41	4.01
		±	0.42	0.03	0.40	0.06	0.79	0.08	0.16
V.B.S.Sa.			NS	NS	NS	NS	NS	NS	NS
V.B.S.			NS	NS	NS	NS	NS	NS	***

Table 27. The mean±SE (n=3) concentrations of nitrogen, phosphorus, potassium, sodium, calcium and magnesium (mg g^{-1}) and ash (%) in the total litter layer in Ross, Gartfairn and Methven on four sample occasions (Table 22). The overall annual means ± SE (n=12) for each of the sites and the variation levels (***, P<0.001; and NS, not significant) for between site x sampling (V.B.S.Sa) and sites independent of sampling (V.B.S.) are shown.

Wood	Sampling		N	P	K	Na	Ca	Mg	Ash
Ross	1		14.3	0.87	1.58	0.11	9.27	1.44	3.50
		±	0.44	0.02	0.06	0.01	0.65	0.12	0.14
	2		9.35	0.65	1.80	0.21	10.7	1.61	3.56
		±	0.41	0.10	0.06	0.02	0.57	0.01	0.08
	3		10.3	0.58	1.06	0.46	7.65	1.19	3.22
		±	0.47	0.07	0.06	0.04	0.33	0.08	0.17
	4		12.1	0.78	1.26	0.19	8.26	1.22	3.53
		±	0.31	0.07	0.03	0.02	0.33	0.10	0.28
Mean			11.5	0.72	1.43	0.24	8.97	1.37	3.45
		±	0.60	0.05	0.09	0.04	0.40	0.06	0.09
Gart-fairn	1		15.1	1.03	2.32	0.15	12.6	2.20	4.24
		±	0.36	0.08	0.11	0.01	0.73	0.03	0.16
	2		12.6	0.94	2.32	0.28	12.2	2.74	3.96
		±	0.76	0.05	0.27	0.04	0.62	0.10	0.24
	3		13.1	0.95	1.54	0.71	8.23	1.92	3.67
		±	0.30	0.01	0.13	0.03	0.74	0.08	0.18
	4		14.4	1.05	1.62	0.31	9.25	1.72	3.74
		±	0.19	0.01	0.13	0.03	0.48	0.01	0.22
Mean			13.8	0.99	1.95	0.36	10.6	2.15	3.90
		±	0.37	0.03	0.13	0.06	0.63	0.12	0.11
Meth-ven	1		15.2	0.93	2.84	0.12	12.6	2.03	5.88
		±	0.65	0.09	0.34	0.00	0.31	0.16	0.30
	2		13.3	0.81	3.47	0.24	12.3	2.05	5.85
		±	0.21	0.07	0.08	0.02	0.31	0.11	0.24
	3		12.1	0.73	1.93	0.40	9.61	1.33	5.13
		±	0.71	0.07	0.00	0.01	0.28	0.12	0.44
	4		14.5	0.90	2.32	0.36	9.24	1.24	4.46
		±	0.77	0.08	0.11	0.01	1.07	0.11	0.45
Mean			13.8	0.84	2.64	0.28	11.0	1.66	5.33
		±	0.44	0.04	0.19	0.03	0.52	0.13	0.24
V.B.S.Sa.			NS	NS	NS	***	NS	*	NS
V.B.S.			***	***	***	***	***	***	***

Nutrient stock

The mean±SE (n=3) of nitrogen, phosphorus, potassium, sodium, calcium, magnesium and ash mass (kg ha^{-1}) for all the litter-layer fractions is shown in Tables 28 to 31. The values for all the elements and ash in all the fractions and total litter layer (Table 31) (except nitrogen and phosphorus in the leaves (Table 28) and sodium in all but fruit (Table 30)) showed statistically significant differences between the sites. All the values were highest for Methven (except sodium and magnesium in leaves (Table 28) which were highest in Gartfairn) and lowest for Ross. The between-sample-occasion differences were statistically significant for nitrogen, potassium, sodium and magnesium in leaf (Table 28), fruit (Table 30) and total litter layer (Table 31) except for nitrogen and sodium in total litter (Table 31) and sodium in fruit (Table 30). The stock of the elements and ash was highest in late November for leaf (Table 28) and total litter layer (Table 31) and early August for fruit (Table 30) in all the sites. It was lowest in mid-June for most of the cases.

k_L values

k_L values for litter mass were least in Ross and highest in Gartfairn. The causes for the relatively low values at Ross are probably related to the high soil acidity (Tables 5-6), relatively low nutrient concentrations of the litter (Table 28) and scarcity of soil animals (earthworms were not observed there). At Gartfairn

Table 28. The mean±SE ($\underline{n}$=3) of nitrogen, phosphorus, potassium, sodium, calcium, magnesium, and ash weight (kg ha^{-1}) in the leaf litter layer in Ross, Gartfairn and Methven on four sample occasions (Table 22). The overall annual means ± SE ($\underline{n}$=12) for each of the sites and the variation levels (***, P<0.001; **, P<0.01; *, P<0.05; and NS, not significant) for between site x sampling (V.B.S.Sa) and sites independent of sampling (V.B.S.) are shown.

Wood	Sampling		N	P	K	Na	Ca	Mg	Ash
Ross	1		34.5	2.09	3.55	0.22	21.3	3.17	84.9
		±	6.03	0.32	0.52	0.06	4.73	0.61	16.7
	2		31.0	2.11	5.61	0.67	36.8	5.52	124
		±	1.36	0.34	0.16	0.10	1.95	0.03	1.65
	3		21.5	1.25	2.02	0.87	15.8	2.69	72.5
		±	1.28	0.22	0.14	0.09	0.84	0.25	4.44
	4		20.1	1.34	2.00	0.18	13.9	2.16	62.4
		±	1.59	0.20	0.16	0.02	1.41	0.36	7.09
Mean			26.8	1.70	3.30	0.49	21.9	3.39	85.4
		±	2.30	0.17	0.46	0.09	2.95	0.42	8.07
Gart-fairn	1		20.0	1.42	2.92	0.15	17.4	2.80	59.1
		±	1.07	0.07	0.13	0.02	1.47	0.19	4.91
	2		36.8	2.79	6.63	0.80	36.8	8.40	122
		±	4.60	0.31	0.99	0.15	1.78	0.77	14.5
	3		23.6	1.75	2.55	1.17	14.5	3.54	69.8
		±	1.93	0.12	0.23	0.09	2.19	0.21	8.05
	4		24.4	1.85	2.59	0.32	16.1	3.00	68.7
		±	3.12	0.23	0.41	0.06	2.42	0.33	10.7
Mean			26.2	1.95	3.67	0.61	21.2	4.44	79.8
		±	2.30	0.18	0.57	0.13	2.86	0.72	8.58
Meth-ven	1		33.1	2.09	6.15	0.21	28.1	4.64	144
		±	2.24	0.12	0.37	0.01	3.31	0.44	19.3
	2		42.4	2.67	10.5	0.76	41.2	6.99	207
		±	2.07	0.42	0.39	0.09	2.07	0.64	7.36
	3		24.0	1.40	2.95	0.69	20.2	2.58	120
		±	4.17	0.17	0.39	0.08	2.46	0.43	19.6
	4		23.3	1.48	3.23	0.42	15.2	2.12	82.2
		±	3.81	0.23	0.48	0.04	3.78	0.35	16.3
Mean			30.7	1.91	5.70	0.52	26.2	4.15	138
		±	2.72	0.19	0.93	0.07	3.22	0.60	15.3
V.B.S.Sa.			*	NS	**	*	NS	**	NS
V.B.S.			NS	NS	***	NS	*	**	***

Table 29. The mean±SE ($\underline{n}$=3) of nitrogen, phosphorus, potassium, sodium, calcium, magnesium, and ash weight (kg ha^{-1}) in small wood litter layer in Ross, Gartfairn and Methven on four sample occasions (Table 22). The overall annual means ± SE ($\underline{n}$=12) for each of the sites and the variation levels (***, P<0.001; **, P<0.01; and NS, not significant) for between site x sampling (V.B.S.Sa) and sites independent of sampling (V.B.S.) are shown.

Wood	Sampling		N	P	K	Na	Ca	Mg	Ash
Ross	1		7.32	0.43	1.00	0.11	5.80	0.95	17.7
		±	2.26	0.09	0.26	0.03	1.09	0.16	3.48
	2		7.83	0.58	1.85	0.19	7.72	1.16	24.3
		±	0.37	0.10	0.21	0.02	0.26	0.09	2.29
	3		8.54	0.46	1.05	0.46	6.57	0.79	21.2
		±	0.37	0.03	0.12	0.02	0.55	0.02	0.96
	4		6.29	0.37	0.77	0.24	4.31	0.55	15.7
		±	0.41	0.05	0.10	0.04	0.56	0.07	2.97
Mean			7.49	0.46	1.17	0.25	6.10	0.86	19.8
		±	0.56	0.04	0.15	0.04	0.47	0.08	1.49
Gart-fairn	1		7.90	0.44	1.29	0.12	5.88	1.26	19.2
		±	2.71	0.11	0.37	0.05	1.82	0.44	6.94
	2		5.83	0.40	1.22	0.15	4.26	0.90	13.1
		±	0.54	0.07	0.31	0.04	0.74	0.15	1.80
	3		8.04	0.55	1.18	0.54	5.36	1.08	19.6
		±	2.09	0.14	0.38	0.15	1.13	0.24	4.92
	4		9.59	0.64	1.28	0.44	5.92	1.06	20.3
		±	1.12	0.08	0.28	0.10	0.83	0.14	2.88
Mean			7.84	0.51	1.24	0.31	5.36	1.07	18.0
		±	0.87	0.05	0.14	0.07	0.55	0.12	2.14
Meth-ven	1		15.8	0.87	2.83	0.14	12.9	1.84	47.4
		±	2.12	0.08	0.24	0.01	2.20	0.22	5.57
	2		11.2	0.64	3.40	0.23	8.92	1.32	29.9
		±	1.50	0.09	0.73	0.06	1.15	0.16	4.95
	3		12.7	0.79	2.86	0.50	8.86	1.12	35.7
		±	1.75	0.11	0.45	0.08	1.69	0.15	5.86
	4		14.0	0.83	2.71	0.48	9.33	1.06	33.2
		±	1.70	0.08	0.33	0.05	1.20	0.06	4.07
Mean			13.4	0.78	2.95	0.34	10.0	1.34	36.6
		±	0.91	0.05	0.22	0.05	0.85	0.11	2.96
V.B.S.Sa.			NS	NS	NS	NS	NS	NS	NS
V.B.S.			***	***	***	NS	***	**	***

Table 30. The mean±SE ($\underline{n}$=3) of nitrogen, phosphorus, potassium, sodium, calcium, magnesium, and ash weight (kg ha^{-1}) in the fruit litter layer in Ross, Gartfairn and Methven on four sample occasions (Table 22). The overall annual means ± SE ($\underline{n}$=12) for each of the sites and the variation levels (***, P<0.001; **, P<0.01; *, P<0.05; and NS, not significant) for between site x sampling (V.B.S.Sa) and sites independent of sampling (V.B.S.) are shown.

Wood	Sampling		N	P	K	Na	Ca	Mg	Ash
Ross	1		0.19	0.01	0.02	0.00	0.12	0.02	0.39
		±	0.10	0.01	0.01	0.00	0.06	0.01	0.20
	2		0.11	0.01	0.06	0.00	0.04	0.01	0.26
		±	0.07	0.01	0.05	0.00	0.02	0.01	0.17
	3		0.08	0.01	0.02	0.00	0.04	0.01	0.15
		±	0.05	0.00	0.01	0.00	0.03	0.00	0.10
	4		0.00	0.00	0.00	0.00	0.00	0.00	0.01
		±	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Mean			0.09	0.01	0.02	0.00	0.05	0.01	0.20
		±	0.03	0.00	0.01	0.00	0.02	0.00	0.07
Gart-fairn	1		0.26	0.02	0.07	0.00	0.17	0.05	0.70
		±	0.12	0.01	0.01	0.00	0.08	0.02	0.42
	2		0.23	0.02	0.10	0.00	0.14	0.05	0.64
		±	0.07	0.01	0.04	0.00	0.05	0.01	0.19
	3		0.10	0.01	0.01	0.01	0.07	0.02	0.26
		±	0.01	0.00	0.00	0.00	0.00	0.00	0.02
	4		0.05	0.00	0.00	0.00	0.03	0.01	0.12
		±	0.03	0.00	0.00	0.00	0.02	0.00	0.07
Mean			0.16	0.01	0.04	0.00	0.10	0.03	0.43
		±	0.04	0.00	0.01	0.00	0.03	0.01	0.12
Meth-ven	1		1.26	0.07	0.24	0.04	1.02	0.19	4.38
		±	0.25	0.01	0.02	0.04	0.32	0.04	0.73
	2		1.08	0.06	0.44	0.01	0.74	0.15	3.77
		±	0.14	0.01	0.07	0.00	0.15	0.02	0.30
	3		0.53	0.04	0.11	0.02	0.35	0.06	1.91
		±	0.16	0.01	0.04	0.01	0.13	0.02	0.49
	4		0.44	0.03	0.06	0.01	0.39	0.04	1.38
		±	0.15	0.01	0.02	0.00	0.21	0.01	0.46
Mean			0.83	0.05	0.21	0.02	0.63	0.11	2.86
		±	0.13	0.01	0.05	0.01	0.12	0.02	0.44
V.B.S.Sa.			*	NS	***	NS	NS	**	**
V.B.S.			***	***	***	*	***	***	***

Table 31. The mean±SE ($\underline{n}$=3) of nitrogen, phosphorus, potassium, sodium, calcium, magnesium, and ash weight (kg ha^{-1}) in the total small litter layer in Ross, Gartfairn and Methven on four sample occasions (Table. 20). The overall annual means ± SE ($\underline{n}$=12) for each of the sites and the variation levels (***, P<0.001; **, P<0.01; *, P<0.05; and NS, not significant) for between site x sampling (V.B.S.Sa) and sites independent of sampling (V.B.S.) are shown.

Wood	Sampling		N	P	K	Na	Ca	Mg	Ash
Ross	1		42.0	2.53	4.57	0.37	27.2	4.15	103
		±	6.85	0.38	0.58	0.07	5.19	0.60	18.4
	2		38.9	2.70	7.52	0.86	44.6	6.69	148
		±	1.09	0.45	0.29	0.09	1.69	0.06	2.55
	3		30.1	1.72	3.09	1.33	22.4	3.49	93.9
		±	0.93	0.25	0.20	0.11	1.40	0.25	5.29
	4		26.4	1.72	2.78	0.42	18.2	2.71	78.1
		±	1.69	0.25	0.24	0.06	1.93	0.38	9.92
Mean			34.4	2.16	4.49	0.74	28.1	4.26	106
		±	2.45	0.20	0.59	0.12	3.28	0.48	9.12
Gart-fairn	1		28.2	1.88	4.27	0.28	23.5	4.11	79.0
		±	3.49	0.11	0.41	0.06	2.95	0.57	10.6
	2		42.9	3.22	7.95	0.96	41.2	9.34	135
		±	5.12	0.38	1.26	0.19	2.39	0.91	16.1
	3		31.8	2.30	3.75	1.72	19.9	4.63	89.6
		±	3.97	0.25	0.61	0.24	2.96	0.45	12.9
	4		34.0	2.49	3.87	0.76	22.0	4.07	89.1
		±	4.15	0.29	0.66	0.16	3.25	0.44	13.5
Mean			34.2	2.47	4.96	0.93	26.7	5.54	98.3
		±	2.43	0.19	0.62	0.17	2.85	0.72	8.73
Meth-ven	1		50.2	3.03	9.22	0.39	41.9	6.67	195
		±	3.42	0.04	0.18	0.03	3.81	0.34	19.0
	2		54.7	3.37	14.3	1.01	50.9	8.45	240
		±	2.50	0.46	0.56	0.14	3.27	0.75	8.58
	3		37.3	2.23	5.93	1.21	29.4	4.04	157
		±	3.37	0.09	0.25	0.06	1.16	0.27	15.1
	4		37.8	2.33	6.00	0.91	24.9	3.22	117
		±	3.69	0.18	0.32	0.05	4.43	0.34	17.4
Mean			45.0	2.74	8.86	0.88	36.8	5.60	177
		±	2.69	0.18	1.04	0.10	3.41	0.66	15.3
V.B.S.Sa.			NS	NS	**	NS	NS	*	NS
V.B.S.			***	*	***	NS	***	***	***

there was a higher proportion of Birch leaves (which decompose more rapidly, Gosz *et al* 1973; Singh & Gupta 1977), higher soil moisture, and the litter had the highest phosphorus concentrations of the three sites (Table 27).

The turnover time (Table 35) for nutrients were in the following rank order : N> P> Ca> Mg> Na> K at Ross; Ca> N> Mg> P> K> Na at Gartfairn; N> P> Ca> Mg> Na> K for leaves at Methven; and Na> Ca> N> Mg> P> K for TSL at Methven.

5.4 DISCUSSION

The masses of leaf, total small litter layer (Table 23) and their contents of nutrient elements (Tables 28-31) were below or near the lower part of the range reported from elsewhere (Table 32). The between-site differences in mass for leaves (except in Ross), fruit, to some extent small wood, and total litter layer (Table 23) reflected the between-site differences in the annual production for each type. The mean leaf litter mass was highest in Ross, despite the lowest leaf production in this wood (Chapter 3), which indicated a slower rate of decomposition there. Between-site differences of nutrient stocks in the litter layer (Tables 28-31) did not follow the differences in the litterfall input. Thus Gartfairn had the highest inputs of phosphorus, sodium, and magnesium and Methven the highest inputs of nitrogen, potassium, and calcium (Table 11, Chapter 3). Litter layer stocks were highest for all nutrients except sodium in Methven (Tables 28 and 31). The temporal variation in mass for each of the individual components of litter layer (Fig. 21) reflected their production pattern (Figs 6-8, Chapter 3). The nutrient element concentrations of the litter layer were highest during early August (Tables 24-27) reflecting the temporal patterns of nutrient concentrations of the litterfall (see Chapter 3). Carlisle *et al* (1966a) found that in Bogle Crag Wood (England) during summer, relatively high amounts of nutrients were added to the forest floor through bud scales, male flowers, frass and other miscellaneous fractions which only contributed a small part of the annual litterfall dry mass.

k_L values

The k_L values for the three sites are high compared with those from elsewhere (Table 36). In comparing these values with those in the literature it must be pointed out that several authors have miscalculated k_L values. They have used mean litter layer mass and not minimum litter layer mass to form the denominator in the equation $k' = L/(A+L)$. It is clear from Jenny *et al* (1949) and Olson (1963) that the minimum value is correct and where the mean values have been used then the k' values will be underestimated. In addition several authors have not made distinction between k' and k_L. These values are recalculated for k_L and given in Table 36 and are annotated where appropriate.

Table 32. Masses (kg ha $^{-1}$) of leaf (a) and total litter layer (b) and their corresponding nutrient elements (-, data not given) reported for temperate forests.

Vegetation	Place		Mass	N	P	K	Na	Ca	Mg	Author
	Missouri									Rochow (1975).
Gercus alba	USA	b	6070	137	10.7	12.4	_	286	15.7	
	Minnesota									Reiners &
Oak forest	USA	b	7010	94.8	6.6	—	—	106	11.4	Reiners (1970).
Ben forest		"	5160	64.7	4.6	—	—	100	6.8	
Swamp forest		"	4890	54.5	4.2	—	—	116	5.2	
	Appalachian									Shure &
Mixed hardwood	mountain USA	a	5550-6800	—	—	—	—	—	—	Phillips (1987).
	Tennessee									Harris <u>et al</u>
Hardwood	USA	b	8400-10500	—	—	—	—	—	—	(1973)*.
	New Jersey									Lang & Forman
Mixed oak	USA	a	2310	36.3	2.3	2.7	_	31.4	1.9	(1978).
" "		b	6200	119	4.3	5.3	_	79	3.8	
	Florida									Lugo <u>et al</u>
Hardwood	USA	b	8200	—	—	—	—	—	—	(1978)*.
Pinus banksiana	Middle Ottawa									Weber (1987).
Stand 1	Canada	b	40379	45.0	30.6	44.8	_	130	12.0	
" 2		"	56223	51.3	36.5	61.8	_	163	23.0	
" 3		"	51427	451	41.1	72.0	_	206	26.0	
" 4		"	24065	225	18.1	21.7	_	72	7.2	
	Meathop wood									Stachell (cit.
Mixed oak	England	a	2000	—	—	—	—	—	—	Brown 1974)
" "		b	7100	—	—	—	—	—	—	
	South Sweden.									Nihlgard
Beech forest		b	5200	86	5.8	10.4	1.2	34.2	4.8	(1972).
Spruce "		b	18500	245	15.4	15.0	4.1	47.9	7.5	
	Holland									Witkamp &
Hardwood		b	3600	—	—	—	—	—	—	Drift (1961).
	Virelles									Duvigneaud &
Mixed oak	Belgium	b	5600-4800	—	—	—	—	—	—	Desmet (1970).*
Quercus ilex	Monte Minardo									Rapp & Leornardi
	Italy	a	10710	136	7.8	16.1	_	272	25.7	(1988).
		b	31060	318	28.8	43.7		654	153	
	Central and									Rawat & Singh
Oak forests	Western	a	5500	—	—	—	—	—	—	(1988 a, b).
	Himalaya	b	6217	84	4.0	12.0	_	102	—	
	Himalaya									Singh <u>et al</u>
Oak forest		b	5700	—	—	—	—	—	—	(1984).
	Temperate									Ovington (1965).
Oak forests	region	a	10100	—	—	—	—	—	—	
		b	31600	312	8.4	34.0	_	826	146	
	This study									
Ross		a	2005	26.8	1.7	3.3	0.49	21.9	3.39	
		b	3053	34.4	2.2	4.5	0.74	28.1	4.26	
Gartfairn		a	1682	26.2	2.0	3.7	0.61	21.2	4.44	
		b	2513	34.2	2.5	5.0	0.93	26.7	5.54	
Methven		a	1896	30.7	1.9	5.7	0.52	26.2	4.15	
		b	3284	45.0	2.7	8.9	0.88	36.8	5.60	

*; (cit. Anderson & Swift 1983).

Among the components of the litter layer the k_L values are lowest for small wood, in agreement with the general view of its slow decomposition which can be ascribed to its relatively low nutrient content and its higher concentration of recalcitrant materials (e.g. Williams & Gray 1974; Anderson 1981; Rawat & Singh 1988b). The turnover time was shortest for acorns which, although hard and woody, undergo other fates like consumption by small mammals and germination and are probably not best considered with the other litter components (Gosz *et al* 1972; Shaw 1974).

Table 33. k_L and k'_L values for leaves, wood, fruit and total litter mass in each of the plots and the mean ± SE (*n*=3) for each of the sites.

Site	Plot	Leaves k_L	Leaves k'_L	Wood k_L	Wood k'_L	Fruit k_L	Fruit k'_L	Total k_L	Total k'_L
Ross	1	1.07	0.66	0.59	0.45	—	1.00	1.03	0.64
	2	1.10	0.67	0.77	0.54	—	1.00	1.07	0.66
	3	0.84	0.57	0.50	0.39	4.52	0.99	0.82	0.56
Mean		1.00	0.63	0.62	0.46	4.52	1.00	0.97	0.62
± SE		0.08	0.03	0.08	0.04	—	0.01	0.08	0.03
Gart-fairn	4	1.31	0.73	1.05	0.65	2.07	0.87	1.32	0.73
	5	1.42	0.76	1.03	0.64	2.14	0.88	1.37	0.75
	6	1.31	0.73	0.52	0.40	1.48	0.77	1.03	0.64
Mean		1.34	0.74	0.87	0.57	1.90	0.84	1.24	0.71
± SE		0.04	0.01	0.17	0.08	0.21	0.03	0.11	0.03
Methven	7	1.19	0.69	0.88	0.58	1.94	0.86	1.20	0.70
	8	1.20	0.70	0.52	0.41	1.64	0.81	0.98	0.62
	9	1.37	0.75	0.72	0.51	2.28	0.90	1.19	0.69
Mean		1.25	0.71	0.71	0.50	1.95	0.85	1.12	0.67
± SE		0.06	0.02	0.10	0.05	0.18	0.03	0.07	0.02

Table 34. k_L and k'_L values for nitrogen, phosphorus, potassium, sodium, calcium and magnesium contents of leaves and total litter in the three sites.

Nutrients		Ross		Gartfairn		Methven	
		Leaf	Total	Leaf	Total	Leaf	Total
N	k'_L	0.52	0.60	0.83	0.86	0.65	0.71
	k_L	0.74	0.92	1.79	1.99	1.06	1.22
P	k'_L	0.57	0.63	0.83	0.77	0.64	0.69
	k_L	0.85	0.99	1.80	1.47	1.03	1.17
K	k'_L	0.66	0.76	0.80	0.93	0.66	0.76
	k_L	1.08	1.44	1.62	2.60	1.09	1.43
Na	k'_L	0.68	0.76	0.79	0.90	0.65	0.73
	k_L	1.15	1.42	1.56	2.26	1.05	1.30
Ca	k'_L	0.67	0.70	0.83	0.71	0.70	0.74
	k_L	1.12	1.20	1.78	1.25	1.19	1.33
Mg	k'_L	0.68	0.73	0.81	0.62	0.66	0.72
	k_L	1.15	1.29	1.64	0.97	1.09	1.27

Table 35. The turnover time ($365/k_L$) (days) for the mass and nutrients of leaves (a) and total small litter in the three sites.

		Mass	N	P	K	Na	Ca	Mg
Ross	(a)	365	493	397	204	183	344	299
	(b)	376	429	369	203	248	354	312
Gart-fairn	(a)	272	338	253	225	140	335	255
	(b)	294	317	257	234	162	348	281
Methven	(a)	292	326	304	205	292	307	274
	(b)	326	317	283	223	376	335	287

Table 36. k_L values for the mass and nutrients of (a) leaves and (b) total small litterfall for a range of deciduous forests. $k_L = -\ln(1-k')$ where $k' = L / (A_{min} + L)$ where L is the annual litter mass (or nutrients) input and A_{min} is the minimum value for litter layer mass (or nutrients) during the year.

		Mass	N	P	K	Na	Ca	Mg
New Jersey								
USA. 1	(a)	1.13	0.92	1.08	1.97	—	0.97	1.47
Mixed oak	(b)	0.73	0.62	0.84	1.66	—	0.60	1.05
Minnesota, USA.								
Oak and	(b)	0.49	0.39	0.60	—	—	0.39	0.63
mixed hard-	(b)	0.58	0.53	0.89	—	—	0.63	0.99
woods. 2	(b)	0.69	0.57	0.91	—	—	0.57	1.20
South Sweden								
Beech 3	(b)	0.73	0.56	0.62	0.87	1.05	0.65	0.63
Himalayas,								
Oak 4	(b)	1.07-1.20	1.07	1.45	1.71	1.83	1.02	—
Missouri USA. 5*								
Quercus alba	(b)	—	0.21	0.26	0.42	—	0.22	0.27
This study								
Ross	(a)	1.00	0.74	0.85	1.08	1.15	1.12	1.15
	(b)	0.97	0.92	0.99	1.44	1.42	1.20	1.29
Gart-fairn	(a)	1.34	1.79	1.80	1.62	1.56	1.78	1.64
	(b)	1.24	1.99	1.47	2.60	2.26	1.25	0.97
Methven	(a)	1.25	1.06	1.03	1.09	1.05	1.19	1.09
	(b)	1.12	1.22	1.17	1.43	1.30	1.33	1.27

Data are recalculated from: 1, Lang & Forman (1978); 2, Reiners & Reiners (1970); 3, Nihlgard (1972); 4, Rawat & Singh (1988 a & b); and 5, Rochow (1975). 5, the values are k_L from Anderson & Swift (1983). *, The author has used the annual mean value for A instead of A_{min} and therefore his k_L values in this table are underestimated.

CHAPTER 6

DECOMPOSITION

6.1 INTRODUCTION

The decomposition of the organic matter is the sum of component losses attributable to catabolism, comminution and leaching (Swift *et al* 1979). It is a complex process in which the products of one stage become the substrate of another. Each stage is regulated by the action (and interaction) of three variables : organisms, resource quality and physical environment. Decomposition is a key process in ecosystem functioning and nutrients released during its course are an important flux in the cycling of nutrients.

In the last chapter I used a relatively crude index of decomposition rates, k_L, to compare the three woodlands at Ross, Gartfairn and Methven. A more detailed investigation was desirable and it was decided to use the litter bag technique (Swift *et al* 1979). In this method weighed amounts of fresh litter are placed in the field in containers (often bags) and their decomposition measured from samples brought in at regular intervals. By varying bag mesh size the technique is able to discriminate between the action of organisms of different sizes; by varying substrate the influence of substrate quality can be assessed; and the influence of the site can be investigated by putting the same substrate in bags in different sites. The measurement of changes of mass and chemical composition enable the process of decomposition to be modelled. The litter bag method may underestimate actual decomposition but it is assumed that the results of litter bag studies will reflect trends characteristic of unconfined decomposing litter, and as such allow for realistic comparisons (Wieder & Lang 1982).

The various models used to describe decomposition have been critically discussed by Wieder & Lang (1982). The most frequently used model is the single exponential decay function first proposed by Jenny *et al* (1949) and elaborated by Olson (1963). In this model, a single constant ,k_{se}, characterises the loss mass and facilitates comparisons. The single exponential model assumes that the absolute decomposition rate decreases linearly as the amount of substrate remaining declines. This fits with the description of the decomposition process given earlier. As decomposition proceeds more recalcitrant materials accumulate and the absolute decomposition rate decreases.

Some authors have modified the above model to a double exponential decay model which assumes that litter has two components : a relatively easily decomposed fraction (A), and a more recalcitrant fraction (1-A). Each fraction decomposes exponentially at rates characterized by k_{1d} and k_{2d} respectively: total decomposition is represented by the sum of losses from each fraction. The proportion of A to (1-A) is a characteristic attributed to initial, undecomposed litter and the double exponential model does not consider any transfer of labile to recalcitrant material, such as the synthesis of microbial biomass during decomposition. As such the double exponential decay function is a compromise between the single exponential function and the ideas of Minderman (1968), who suggested that each of several fractions of fresh litter would decompose exponentially and that the total decomposition should be represented by the sum of the individual fractions.

A further model, related to both the single exponential and double exponential models, is the asymptotic model (Wieder & Lang 1982). All three are similar in that the absolute decomposition rate tends towards zero as time progresses. The relative decomposition rate is constant for the single exponential model and approaches a constant value ($-k_{2d}$) for the double exponential model as the remaining mass of the labile fraction diminishes. For the asymptotic model, the relative decomposition rate, as originally defined, approaches zero as time progress.

Experiments

Three Experiments were made. Experiment A tested the hypothesis that there were differences in the rate of indigenous leaf litter decomposition and element mineralization among the sites. It also tested the hypothesis that the influence of soil animals on decomposition differed between the sites. Experiment B tested the hypothesis that even the larger mesh-size bags slowed decomposition compared with unconstrained leaves. Experiment C tested the hypothesis that litter quality differences are important in determining differences in decomposition rates and element mineralization among the sites.

Mathematical models were fitted to estimate constants that describe the loss of mass over time.

6.2 MATERIALS AND METHODS

Experiment A

In September and October 1988 falling leaves were collected from every plot in each of the three sites in randomly positioned nets about 1 m above the ground. The leaves were air-dried and sub-samples were taken to enable the calculation of oven-dry (85 °C) weights. The sub-samples were later ashed (375 °C) and reweighed so that ash-free weights could be calculated.

5 g of air-dried leaves were placed (after being stored air-dried for at most 15 days) in containers of two mesh sizes: 5-mm mesh plastic boxes (hence referred to as 'coarse mesh') of about 12 X 12 cm^2 area and 3 cm deep and 64 μ mesh nylon bags (hence referred to as 'fine mesh' which had a similar area to the coarse mesh and a depth of about 2 cm. Indigenous leaves were used for each plot. There were twenty-eight coarse mesh and twelve fine mesh placed randomly in each plot - the numbers of replicates were different because of the high cost of the fine mesh material. Seven coarse and three fine mesh were recovered on four occasions (Table 37). After recovery the material inside each container was removed, cleaned (where necessary), oven-dried (85 °C) and weighed. For each recovery the material was then bulked for each plot and (as also

for initial leaves) chemically analyzed as described for litterfall (chapter 3). Carbon was calculated as 50% of the ash-free weight (Mc Brayer & Cromack 1980, cited by Upadhyay & Singh 1989). A nested analysis of variance (unbalanced when required) was employed to compare the differences between decomposing leaf mass and nutrients between and within the sites and between different containers, on different sampling occasions.

Experiment B

This experiment was made in plot seven in Methven only. The decomposition in the containers used in experiment A was compared with that in twenty-eight randomly-placed aluminium frames. These were bottomless aluminium boxes of 15 x 15 cm which were 6 cm deep. Four holes of 5 mm diameter were drilled in each side. The frames were pressed 1-2 cm into the soil (which had been cleared of leaf litter) and each was filled with 8 g of the air dried oak leaf litter (a proportion of weight per surface area that was similar to that in the coarse mesh and fine mesh). The frames were covered with plastic 5 mm mesh and fixed with two ties. Some of these receptacles were found vandalized so only five frames could be recovered on each sampling occasion (Table 37). Subsequent treatment of material was similar to that described for Experiment A.

Experiment C

Leaves from two other woodland sites were placed in twenty-eight random coarse mesh in one plot in each of the three sites (plots 1, 4 and 7). Their decomposition was compared with that of the indigenous leaves in the coarse mesh in experiment A. Recovery and subsequent treatments were similar to those described for Experiment A.

Table 37. The dates of litter substrate emplacement and sampling for experiments A, B and C in the three woodlands. The number of days between samplings are given in parentheses.

	Ross	Gartfairn	Methven
Starting dates	21 Nov 1988	20 Nov 1988	22 Nov 1988
	(135)	(137)	(127)
Sample dates			
1	04 Apr 1989	05 Apr 1989	28 Apr 1989
	(73)	(73)	(79)
2	16 Jun 1989	17 Jun 1989	15 Jun 1989
	(67)	(66)	(67)
3	23 Aug 1989	23 Aug 1989	21 Aug 1989
	(91)	(91)	(91)
4	22 Nov 1989	22 Nov 1989	20 Nov 1989

6.3 RESULTS

Experiment A

Leaf mass loss

The results are shown in Table 38. The loss was faster for coarse mesh at Gartfairn and for fine mesh at Ross. At Ross the mesh size had no effect while at Gartfairn and Methven, from the second sampling, decomposition was slower in fine mesh bags.

A simple linear model (y=a+bx), where y is percentage of remaining material from litter bags, x is time elapsed (days), a is intercept and b is slope) gave the best fit. The turnover time (T= -a/b), the correlation coefficients (r) of the relationships, and the k values (k= 365/T) are given in Table 39. The turnover times for leaf litter were for coarse and fine mesh: Ross, 701 and 726 days; Gartfairn, 556 and 817 days; and Methven, 652 and 1004 days.

Table 38. Experiment A. Mean leaf mass percentage (ash free) remaining in coarse (5-mm) and fine (64 μ) mesh containers in Ross, Gartfairn and Methven on four sampling dates. Variation levels (***, P<0.001; **, P<0.01; *, P<0.05 and NS, not significant) for between woods (VLbW), between plots (VLBP) and between containers are given.

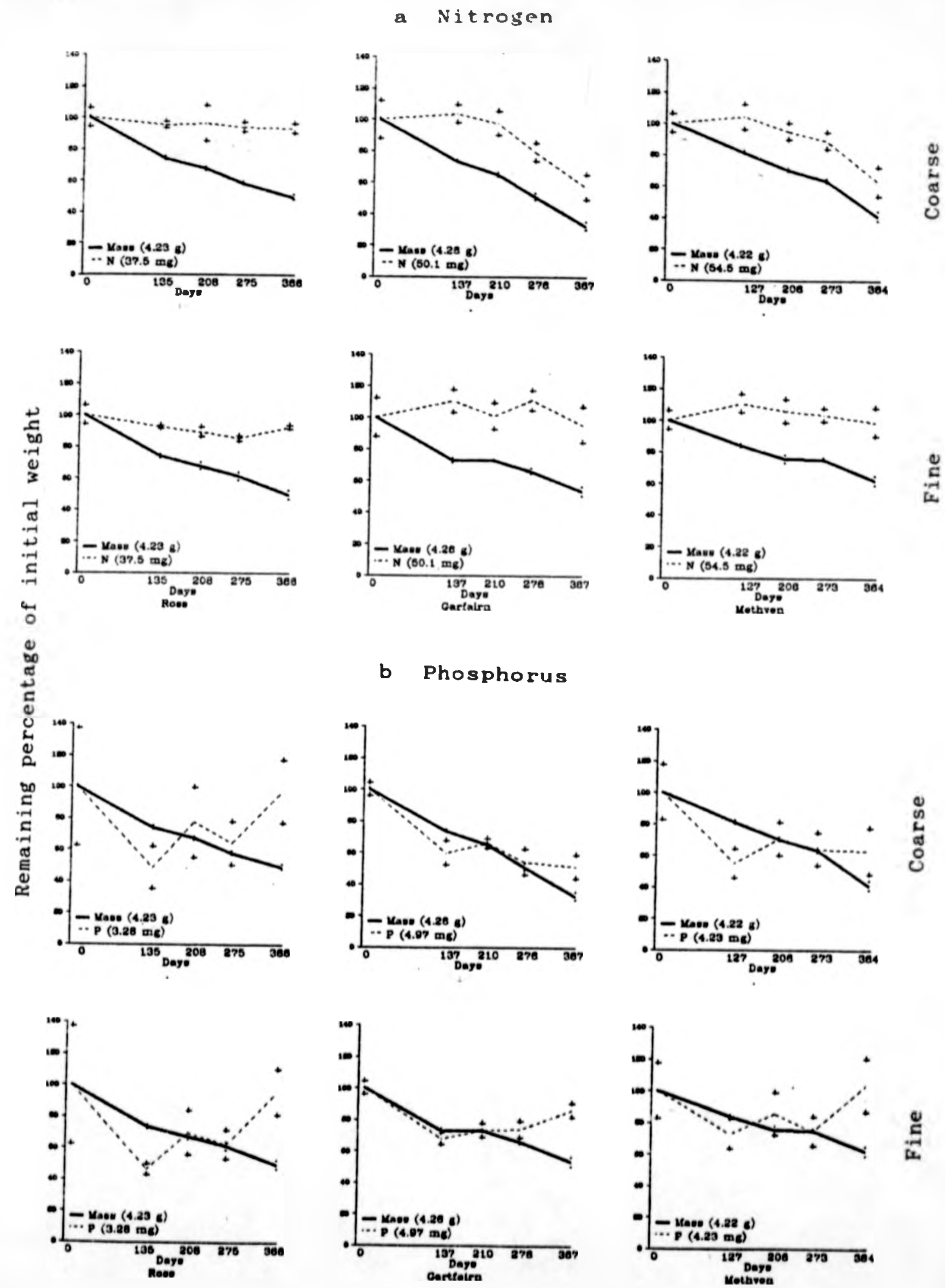
Receptacle	Occasion	Ross	Gartfairn	Methven	VLBW	VLBP
Coarse	1	74.1	73.7	81.3	*	NS
	2	67.3	65.2	70.7	NS	*
	3	57.9	51.1	63.3	*	**
	4	49.2	32.7	41.0	*	NS
Fine	1	73.8	72.9	84.0	**	NS
	2	67.6	72.8	75.7	NS	NS
	3	61.3	66.3	75.3	*	*
	4	49.6	53.5	62.2	NS	**
Variations between coarse & fine	1	NS	NS	NS	***	*
	2	NS	***	*	***	***
	3	NS	***	***	***	**
	4	NS	***	***	**	**

Table 39. Experiment A. Relationship between percentage weight remaining of leaf litter (y) and number of days elapsed (x) (y=a+bx) for coarse mesh (5-mm) and fine mesh (64 μ) bags using indigenous leaves. The turnover time (T= -a/b) (days) and the k values (k= 365/T) (yr^{-1}) and are shown.

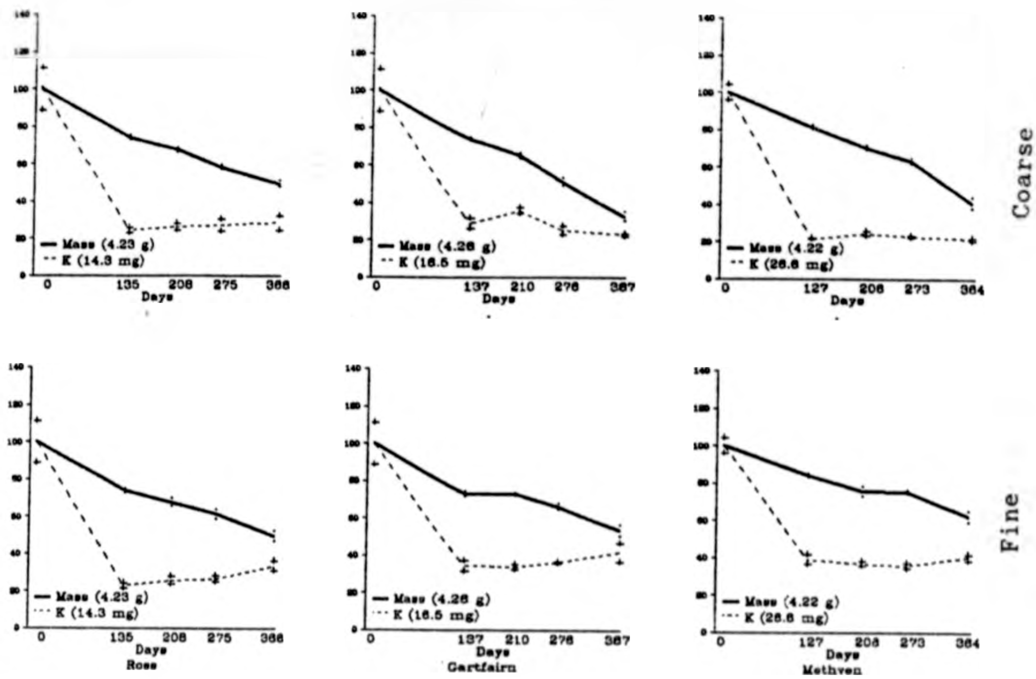
Receptacle	Site	Intercept (a)	Slope (b)	r	k	Turnover time
Coarse	Ross	96.8	-0.138	0.949	0.52	701
	Gartfairn	100	-0.180	0.948	0.66	556
	Methven	101	-0.155	0.924	0.56	652
Fine	Ross	96.6	-0.133	0.935	0.50	726
	Gartfairn	96.4	-0.118	0.923	0.45	817
	Methven	98.5	-0.0981	0.905	0.36	1004

All correlations are significant at level of P<0.001

Fig. 22. Experiment A. Changes in the remaining percentages of (a) nitrogen, (b) phosphorus, (c) potassium, (d) sodium, (e) calcium, (f) magnesium and (g) ash and also ash free leaf mass in 5-mm meshes (coarse) and 64 µ meshes (fine), in Ross, Gartfairn and Methven during one year period. The SE for leaf mass (.) ($\underline{n}$=21 for coarse and 9 for fine mesh) and the elements and ash (+) ($\underline{n}$=3) are shown. The mean for initial leaf mass and the elements and ash are given in parenthesis.

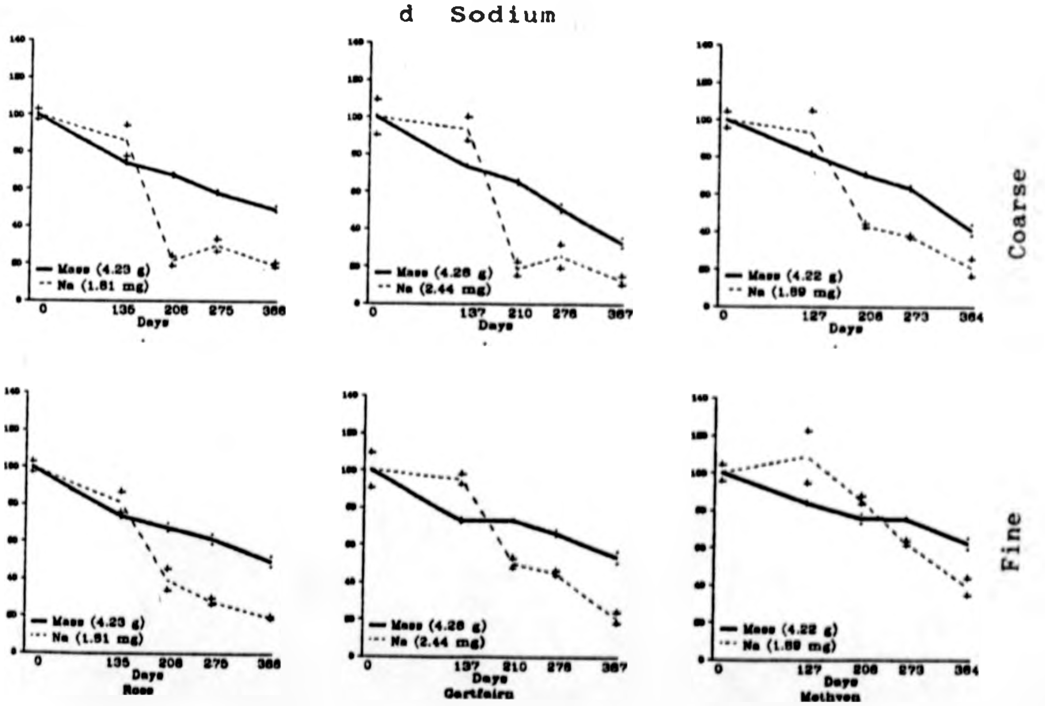


c Potassium



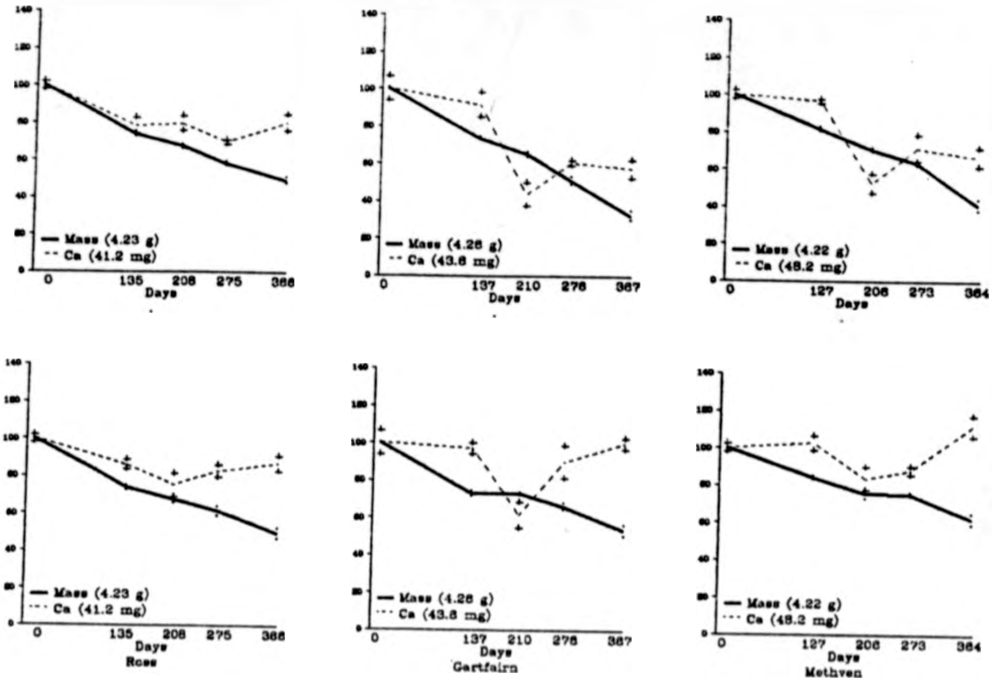
Remaining percentage of initial weight

d Sodium



Remaining percentage of initial weight

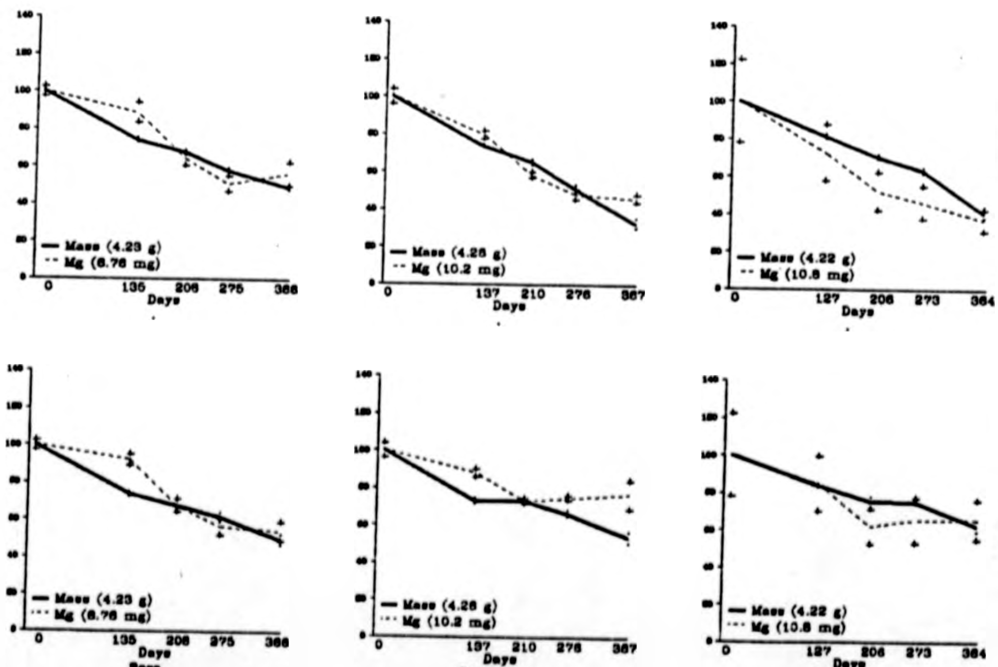
e Calcium



Coarse

Fine

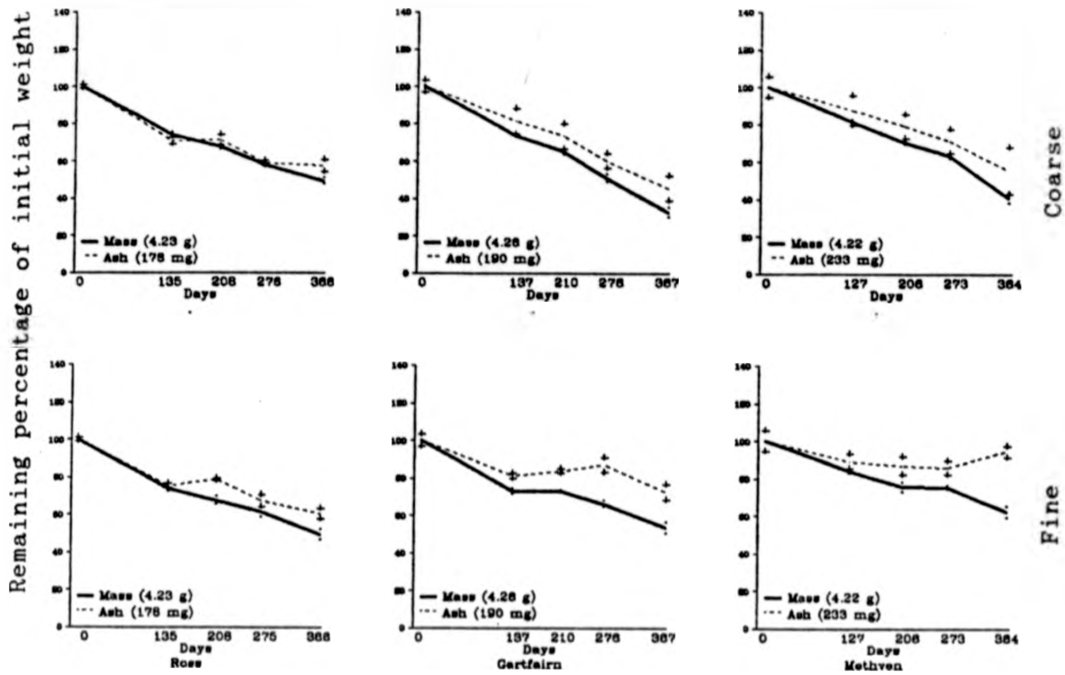
f Magnesium



Coarse

Fine

g Ash


Remaining percentage of initial weight
Coarse
Fine
Mass (4.23 g)
Ash (178 mg)
Mass (4.26 g)
Ash (190 mg)
Mass (4.22 g)
Ash (233 mg)
0 135 208 275 366
0 137 210 276 367
0 127 206 273 364
Days
Ross
Gartfairn
Methven

Nutrient immobilization and mineralization

The changes in element concentrations with time are shown in Fig. 22 and the significance of the differences between coarse and fine mesh are shown in Table 40. Nitrogen showed the slowest release of all the elements in both coarse and fine mesh. There was no net release from both coarse and fine mesh at Ross and from fine mesh from Gartfairn and Methven. Phosphorus also showed no change of concentration in coarse and fine mesh at Gartfairn and from fine mesh at Methven. In all cases however there was a decrease in phosphorus concentration at the first sample date followed by an increase later. Potassium and sodium were lost relatively quickly from all the samples although sodium showed an initial slower loss than potassium. Calcium concentration were very similar to those initially in both coarse and fine mesh at Ross, and fine mesh at Gartfairn and Methven. Magnesium concentrations declined in all sites, most slowly in the fine mesh at Gartfairn. Ash concentrations declined more slowly than those of mass but in general in a parallel way except in the fine mesh at Methven where the ash concentration had not declined at the end of the experiment.

Experiment B

Leaf mass loss

The results are shown in Table 41. The loss was fastest in the frames and slowest in the fine mesh on all the sampling occasions (although the differences were not significant at the first sampling). k values was calculated using a linear model as in experiment A (Table 42) and the calculated litter turnover times were: Coarse mesh, 595 days; fine mesh, 841 days; and frames, 540 days.

Nutrient immobilization and mineralization

The reductions of element concentrations were similar overall in the coarse mesh and frames and generally faster than the fine mesh (Fig 23).

Experiment C

Leaf mass loss

The results are shown in Table 43. The most significant differences were between sites rather between litter origin. In all cases the leaves decomposed more quickly at Gartfairn. A correlation (as in experiment A) was fitted to the data (Table 44) and showed turnover times ranging from 493 to 676 days with the fastest being Methven leaves at Gartfairn and the slowest Ross leaves at Ross.

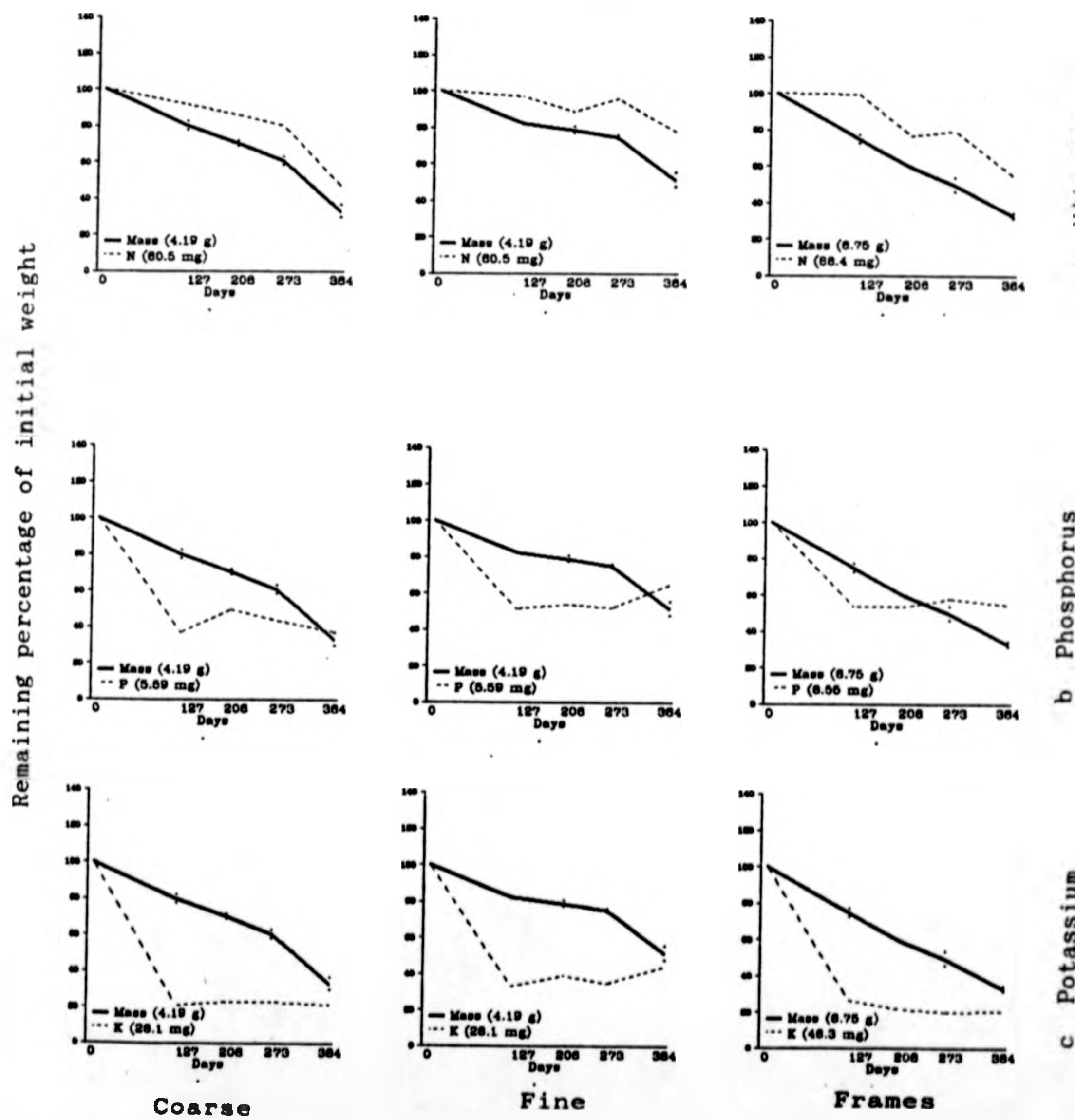
Nutrient immobilization and mineralization

Changes in element concentrations were least at Ross and fairly similar between Gartfairn and Methven (Fig. 24).

Table 40. Experiment A: the levels of significance (***, P<0.001; **, P<0.01; *, P<0.05 and NS, not significant) of differences in remaining nutrients and ash (% of their initial weight) in coarse (5-mm) and fine (64 μ) mesh size containers between Ross, Gartfairn and Methven and between mesh sizes (C & F) on four sampling occasions.

Occasion	Ross C & F	Gartfairn C & F	Methven C & F	Three sites Coarse	Three sites Fine
Nitrogen					
1	NS	NS	NS	NS	NS
2	NS	NS	NS	NS	NS
3	NS	*	NS	NS	*
4	NS	NS	NS	*	NS
Phosphorus					
1	NS	NS	NS	NS	NS
2	NS	NS	NS	NS	NS
3	NS	NS	NS	NS	NS
4	NS	*	NS	NS	NS
Potassium					
1	NS	NS	**	NS	*
2	NS	NS	**	**	*
3	NS	**	**	NS	**
4	NS	*	***	NS	NS
Sodium					
1	NS	NS	NS	NS	NS
2	NS	**	***	***	***
3	NS	*	**	NS	***
4	NS	NS	NS	NS	*
Calcium					
1	NS	NS	NS	NS	NS
2	NS	NS	*	***	NS
3	*	*	NS	NS	NS
4	NS	**	**	*	*
Magnesium					
1	NS	NS	NS	NS	NS
2	NS	**	NS	NS	NS
3	NS	***	NS	NS	NS
4	NS	*	NS	NS	NS
Ash					
1	NS	NS	NS	NS	NS
2	NS	NS	NS	NS	NS
3	NS	*	NS	NS	*
4	NS	*	*	NS	**

Fig. 23. Experiment B. Changes in the remaining percentages of (a) nitrogen, (b) phosphorus, (c) potassium, (d) sodium, (e) calcium, (f) magnesium, and (g) ash and also ash free leaf mass in 5-mm meshes (coarse), 64 μ meshes (fine) and frames in Methven (plot 7) during one year period. The mean for the initial leaf mass and the elements and ash (in parenthesis) and the SE (n is ; 7 for coarse, 3 for fine meshes and 5 for frames) for leaf mass (.) are shown.



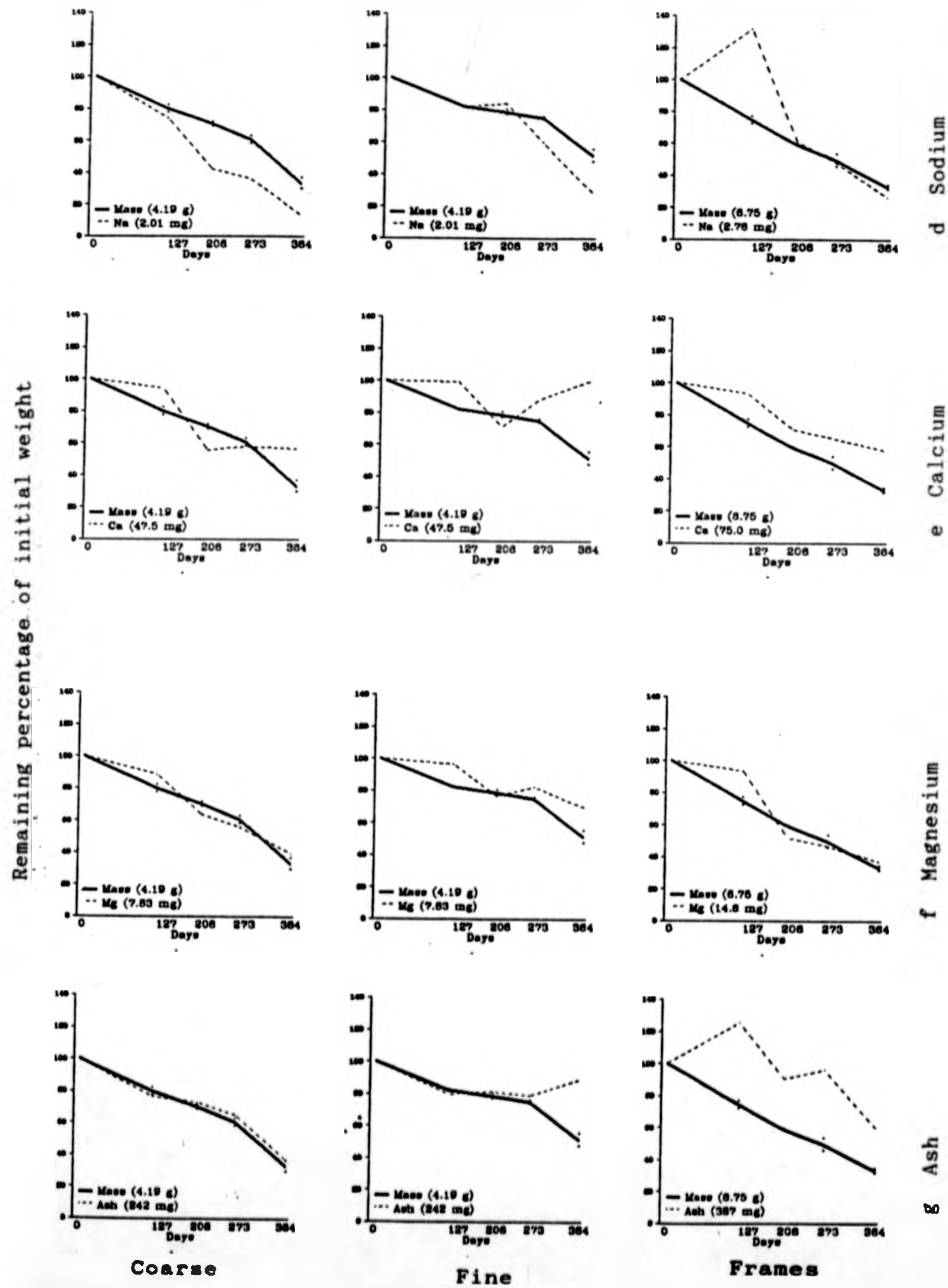

Remaining percentage of initial weight
d Sodium
e Calcium
f Magnesium
g Ash
Mass (4.19 g)
Na (2.01 mg)
Mass (6.75 g)
Na (2.76 mg)
Ca (47.5 mg)
Ca (75.0 mg)
Mg (7.63 mg)
Mg (14.6 mg)
Ash (242 mg)
Ash (387 mg)
Days
0
127
206
273
364
Coarse
Fine
Frames

Fig. 24a. Experiment C. Changes in the remaining percentages of nitrogen and ash free mass in 5-mm meshes containing leaves from different sites incubated in Ross (plot 1), Gartfairn (plot 4) and Methven (plot 7) during a one year period. The mean for initial leaf mass and nitrogen (in parenthesis) and the SE (n=7) for leaf mass (.) are shown.

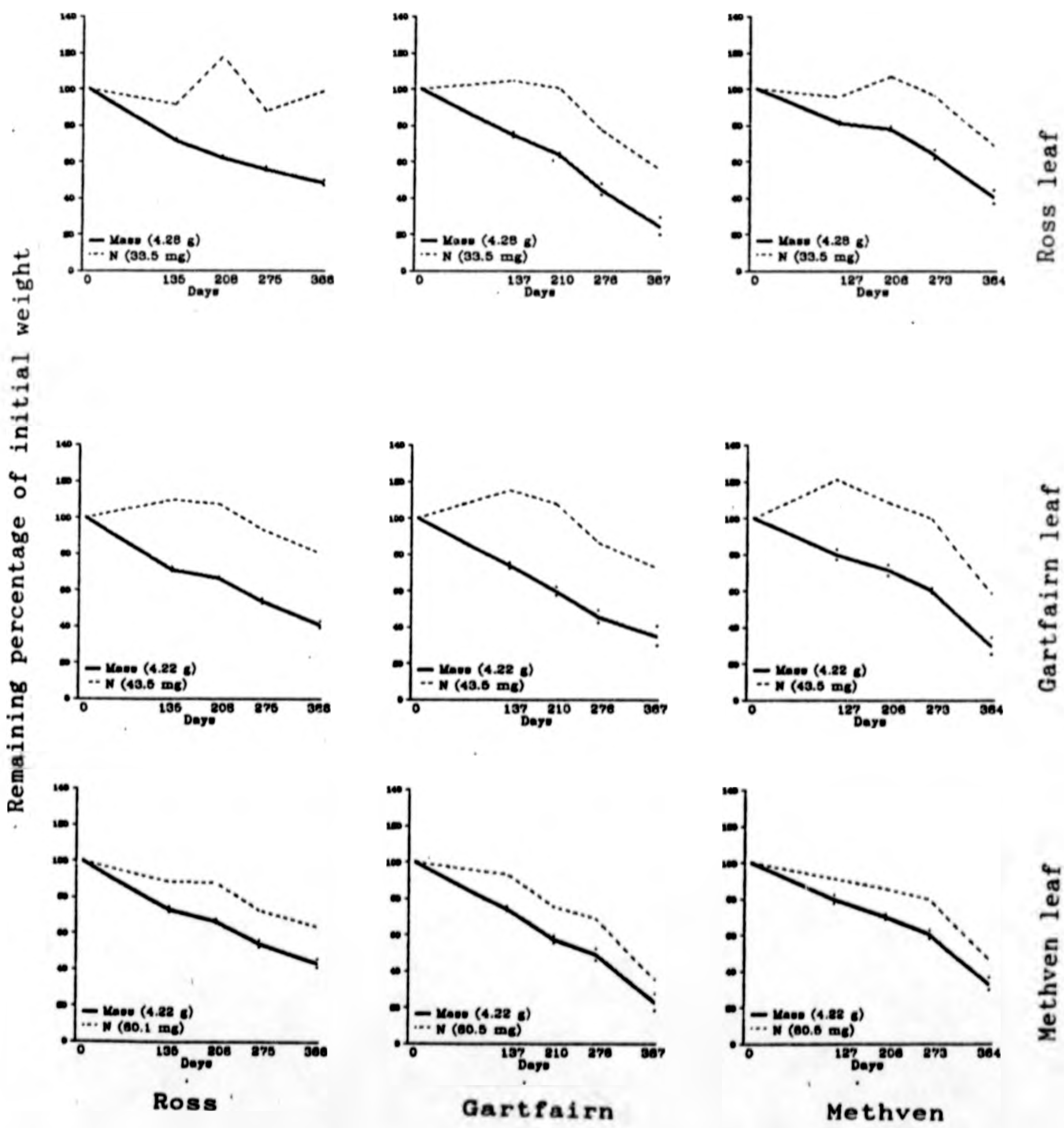


Fig. 24b. Experiment C. Changes in the remaining percentages of phosphorus and ash free mass in 5-mm meshes containing leaves from different sites incubated in Ross (plot 1), Gartfairn (plot 4) and Methven (plot 7) during a one year period. The mean for initial leaf mass and phosphorus (in parenthesis) and the SE ($\underline{n}$=7) for leaf mass (.) are shown.

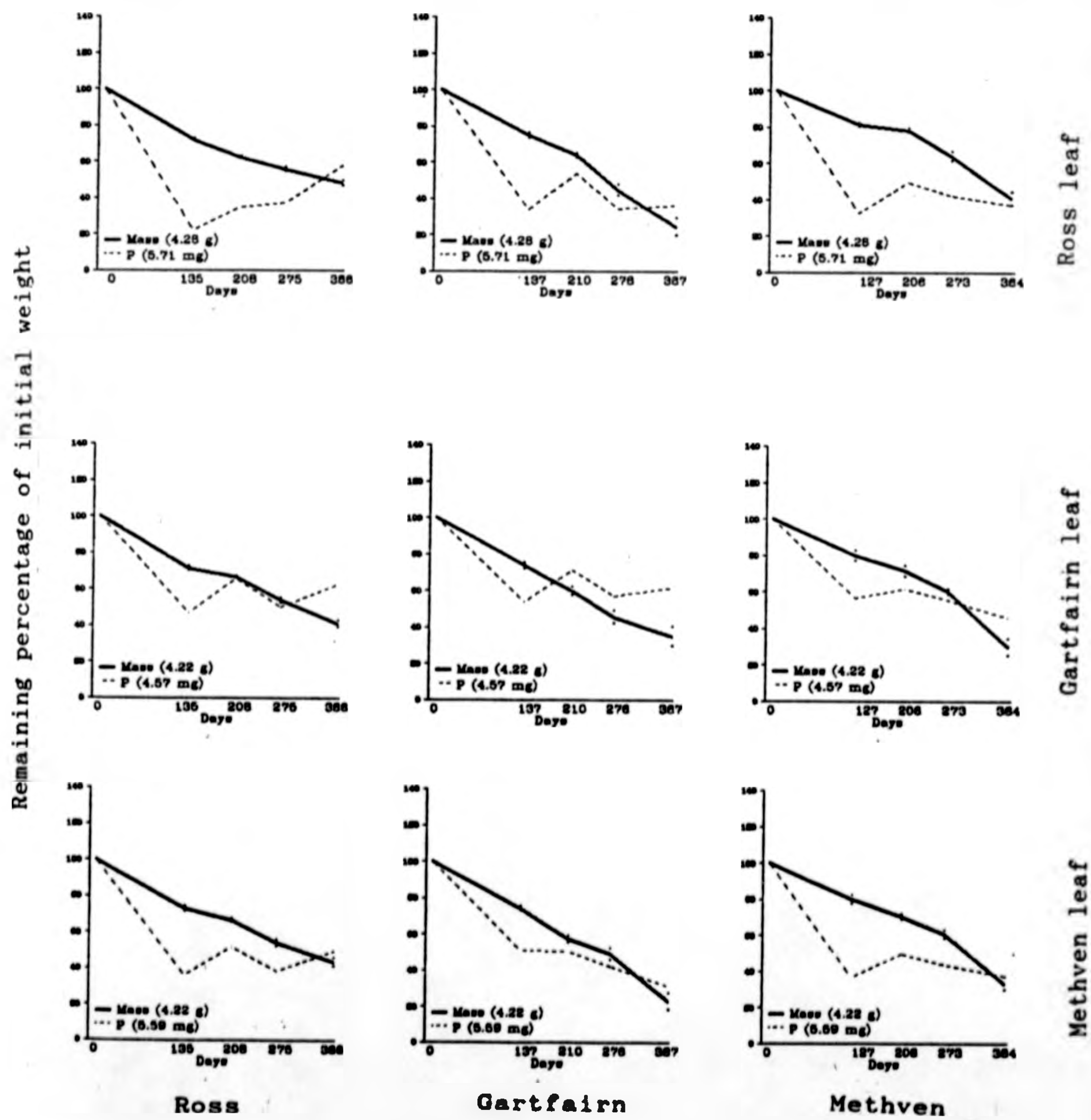


Fig. 24c. Experiment C. Changes in the remaining percentages of potassium and ash free mass in 5-mm meshes containing leaves from different sites incubated in Ross (plot 1), Gartfairn (plot 4) and Methven (plot 7) during a one year period. The mean for initial leaf mass and potassium (in parenthesis) and the SE (n=7) for leaf mass (.) are shown.

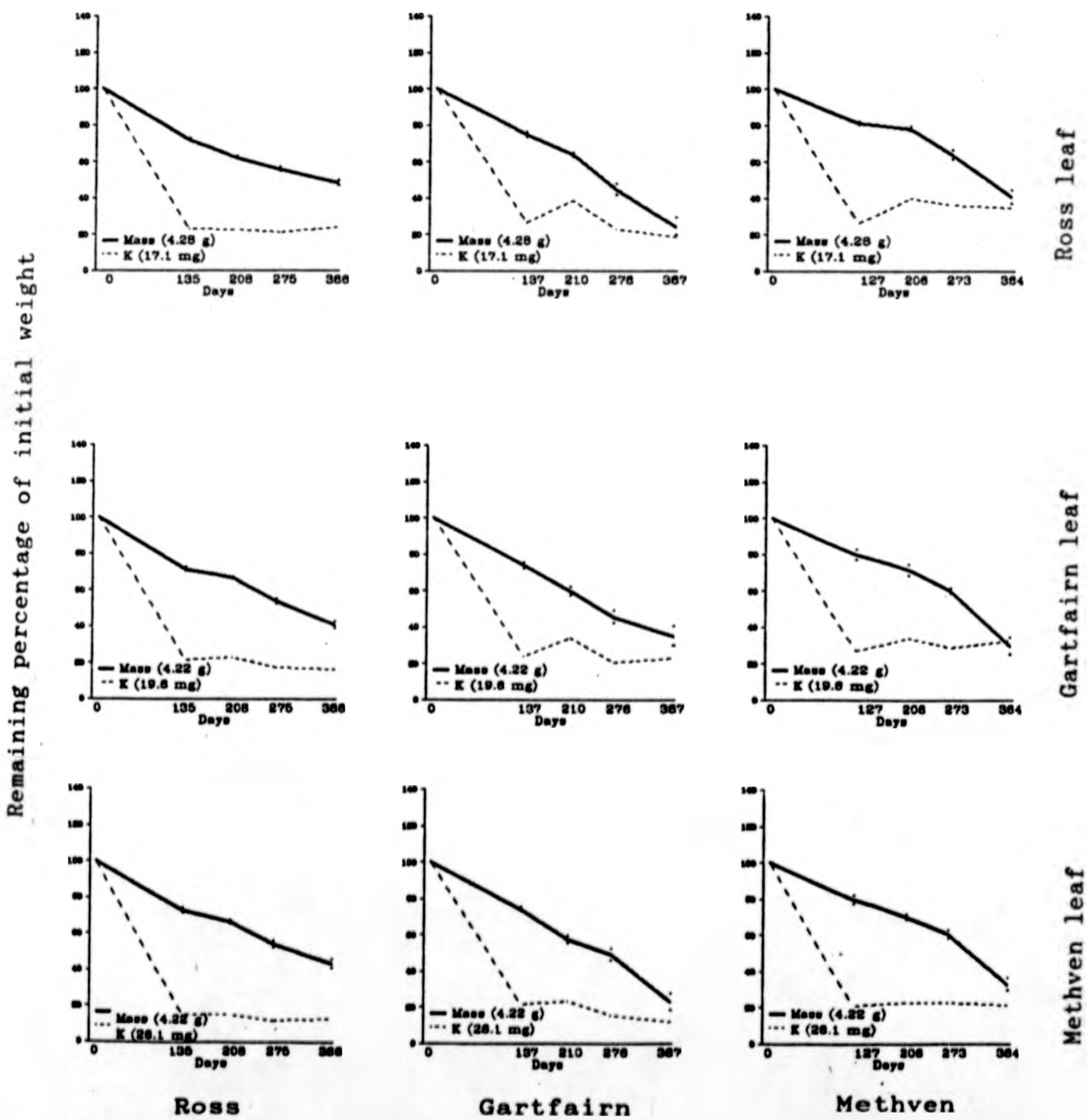


Fig. 24d. Experiment C. Changes in the remaining percentages of sodium and ash free mass in 5-mm meshes containing leaves from different sites incubated in Ross (plot 1), Gartfairn (plot 4) and Methven (plot 7) during a one year period. The mean for initial leaf mass and sodium (in parenthesis) and the SE (n=7) for leaf mass (.) are shown.

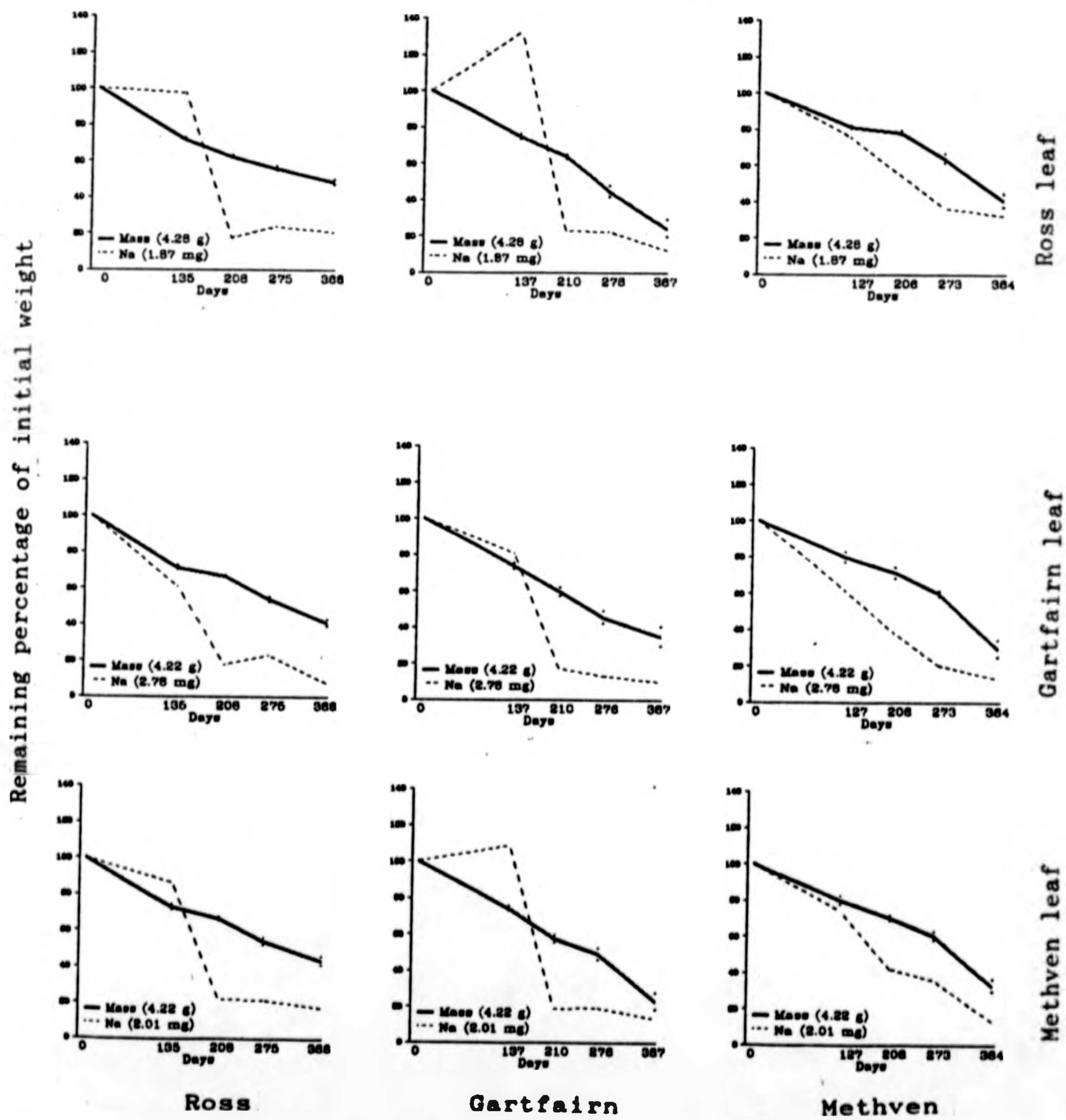


Fig. 24e. Experiment C. Changes in the remaining percentages of calcium and ash free mass in 5-mm meshes containing leaves from different sites incubated in Ross (plot 1), Gartfairn (plot 4) and Methven (plot 7) during a one year period. The mean for initial leaf mass and calcium (in parenthesis) and the SE (n=7) for leaf mass (.) are shown.

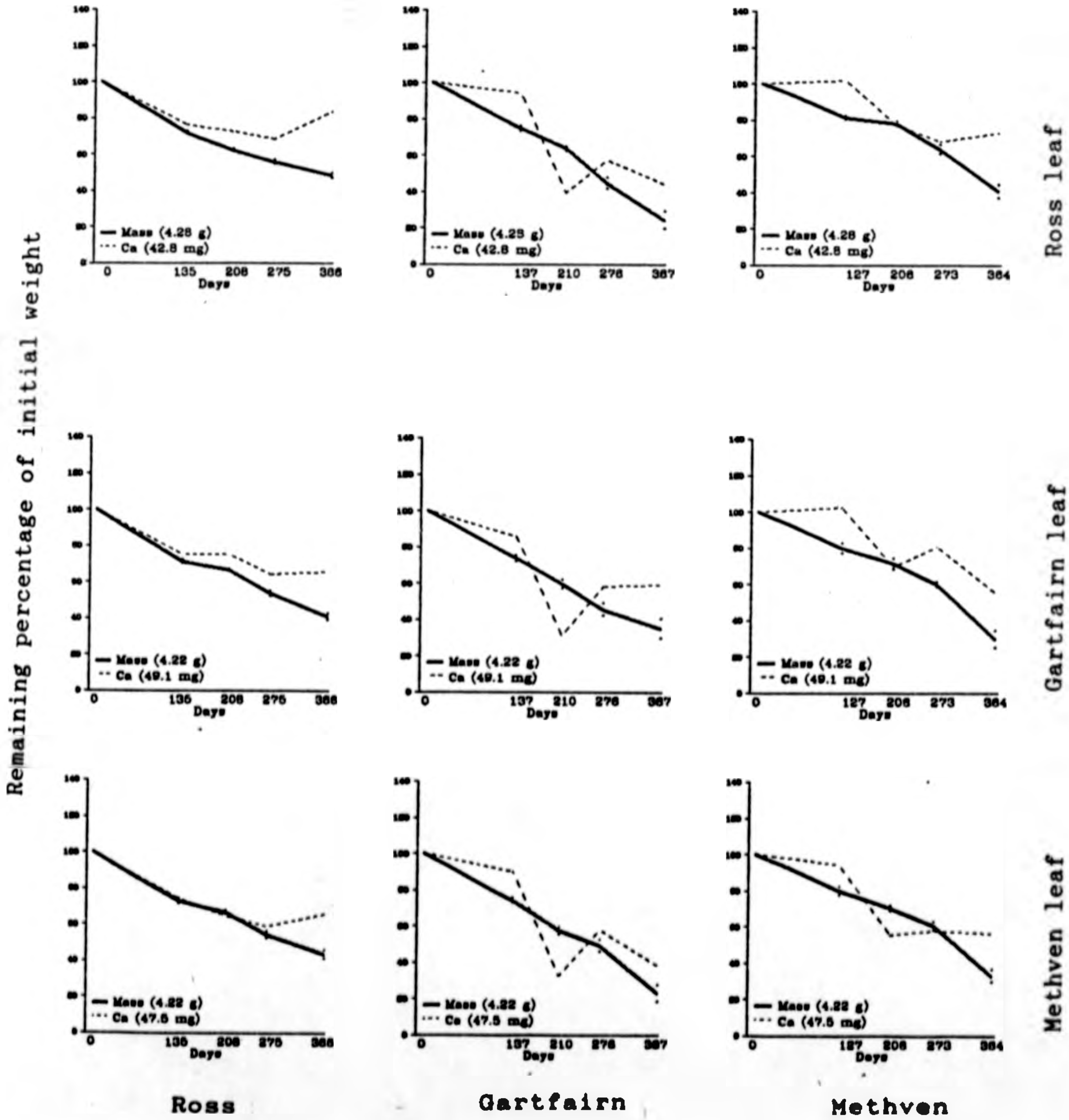


Fig. 24f. Experiment C. Changes in the remaining percentages of magnesium and ash free mass in 5-mm meshes containing leaves from different sites incubated in Ross (plot 1), Gartfairn (plot 4) and Methven (plot 7) during a one year period. The mean for initial leaf mass and magnesium (in parenthesis) and the ($\underline{n}$=7) SE for leaf mass (.) are shown.

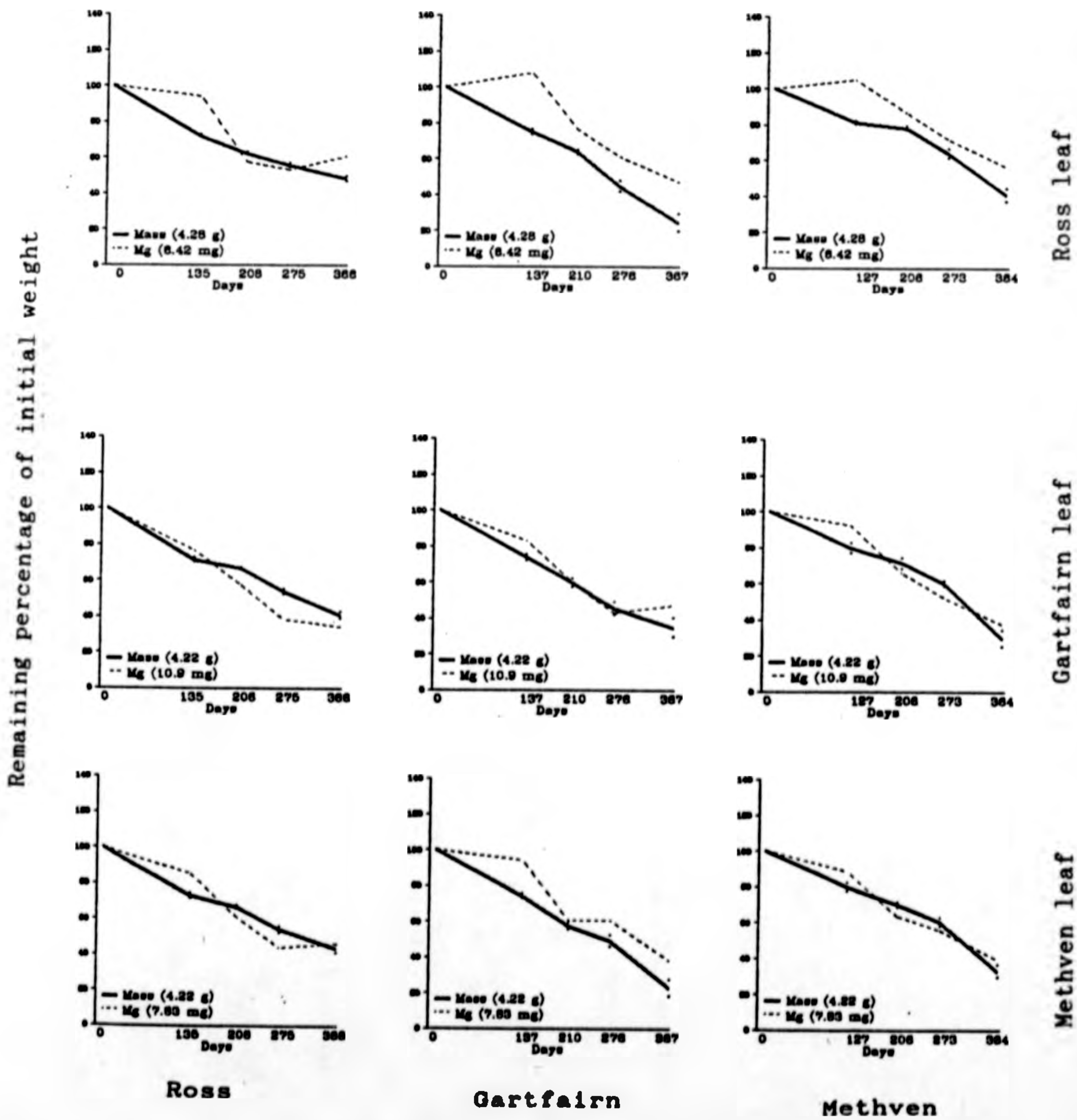


Fig. 24g. Experiment C. Changes in the remaining percentages of ash and ash free mass in 5-mm meshes containing leaves from different sites incubated in Ross (plot 1), Gartfairn (plot 4) and Methven (plot 7) during a one year period. The mean for initial leaf mass and ash (in parenthesis) and the SE (n=7) for leaf mass (.) are shown.

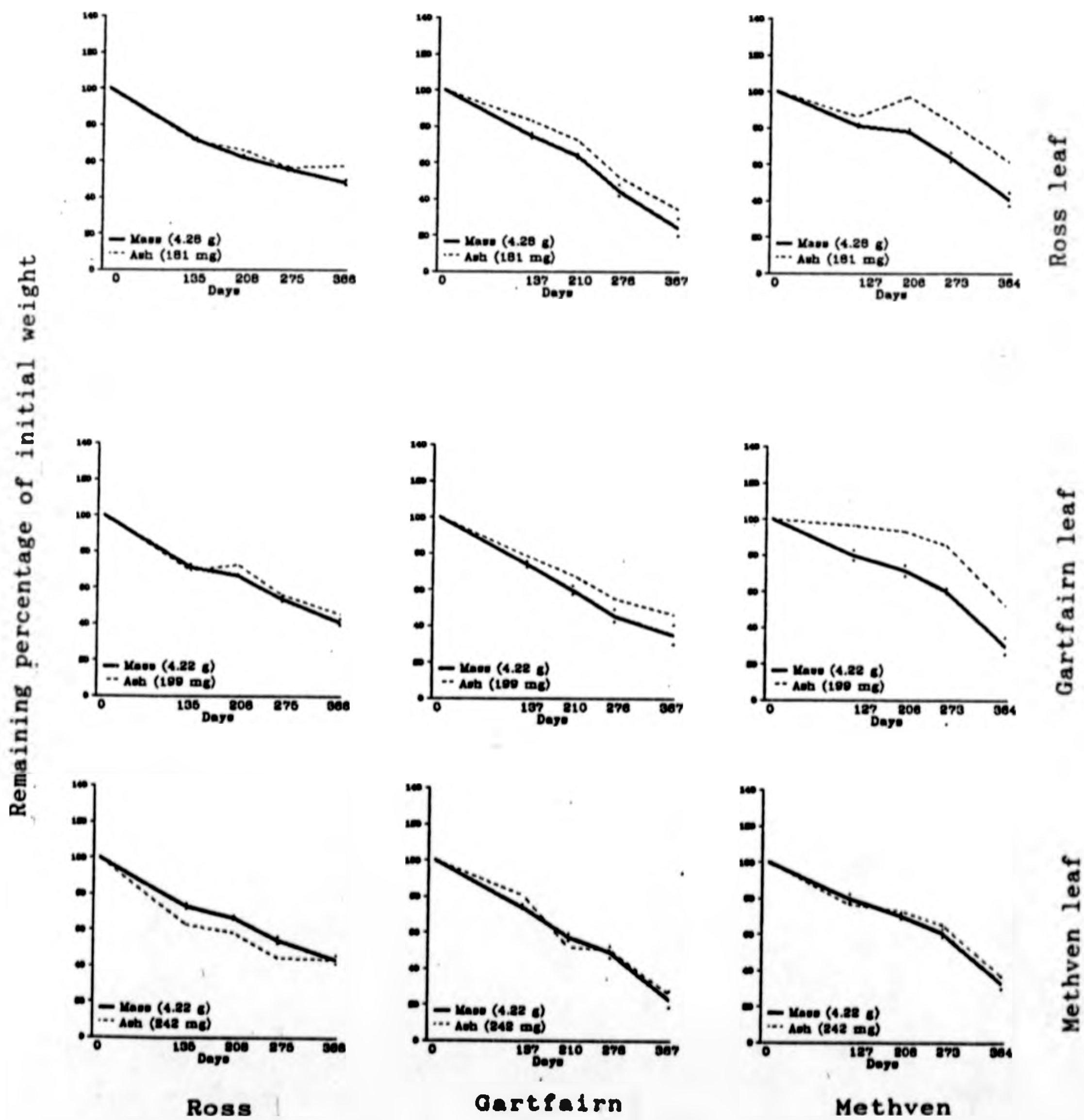


Table 41. Experiment B. Mean leaf mass percentage (ash free) remaining in coarse (5-mm), fine (64 μ) mesh and frames in Methven on four sampling occasions. Variation levels (***, P<0.001; **, P<0.01; *, P<0.05 and NS, not significant) for between containers (VLBC) are given.

Sampling	Coarse	Fine	Frames	VLBC
1	79.86	81.99	74.90	NS
2	70.38	78.60	59.23	***
3	60.46	74.73	49.69	**
4	33.21	51.58	32.89	**

Table 42. Experiment B. Relationship between percentage weight remaining of leaf litter (y) and number of days elapsed (x) (y=a+bx) for coarse mesh (5-mm) (n=7), fine mesh (64 μ) (n=3) and frames (n=5) in Methven (plot 7). The turnover time (T= -a/b) (days) and the k values (k= 365/T) (yr^{-1}) and are shown.

Containers	Intercept	Slope	r	k	Turnover time
Coarse mesh	103	-0.174	0.953	0.62	592
Fine mesh	101	-0.120	0.946	0.43	841
Frame	98.9	-0.183	0.982	0.68	540

All correlations are significant at level of P<0.001

6.4 DISCUSSION

Decay function and mass values

In the present work none of the models previously discussed fitted to the data as well as the linear model. This implies that the absolute decomposition rate is constant throughout decomposition while the relative decomposition rate increases with time. This is an unexpected result from the description of the decomposition process given earlier but its occurrence in the present case can be explained. First there are only five sampling times and any curve would be difficult to define; secondly the period from leaf collection to first sampling is long (28 days after air-drying plus 127 - 137 days (Table 37) in the field); thirdly, a substantial amount (30 - 62%) of the leaf mass was left after the sampling finished and this may be highly recalcitrant but uninvestigated. Linear models have been found to be applicable by other workers in situations where the quantity of mass lost is small over the course of decomposition eg. Woodwell & Marples (1968), Howard & Howard (1974), and Grigal & McColl (1977).

Mass loss

Experiment A

The rate of indigenous leaf decomposition varied significantly between the sites with the slowest rates at Ross and the fastest at Gartfairn. Using the calculated k value (Table 39) the turnover times for leaves (in coarse mesh were: Ross 701 days, Gartfairn 556 days, and Methven 652 days. The turnover time for leaf litter calculated from k_L values (Table 35) were in the same rank order but more rapid: Ross 365 days, Gartfairn 272 days, and Methven 292 days. Even in the open frame (Experiment B) the leaf turnover rate at Methven was still 540 days (Table 42) much higher than that calculated from k_L for plot 7 in Methven (307 days). The differences may result from the inadequacies of k_L values discussed in the previous chapter and possibly the results from the (coarse mesh) litter bags give an indication of true turnover time. Mass loss in the three woods was within the range reported for Oak leaves in other temperate forests (Table 45). There was a more rapid decomposition in leaves in coarse mesh than in fine mesh bags at Gartfairn and Methven (Tables 38-39). This has been commonly observed elsewhere (Edwards & Heath 1963; Heath *et al* 1966; McClaugherty *et al* 1985; DeCatanzaro & Kimmins 1985; Singh & Gupta 1977). Edwards & Heath 1963 found that Oak and Beech leaves disappeared three times faster in 7-mm mesh bags than in 0.5 mm. The differences for the 5-mm and 64 μ mesh bags in this study were much less. Other workers eg. Louisier & Parkinson (1976) found no differences in weight loss of leaves for 3 mm and 10 mm bags for the first 12 months but later the loss rate was more in the 3 mm bags which they attributed to the better moisture retention in the fine mesh bags.

In the present study there was no significant difference in the remaining leaf litter mass between the containers at the first sampling (Tables 38 and 42). This suggest that weight loss is initially dominated by leaching and agrees with Bocock (1963), Dziadowiec (1987), and McClaugherty *et al* (1985). The later differences between coarse and fine mesh are probably caused by the effects of soil animals. The fine mesh only lets in microorganisms (Swift *et al* 1979) whilst the coarse mesh and the frames let in meso-fauna and some macrofauna. At Ross the podzolic soil had no earthworms, whilst these were observed at Gartfairn and Methven, and this probably explains the lack of a significant difference between the fine and coarse mesh rates at Ross.

Table 43. Experiment C. Mean leaf mass percentage (ash free) remaining in coarse (5-mm) mesh size containers in Ross, Gartfairn and Methven using leaves from each of the different sites during four sampling occasions. Variation levels (***, P<0.001; **, P<0.01; *, P<0.05 and NS, not significant), between different woods using similar leaves (VBWSL), and between different leaves in the same wood (VBLSW).

Leaf origin	Sampling	Ross	Gartfairn	Methven	VBWSL
Ross	1	71.73	74.77	81.31	***
	2	62.18	63.68	78.20	***
	3	55.71	44.73	63.98	***
	4	48.10	24.47	40.89	***
Gartfairn	1	71.33	73.70	79.88	*
	2	66.60	59.82	71.46	**
	3	53.59	45.63	60.09	***
	4	40.79	34.97	29.62	NS
Methven	1	72.82	73.97	79.86	*
	2	66.39	57.52	70.38	***
	3	54.27	48.98	60.46	*
	4	43.57	22.92	33.21	**
VBLSW	1	NS	NS	NS	
	2	***	NS	*	
	3	NS	NS	NS	
	4	*	NS	NS	

Table 44. Experiment C. Relationship between percentage weight remaining of leaf litter (y) and number of days elapsed (x) (y=a+bx) for coarse mesh (5-mm) (n=7), using leaves from the different origin, incubated in one of the plots in each of the three sites. The turnover time (T= -a/b) (days) and the k values (k= 365/T) (yr^{-1}) and are shown.

Leaf origin	Incubation site (plot)	Intercept	Slope	r	k	Turnover time
Ross plot 1	Ross (1)	95.5	-0.141	0.967	0.54	676
	Gartfairn (4)	102	-0.206	0.966	0.74	495
	Methven (7)	103	-0.154	0.941	0.55	669
Gart-fairn plot 4	Ross (1)	97.6	-0.158	0.982	0.59	618
	Gartfairn (4)	98.8	-0.182	0.947	0.67	542
	Methven (7)	104	-0.182	0.936	0.64	571
Methven plot 7	Ross (1)	97.5	-0.153	0.975	0.57	637
	Gartfairn (4)	101	-0.205	0.963	0.74	493
	Methven (7)	103	-0.174	0.953	0.62	593

All correlations are significant at level of P<0.001.

Experiment B

The higher mass loss in the frames in Methven (Table 42) shows the importance of the larger fauna. The turnover time for the frames was only 10% less than that for the coarse mesh and suggest that the coarse mesh bags have only a mild retarding effect on litter decomposition.

Experiment C

The patterns of mass loss were more site than substrate related (Fig. 24). Microclimate, especially moisture, influences decomposition rates (Witkamp & Olson 1963; Witkamp 1963; Staaf 1988; Anderson *et al* 1983; Luizâo & Schubart 1987; Jansson & Berg 1985; Meentemeyer 1978). Faster loss rates from bags in Gartfairn compared with Methven (Table 39) could be attributed to the drier conditions at Methven (see Fig. 1 chapter 2). Low temperatures reduce mass loss (Upadhyay *et al* 1989; Witkamp & van der Drift 1961; Williams & Gray 1974). During the study period (December 1988 to November 1989) in Methven the mean temperature was slightly lower (only by 0.62 °C) than in the two other sites but wider differences for mean minimum and absolute minimum (4.5 and -7.0 °C respectively for Methven compared with 5.4 and -4.1 °C for the other two sites which are similar climatically) could possibly impose a retarding effect on decomposition in Methven during the winter (see also Fig. 2. Chapter 2). However Daubenmire & Prusso (1963) in laboratory work found that loss rate was more effected by substrate quality than temperature.

Among the edaphic factors, only pH of the top soil was correlated with loss rates (See Chapter 2). Positive trends between soil pH and mass loss have been reported elsewhere (Moore 1981; Day 1982). Using the data for experiment A (which the best replicated) there were significant negative correlations in fine mesh between pH and loss rates for all sample dates (Table 46) while in the coarse mesh the correlations were significant at the first sampling (negatively) and the fourth (positively). This picture is possibly linked to the pH dependence of the different decomposers present in the soil (Wit-kamp & Drift 1961). Wetter soils in Gartfairn (which kept the litter moist when it might have been dry elsewhere) could be a reason for faster decomposition in this site.

The chemical composition of the substrate influences decomposition (Williams & Gray 1974; Meentemeyer & Berg 1986; Upadhyay *et al* 1989; Stohlgren 1988a) especially in the initial stages (Anderson 1973; Singh & Gupta 1977). When the percentage of the remaining weight in the coarse mesh was correlated with initial element weight (Table 47) all the correlations were highly significant (except for phosphorus and sodium) for the first sampling (after 125-137 days). The simultaneous contribution of different elements in the correlation gave higher correlation coefficients which were highly significant for all the sampling occasions. Higher concentrations of basic elements (Na, Ca and Mg) in initial leaves From Gartfairn

Table 45. Annual loss (%) from oak and beech leaves in a range of studies: K, estimated from turnover rate; W, wire net containers; B, litter bags; T, tethered leaves; CB, coarse mesh and FB, fine mesh.

Leaves	Places		Loss %	Author(s)
Oak forests	Missouri	USA	35K	Rochow (1974)
Mixed oak forests	New Jersey	"	68K	Lang (1974)
Quercus alba	Tennessee	"	55B	Witkamp (1966)
Quercus sp.	Tennessee	"	32-51B	Kelly & Beauchamp (1987)+
White oak	Brookhaven	"	66T	Woodwell & Marple (1968)
"	New Jersey	"	69T	Lang (1973)*
Quercus harvardii	New Mexico	"	23B	Elkins *et al* (1982)
Quercus alba	Wisconsin	"	40-45B	McClaugherty *et al* (1985)
Quercus alba	Eastern United States		39B	Shanks & Olson (1961)
Quercus alba	"		46B	Witkamp & Olson (1963)
Oak leaves	Rothamsted	England	109B	Edwards & Heath (1963)
Quercus robur	"	"	87.6B	Heath *et al* (1966)
Quercus petraea	Roudsea Wood	"	44-51W	Bocock & Gilbert (1957)*
Quercus robur	"	"	34W	
Quercus robur		USSR	33-35B	Zlotin *
Quercus robur		Poland	36.5B	Dziadowiec (1987)
Different oak species	Central Himalaya	India	95-100B	Upadhyay *et al* (1989)x
"	"	"	55-100	Singh & Singh (1987)?
Beech	Rothamsted	England	84B	Edwards & Heath (1963)
Fagus sylvatica	"	"	66B	Heath *et al* (1966)
Fagus sylvatica	Kent	"	16-22B	Anderson (1973)
Oak leaves	Ross	Scotland	51CB	Present study
	"	"	50FB	
"	Gartfairn	"	67CB	"
"	"	"	46FB	"
"	Methven	"	59CB	"
"	"	"	38FB	"

*; Cited in Singh & Gupta (1977) and converted from daily loss. +; Measured from graph at the end of the first year. x; Calculated from their regression equation. ?; reported from different authors and method not described.

Table 46. Correlation coefficients and significance levels (SL) (***, P<0.001; **, P<0.01; *, P<0.05 and NS, not significant) of percentage mass loss in coarse mesh and fine mesh on four sampling occasions with soil (top 10 cm) pH_{H2O} (measured on one occasion) in the three sites (n=9).

Sampling	Coarse	SL	fine	SL
1	-0.39	**	-0.55	**
2	-0.15	NS	-0.54	**
3	-0.15	NS	-0.68	***
4	+0.39	***	-0.47	*

(Fig. 24) could probably have enhanced decomposition as a greater available source of supply for decomposers' requirements and also by reducing acidity.

Nutrient dynamics

It is reported that nutrient dynamics in decomposing litter species may show three sequential stages: (1) initial release due to leaching; (2) net immobilisation in which nutrient elements are imported into the residual material through microbial activities; and (3) a net release with absolute decrease in nutrient mass (Gosz *et al* 1973; Staaf & Berg, 1982). In this study these three sequential stages were observed for phosphorus, calcium but not for potassium, sodium, magnesium and nitrogen (Figs. 22). The nutrient data for experiment B (Fig 23) and Experiment C (Fig 24) are from less well replicated samples. They are in broad agreement with those for experiment A.

Table 47. Correlation coefficient (r) and significance levels (***, P<0.001; **, P<0.01; *, P<0.05 and NS, not significant) between percentage remaining leaf weight (y) and initial nutrient and ash mass (x) (y=a+bx), in coarse mesh in the three sites (n=9), after time period (days) elapsed.

Nutrient and/or ash	Days elapsed			
	127-137	206-210	273-276	364-367
N	0.35 **	0.28 *	0.03 NS	0.28 *
P	-0.19 NS	-0.32 **	-0.28 *	-0.42 ***
K	0.49 ***	0.08 NS	0.25 *	-0.07 NS
Na	0.19 NS	-0.33 **	-0.58 ***	-0.31 *
Ca	0.43 ***	-0.03 NS	-0.13 NS	-0.05 NS
Mg	0.32 **	0.13 NS	0.13 NS	-0.11 NS
Ash	0.50 ***	0.14 NS	0.22 *	-0.12 NS
<u>N, P & K</u>	0.61 ***	0.52 ***	0.43 ***	0.46 **
<u>N, P & Ca</u>	0.60 ***	0.53 ***	0.34 *	0.44 **
<u>N, P & ash</u>	0.61 ***	0.52 ***	0.43 **	0.46 **
<u>N, P, K & Ca</u>	0.62 ***	0.53 ***	0.47 **	0.47 **
<u>All the elements and ash</u>	0.67 ***	0.68 ***	0.71 ***	0.52 *

Underlining indicates linear multiple regression

Nitrogen and phosphorus dynamics

A general pattern in decomposing litter, of an early immobilisation followed by net release of nitrogen and phosphorus, for temperate and boreal forests has been suggested by Vitousek & Sanford (1985) (cit. Upadhyay & Singh 1989). This pattern is followed for nitrogen in Gartfairn and Methven but in no other case. Nitrogen and phosphorus have been reported to accumulate (Bocock 1963; Gilbert & Bocock 1960; Gosz *et al* 1973; Staaf & Berg 1982; Stohlgren 1988b; Day 1982; Anderson *et al* 1983; Rapp & Leornardi 1988; Kelly & Beauchamp 1987; O'Connell 1988) and sometimes diminish (Attiwill 1968; Kelly & Henderson 1978; Lousier & Parkinson 1978; Reiners & Reiners 1970;

Gloaguen & Touffet 1980; Cameron & Spencer 1989). In some other studies (Schlesinger & Hasey 1981; Schlesinger 1985) nitrogen showed an increase while phosphorus had an initial release but was variable later. In my study, nitrogen was initially immobilized and later (except for Ross) started to be released while phosphorus had an initial release and later was variable and frequently accumulated. Similar patterns for nitrogen and phosphorus were seen by Dziadowiec 1987; Staaf 1988; DeCatanzaro & Kimmins 1985.

The critical ratio of C:element, the point of balance at which immobilization of elements in decomposing material changes to mineralization, is a response to the ratio of C:element in the body of different decomposers and their ratio of production to assimilation (Staaf & Berg 1982). The substrates with higher initial C:element ratios have shown longer nutrient immobilization and slower release from the litter (Upadhyay & Singh 1989). In the present study I obtained an indication of critical C : element ratios from observing the breaks in the curves in Fig. 22. In Ross with an initial C:N ratio of 57:1 (Table 48) the initial amount of N was retained until the end of the study while in Gartfairn (C:N, 44:1) and Methven (C:N, 39:1) an accumulation occurred up to the first sampling (127-137 days) and then net mineralization started. This suggests that nitrogen, which was higher in the leaves from Gartfairn and Methven, was still limiting there. The critical C:N ratio in Gartfairn and Methven

(Table 48) falls into the range of 25-30:1 suggested by Anderson (1981), and is consistent with Dziadowiec (1987). However this range is not fixed (Berg & Ekbohm 1983) and ranges of 15:1 to 109:1 have been reported (Upadhyay & Singh, 1989; Berg & Ekbohm 1983). The ratios of P:N at the critical C:N point reported by Upadhyay & Singh (1989), ranged from 4.38 to 16.30 for different species in Himalaya. These P:N ranges were lower than my study (Table 48), and in contrast to their study I found consistently a rise in P:N ratio until a critical C:N point but later (during the net release of nitrogen) the situation was similar to that observed by them in that P:N ratio did not show a consistent trend with C:N pattern.

Upadhyay & Singh (1989) found net phosphorus immobilization at initial C:P ratios ranging from 171:1 to 683:1 for some of the species while for some other species this range was irrelevant since an initial leaching of phosphorus was dominant. These were species with a thin cuticle and less leaf sclerenchyma. In my study the initial C:P ratio ranged from 813:1 for Ross to 428:1 for Gartfairn and initial leaching in all the cases was dominant. Phosphorus accumulated in fine mesh at the end of the study in all the sites and in the coarse mesh in Ross (Fig. 22) which again suggests that the decomposition for both containers in Ross, as well as fine mesh in Gartfairn and Methven, is governed by similar mechanisms and probably rather by micro organisms than mesofauna or macrofauna. Day (1982) found a slower rate of phosphorus loss from leaves in soils with a lower pH which is also supported by Figs 3 and 22b. The critical C:P ratios for coarse mesh in Gartfairn is 424:1 and Methven 527:1 (Table 48) which are not different from their corresponding initial C:P, supporting the hypothesis that initial phosphorus levels are not limiting decomposition. The possible sources for external phosphorus inputs during the later accumulation are plant reproductive materials (Lousier & Parkinson 1976) and leaching from the canopy (Carlisle *et al* 1966b, 1967). Carlisle *et al* (1966a) reported 40.2 % of phosphorus in litterfall is added to the forest floor by non-leafy materials such as male flowers, bud scales, and insect frass.

Potassium is well known as the most leachable cation with a rapid initial loss (eg. Weber 1987; Rapp & Leornardi 1988; Stohlgren 1988b). Two phases have been reported for loss of this element; a fast initial loss being linked with rapidly decomposable components of the litter, followed by a slow release which is governed by refractory components (Moore 1984; Schlesinger 1985; Staaf & Berg 1982; Lousier & Parkinson 1976; Weber 1987). Some potassium immobilization by hetrotrophic micro-organisms may occur after an initial leaching (DeCatanzaro & Kimmins 1985; Lousier & Parkinson 1978; Gosz *et al* 1973; Cameron & Spencer 1989) and this appears to have happened in some of the cases in my study (Figs. 22c-24c). The relatively low initial C:K ratio (cf. its critical value) (Table 48) suggests that the potassium concentration in the fresh litter is far above micro-organism requirements (see also Gosz *et al* 1972, 1973). Sources for the later enrichment of nutrients in the litter bags could be throughfall from fresh litter and the canopy.

Table 48. Initial and critical C:nutrient and nutrient ratios in decomposing leaves in coarse (5-mm) and fine (64 μ) mesh.

	Ross		Gartfairn		Methven	
	Coarse	Fine	Coarse	Fine	Coarse	Fine
Initial						
C:N	56.8		43.6		38.9	
N:P	11.5		10.1		12.9	
Critical						
C:N	___	___	28.8	25.7	30.4	29.5
N:P	___	___	14.7	15.0	25.4	20.2
Initial						
C:P	813		428		527	
P:Ca	0.079		0.114		0.088	
Critical						
C:P	___	___	424	___	521	___
Initial						
C:K	151		132		79.2	
Critical						
C:K	___	___	234	___	226	___
Initial						
C:Na	1172		888		1115	
Critical						
C:Na	1008	1065	694	671	984	875
Initial						
C:Ca	51.3		49.3		43.7	
Critical						
C:Ca	43.3	___	39.5	36.5	36.9	35.8
Initial						
C:Mg	313		210		212	
Critical						
C:Mg	262	251	193	173	___	212

Sodium is not an essential nutrient for most higher plants but occurs in higher concentrations in fungal tissues than the litter they decompose (Cromack *et al* 1975 cit. Anderson *et al* 1983). The pattern of sodium gains and losses is known to vary (Likens *et al* 1967). Sodium usually showed erratic losses in this study (Figs. 22d-24d). However in some cases an initial or a secondary immobilization was noticed which indicated that the initial amount of this element (Table 48) was below the requirement of decomposers.

Calcium was released more slowly than the other cations. A possible reason for this is that the refractory calcium pectinates of the lamellae between the cell walls (Kirkby & Pilbeam 1984) which are not released until the cell walls disintegrate (Schlesinger 1985; Dziadowiec 1987). The variation in the pattern of calcium release observed in this study (Figs 22e-24e) has been reported elsewhere (Weber 1987; DeCatanzaro & Kimmins 1985). Initial and critical C:Ca ratios indicated that the initial amount of this element in all the sites was below the fungal demands. Preferential accumulation of this element in fungal hyphae is needed for carbohydrate metabolism (Cromack & Monk 1975 cit. Upadhyay & Singh 1989). Translocation from the forest floor through the fungal hyphae (Upadhyay & Singh 1989) and also the retention of calcium added through precipitation, foliar leaching, non-leafy litterfall (Carlisle *et al* 1966 a, b), airborne particles (White & Turner 1970; Lovett & Lindberg 1984) are potential sources of calcium. The pattern of release of calcium in this study, was site specific (Figs 22e-24e), and in that respect resembles Weber (1987).

The pattern of magnesium release has been reported to exhibit variations and in some cases to accumulate (Weber 1987) while in others it is dominated by leaching and disappears in a similar pattern to mass loss (Decatanzaro & Kimmins 1985; Cameron & Spencer 1989; Gloaguen & Touffet 1980). In my study the latter situation prevailed (Figs 22f-24f). However in some cases there was some retention which indicated that the initial magnesium is less than the possible requirements of biological activity in the litter (Table 48).

Ash was lost almost parallel to weight loss but in some cases the loss was slower than mass release which reflects either retention or accumulation of some of the elements in process of decomposition.

Most of the nutrients were released faster from coarse mesh than from fine mesh which is possibly due to the effect of mesofauna and macrofauna (Anderson & Ineson 1983).

CONCLUSIONS

1. The production of litter by three contrasting Scottish Oak woods (at Ross, Gartfairn and Methven) falls within the ranges reported elsewhere for temperate broad-leaved woodland.

2. Soil analyses, when expressed on a volume basis, showed that the podzolic soil (at Ross) is poorest in nutrients, and the brown earth (at Methven) the richest in nutrients except nitrogen, which is highest in the gleyed soil (at Gartfairn). Although not measured, the percentage base saturation is likely to be least in Ross and highest in Methven.

3. The litter production was in the same rank order as the site soil phosphorus and the total exchangeable bases (per unit volume) and this order was similar to that for estimated above-ground biomass for the three sites.

4. The Oaks in the nutrient poor soil (at Ross) were more nutrient efficient in terms of litter dry mass per unit nutrient than those at the other sites.

5. The turnover times of litterfall and the individual nutrients calculated from k_L were within the ranges reported from elsewhere for temperate broad-leaved woodland. They were fastest at Gartfairn where higher soil moisture, and also a higher proportion of birch leaves in the litter, may have enhanced the decomposition rate.

6 The results of a litter bag study of the decomposition of weighed leaves were complex. Where soil animals were permitted to reach the leaves, through a mesh size of 5mm or in an open frame, then disappearance of the leaves was faster than a mesh size of 64µ at Gartfairn and Methven. At Ross, the rate of decomposition was similar in both mesh sizes and this reflects the paucity of soil animals in the podzolic soils there. The rank order of decomposition rate in 5-mm meshes at the sites was similar to that calculated for k_L values (Gartfairn> Methven> Ross).

7 This study has given an insight into some aspects of production and nutrient cycling in Scottish Oak woods. Much more work is required before a complete picture can emerge however.

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APPENDICES

APPENDIX 1

Appendix 1A

Profile description for soil pits in Ross (No. 1b, 2a, 2b, 3a 3b and 3c), Gartfairn (No. 5 and 6), and Methven woods (No. 7-8). The terminology used is followed Hodgson (1976).

Profile No : 1b
Location : plot 1 (down the slope), Ross wood.
Altitude : 19 m. Slope : 11°. Aspect : S.SW.
Soil type : podzol.
Horizons

L few mm	Leaves complete on the top with some broken down underneath.
F&H 1-10	Dark reddish brown (5YR 2.5/2). No stones. woody and fibrous root sized (1 to 3), abundance (4)
H 10-13 cm	Black colour (2.5YR 2.5/0) as evidence of high iron content. Mor humus to slightly peaty and clay loam texture with no stones. Root size (1 to 3), abundance (3) and woody or fibrous
Ea 13-16 cm	Pinkish grey (7.5YR 6/2) sandy loam, stone size and abundance (1 to 2) and (1) respectively. Root size(1 to 3), abundance (2) woody and fibrous. Leached of iron and humus.
Bh 16-70 cm	Strong brown (7.5YR 5/8) with higher content of iron and aluminium, loamy sand texture and stone size and abundance of (1 to 3) and (1) respectively. Root size is (1 to 3) and abundance is (1).
C 70 cm	Olive (5Y 5/3). Sandy with glacial boulders.

Appendix 1A continued

Profile No : 2a
Location :Plot 2 (Top of slope), Ross wood.
Altitude : 83 m. Slope : 15°. Aspect : East.
Soil type : Podzolic
Horizons

L	A thin layer of almost oak leaf litter.
F&H 0-9 cm	Black colour (10YR 2.5/1), mor humus, stoneless with woody and fibrous roots sized (1 to 4) and abundance (4).
H 9-10 cm	Black (7.5YR 2.5/0). Poorly seen, very rich inorganic matter, stoneless, with roots same as the above layer.
Ea 10-14 cm	White colour (10YR 8/1), leached from iron and sandy clay loam texture. Stone size and abundance are (1 to 2) and (1) respectively. Root size (1 to 3), abundance (3) and woody with few fibrous.
Bh 13-15 cm	Eluvial very dark grey (2.5Y 3/0). Stones and roots almost same as the above layer.
BC 15-48 cm	Yellow colour (10YR 7/6). Sandy loam texture which is more gleyed on the lower parts. Rich of iron which due to water fluctuations is more oxidized toward the top causing darker colour. Root size (1 to 3), abundance (1) and woody or fibrous nature. Stones are sized (1 to 3) with abundance of (2).

Appendix 1A continued

Profile No : 2b
Location : Plot 2 (down the slope), Ross wood.
Altitude : 79 m. Slope : 15°. Aspect : East.
Soil type : Acid brown forest soil.

Horizons

L	A thin layer of oak dead leaves.
F&H 0-10 cm	Black (2.5Y 2.5/0), sandy loam texture and without stones. Root size (1 to 4), abundance (4), woody and fibrous.
Ea 10-11 cm	Very pale brown (10YR 7/3), sandy clay loam with root size and abundance same as the above layer. Stone are sized (1 to 2) with abundance of (1).
Bh 11-55 cm	Yellowish red (5YR 5/8). Fluctuations of water have caused fairly uniform colour with high iron content reducing on lower parts causing slightly changes. Sandy loam texture, stone size (1 to 3), abundance of (2) and root size of (1 to 4) with abundance of (2).
55 cm	Rock.

Profile No : 3a
Location : Plot 3 (top of slope), Ross wood.
Altitude : 58 m. Slope : 8°. Aspect : N.NW.
Soil type : Podzolic.
Horizons

L	very thin layer of dead oak leaves
F&H 0-9 cm	Black colour (5YR 2.5/1), slightly peaty and sandy silt loam texture. Without stone, with root size (1 to 4), abundance (4), woody or fibrous.
Ea 9-13 cm	Light grey (5YR 7/1), sandy loam,stone size (1 to 3) and abundance of (2). Root size (1 to 4), abundance (3), woody with some fibrous.
Bh 13-45 cm	Light brown (7.5YR 6/4), enriched of eluvial iron transferred from B1, sandy loam texture with stone size and abundance of (1 to 3) and (3) respectively. Root size and abundance are (1 to 4) and (2 to 3) respectively.
C 45 cm	Pinkish grey (5YR 7/2), sandy loam impeded by rocks.

Appendix 1A continued

Profile No : 3b
Location : Plot 3 (down the slope), Ross wood.
Altitude : 56 m. Slope : 8°. Aspect : N.NW.
Soil type : Podzolic
Horizons

L	Thin layer of oak leaves.
F&H 0-10 cm	Black (5YR 2.5/1), sandy silt loam texture, without stone. Root size and abundance are (1 to 4) and (4) respectively and have nature of woody and fibrous.
Ea 10-17 cm	White (5YR 8/1), leached of iron and clay and sandy loam texture with stone size and abundance of(1 to 2) and (1) respectively. Root size and abundance are (1 to 4) and (4) respectively, woody and few fibrous.
Bh 17-55 cm	Reddish brown (5YR 4/4),indicating enriched of eluvial iron,sandy loam texture. Stone size and abundance are (1 to 3) and (1). Root size and abundance are (1 to 4) and (3) woody.
C 55 cm	Brown to dark brown colour (7.5YR 4/4), very rich in eluvial iron caused by water movements from both upper layer and higher altitudes. Sandy loam texture and impeded with rocks.

Profile No : 3c

Location : plot 3 (down the slope near a hollow), Ross.
Altitude : 55 m. Slope : 2°. Aspect : N.NW.
Soil type : Peat.
Horizons

F&O 0-35 cm	Black colour (2.5YR 2.5/0), peat.
Omh	Very dark grey (2.5YR 3/0), peat mixed with mineral with sand loam texture. Only in May and June this pit was dry of water.

Appendix 1A continued

Profile No : 5
Location : Plot 5, Gartfairn wood
Altitude : 10.5 m.   Slope : 0-1°.   Aspect : West.
Soil type : Peaty.
Horizons

L	Thin layer of dead (oak and some birch) leaves.
F&H 0-2 cm	Black (5YR 2.5/1), fibrous texture and without stones. Roots are woody, fibrous and fleshy with size and abundance of (1 to 3) and(2) respec tively.
O 2-10 cm	Black (2.5YR 2.5), peat with a sandy loam texture and without stone. Roots are woody, fibrous and fleshy with size and abundance of (1 to 3) and (2) respectively.
Ah 10-17 cm	Dark brown (7.5YR 4/2), sandy loam texture. Stones are almost schist with some other metamorphic rounded shape with size and abundance of (1 to 2) and (1) respectively. Root are woody and fibrous with size and abundance of (1 to 3) and (2) respectively.
Eb(g) 17-38 cm	Dark brown (7.5YR 4/4) with patches of strong brown (7.5YR 5/6) sandy texture with round and sub-rounded schist stones with size of(1 to 2) and abundance of(2). Root size and abundance of (1 to 3) and (2) respectively.
Cg 38-110 cm	Greyish brown (10YR 5/2), fine sand texture with rounded schist stones which sized (1 to 3) with abundance of (3). Roots woody with few fibrous, sized (1 to 4) with abundance of (1). Dead roots of about 2cm diameter were found at about one meter dept.

Appendix 1A continued

Profile No : 6
Location : Plot 6, Gartfairn wood
Altitude : 9.5 m. Slope : 0°
Soil type : peaty
Horizons

L	Very thin layer of dead, oak with some birch, leaves. Waste materials same as in plot 4 have been flooded on lower part of the this plot.
F&H 0-10 cm	Reddish black colour (10R 2.5/1), sandy loam and without stone. Roots sized (1 to 2) with abundance of (1).
Ah 10-35 cm	Dark brown colour (7.5R 3/2), sand texture without stone. Root size and abundance are (1 to 3) and (2) respectively.
Cg 35-110 cm	Dark reddish brown (5YR 3/4), sand, without stones. Roots sized (1 to 3) with abundance of (2) are seen down to 55 cm.

Profile No : 7
Location : Plot No 7, Methven wood.
Altitude : 80 m. Slope : 7°. Aspect : W.SW.
Soil type : Brown forest soil
Horizons

L	There were some scattered leaves on the surface
Ah 0-10 cm	Brown to dark brown (7.5YR 4/2), texture (clay loam) and other specifications are the same as in profiles (8 and 9) except that burrower are more active.
Bt 10-51 cm	Reddish brown (5YR 4/4), almost the same as in profiles (8 and 9).
Cgf 51-105 cm	Weak red (2.5YR 4/2) with other specifications same as the following profiles.

Appendix 1A continued

Profile No : 8
Location : Plot No 8, Methven wood.
Altitude : 83.7 m. Slope : 9°. Aspect : S.W.
Soil type : Brown forest soil.
Horizons

L	leave were not seen just on the edge of the profile but they were scattered elsewhere.
Ah 0-13 cm	Brown to dark brown colour (7.5YR 4/2), clay loam texture, with rounded and sub-rounded stones sized (1 to 5) with abundance of (1). Roots are woody, fibrous and fleshy sized (1 to 4) with abundance of (2). Earth worm activities (casts) are common. Rabbits and hare activities as well through which the dead organic material and the top soil is mixed with the lower horizon are less than in the other two plots (7 and 9) in Methven
Bs 13-55 cm	Reddish brown (5YR 4/4). Stone and roots are almost the same as the above layer. Burrows filled with surface materials and earth worm casts can be recognised.
Cgf 55-100 cm	Weak red (2.5YR 4/2), clay loam of glacial till origin.

Appendix 1B

Tables 4.2, 4.3 & 4.5-4.8. Analytical data (pH, loss-on-ignition, exchangeable cations and total nitrogen and phosphorus) for corresponding profiles. Values are means (± S.E.) (n=3) and expressed on an oven dry (85 °C) basis where appropriate.

Table 4.2. Soil analytical data for profile No 2a.

Horizon	F&H	Ea&Bh	BC
Dept (cm)	2-9	10-15	30-40
pH in water	2.88±0.02	3.72±0.08	4.29±0.01
pH in CaCl2	ND	ND	ND
L.O.I %	81.9±6.74	9.54±3.57	1.13±0.04
Extractable cation (m-equiv/Kg)			
K	13.9±2.43	1.26±0.28	0.35±0.07
Na	5.50 1.17	2.11 0.16	2.26 0.35
Ca	53.6 14.9	1.51 0.05	0.96 0.09
Mg	46.8 7.24	1.11 0.43	0.22 0.05
Total (mg g^{-1})			
N	21.1±0.51	1.28±0.72	0.00±0.00
P	0.82 0.06	0.36 0.03	0.15 0.02

Table 4.3. Soil analytical data for profile No 3b.

Horizon	F&H	Ea	Bh
Dept (cm)	1-9	10-17	30-40
pH in water	2.97±0.07	3.99±0.07	4.36±0.05
pH in CaCl2	ND	ND	ND
L.O.I %	82.2±3.52	7.15±0.44	3.71±0.26
Extractable cation (m-equiv/Kg)			
K	16.2±2.73	1.33±0.19	0.47±0.07
Na	3.79 0.40	1.14 0.08	0.52 0.03
Ca	50.5 1.42	0.74 0.06	0.28 0.04
Mg	42.1 3.55	0.64 0.06	0.17 0.00
Total (mg g^{-1})			
N	20.3±0.50	0.69±0.13	0.37±0.22
P	0.79 0.06	0.30 0.02	0.24 0.00

Appendix 1B. Continued.

Table 4.5. Soil analytical data for profile No 5.

Horizon	O	Ah	Eb(g)	Cg
Dept (cm)	3-9	11-17	20-30	40-50
pH in water	4.05±0.02	3.87±0.00	4.36±0.05	4.55±0.05
pH in CaCl2	3.27 0.01	3.34 0.01	4.03 0.03	4.26 0.01
L.O.I %	64.6±4.23	7.08±0.42	1.19±0.09	0.71±0.05T
Extractable cation (m-equiv/Kg)				
K	4.0±0.72	0.70±0.05	0.20±0.02	0.19±0.02T
Na	6.49 0.81	1.58 0.33	0.70 0.17	0.73 0.28T
Ca	15.8 3.91	2.61 0.38	0.98 0.14	0.99 0.04T
Mg	31.0 3.47	2.36 0.30	0.35 0.00	0.26 0.08T
Total (mg g^{-1})				
N	20.6±0.94	2.42±0.20	0.00±0.00	0.00 0.00T
P	1.56 0.03	0.43 0.07	0.12 0.00	0.08 0.02T

T=Two samples

Table 4.6. Soil analytical data for profile No 6.

Horizon	F&H	Ah	Cg
Dept (cm)	2-9	15-25	45-50
pH in water	4.14±0.02	4.75±0.08	4.60±0.02
pH in CaCl2	3.67 0.01	4.12 0.02	4.38 0.01
L.O.I %	19.1±2.34	3.73±0.70	1.88±0.16
Extractable cation (m-equiv/Kg)			
K	3.74±0.41	0.60±0.09	0.33±0.02
Na	2.25 0.42	1.19 0.19	0.96 0.12
Ca	19.0 2.65	4.32 0.62	1.17 0.14
Mg	6.62 0.89	1.07 0.06	0.34 0.00
Total (mg g^{-1})			
N	7.65±1.23	0.42±0.36	0.00±0.00
P	1.13 0.15	0.20 0.06	0.20 0.01

Appendix 1B. Continued.

Table 4.7. Soil analytical data for profile No 7.

Horizon	Ah	Bt	Cgf
Dept (cm)	2-8	30-40	55-65
pH in water	4.61±0.12	4.39±0.04	4.87±0.07
pH in CaCl2	4.16 0.11	4.15 0.01	4.14 0.08
L.O.I %	9.95±0.37	4.37±0.37	1.62±0.04
Extractable cation (m-equiv/Kg)			
K	8.83±1.14	1.65±0.02	1.55±0.10
Na	1.29 0.11	1.07 0.08	1.84 0.18
Ca	22.3 8.69	2.24 0.46	27.7 6.72
Mg	7.66 1.61	1.27 0.35	22.6 5.31
Total (mg g^{-1})			
N	2.83±0.07	0.41±0.20	0.00 0.00
P	0.70 0.04	0.47 0.05	0.48 0.07

Table 4.8. Soil analytical data for profile No 8.

Horizon	Ah	Bs	Cgf
Dept (cm)	2-10	30-40	55-65
pH in water	4.51±0.06	4.57±0.06	4.91±0.05
pH in CaCl2	4.01 0.04	4.06 0.02	4.12 0.05
L.O.I %	7.87±0.58	3.98±0.33	1.75±0.11
Extractable cation (m-equiv/Kg)			
K	5.27±1.26	1.81±0.37	1.57±0.08
Na	1.54 0.06	1.53 0.19	2.04 0.16
Ca	19.2 5.68	4.57 0.87	23.4 4.14
Mg	10.0 1.94	3.74 1.06	22.2 2.60
Total (mg g^{-1})			
N	2.11±0.11	0.00±0.00	0.00±0.00
P	0.69 0.03	0.49 0.03	0.54 0.05

Appendix 1C

Soil element concentration (ppm) for total N and P (0.5 g sample digested in acid and made up to 75 ml),exchangeable K, Na, Mg and Ca (5g leached with ammonium acetate and made up to 100 ml). Loss-on-ignition 'LOI' (% at 375 °C) and pH in water and Cl^2Ca suspension (chapter 2).

Part 1. Surface soil.

Plot 1

N	P	K	Na	Mg	Ca	LOI	pH W	pH Cl^2Ca
123.4	6.7	40.0	9.2	50.0	73.0	94.2	2.9	
89.0	7.5	30.0	6.2	29.0	50.1	66.4	2.9	
104.7	6.7	34.0	6.8	40.0	53.1	90.5	2.9	
91.5	5.5	32.0	8.2	32.0	51.0	77.1	3.1	
97.4	7.5	33.0	9.2	35.0	61.0	92.0	2.9	
116.5	5.9	30.0	8.6	39.0	70.0	89.2	2.8	
118.2	7.4	32.0	15.4	40.0	85.0	93.0	2.9	
85.6	4.8	25.0	6.9	24.0	57.0	52.0	2.9	
90.6	5.6	34.0	8.3	33.0	116.0	94.1	2.8	

Plot 2

81.8	5.7	19.7	5.4	15.0	46.4	53.1	3.0
11.7	6.7	29.0	7.0	30.0	38.6	84.8	2.9
57.9	4.3	13.5	4.2	12.0	35.0	39.4	3.1
115.8	6.6	32.0	6.3	30.0	81.0	93.9	3.0
124.2	5.0	52.0	9.9	29.0	77.0	83.3	3.1
64.5	4.8	17.7	4.9	16.0	30.7	42.4	3.0
79.5	5.3	30.0	8.5	13.0	33.5	46.2	3.0
72.9	5.7	12.2	3.8	9.0	26.4	43.5	3.2
68.0	5.0	12.9	2.8	11.0	22.6	45.4	2.9

Plot 3

40.9	2.1	12.7	3.8	11.0	18.9	33.5	3.1
66.9	2.5	14.8	3.1	18.0	29.0	40.2	2.9
49.5	2.1	9.1	2.4	12.0	18.1	32.8	2.9
110.2	4.5	31.0	4.9	23.0	42.6	92.5	3.0
49.5	2.4	13.3	2.1	15.0	27.4	50.9	3.1
98.2	3.5	17.6	3.9	19.0	27.4	61.2	2.9
79.8	3.0	15.6	3.4	20.0	21.6	58.0	2.9
114.5	4.5	22.0	5.6	27.0	36.1	93.8	2.9
101.9	3.8	28.0	5.8	22.0	32.7	86.4	2.9

Appendix 1C. part 1 continued.

N	P	K	Na	Mg	Ca	LOI	pH W.	PH Cl^2Ca
Plot 4								
34.9	4.7	6.3	2.4	4.1	7.1	17.6	4.0	3.5
51.2	7.9	7.3	3.0	6.4	16.4	24.0	4.1	3.7
31.9	5.0	8.2	3.3	6.6	12.6	17.0	4.0	3.5
48.2	4.5	6.6	2.7	4.2	8.3	14.6	4.1	3.6
38.5	5.7	10.8	2.5	8.0	27.0	20.4	4.1	3.7
36.2	4.9	6.7	3.2	8.0	42.8	16.4	4.3	3.9
60.4	5.7	6.7	3.2	4.6	4.7	23.7	3.8	3.4
48.5	5.9	6.2	2.9	3.9	7.0	20.2	4.0	3.5
65.1	6.1	8.4	2.8	7.0	17.9	31.3	3.8	3.3
Plot 5								
58.1	5.3	6.7	6.0	7.0	16.1	26.3	3.8	3.4
51.8	5.1	8.7	2.7	7.0	16.6	24.1	3.9	3.3
75.9	6.8	3.9	10.8	8.0	16.7	55.2	5.0	4.7
69.8	7.5	9.3	6.2	15.0	36.3	27.8	4.1	3.7
32.0	4.5	6.1	4.6	13.0	9.5	20.8	4.0	3.5
25.5	3.8	3.5	9.5	6.0	61.0	12.0	4.7	4.4
43.1	7.5	5.1	6.5	9.0	87.0	20.3	4.7	4.3
15.4	3.5	3.1	1.5	7.0	20.9	8.0	4.7	4.1
40.1	6.0	19.3	3.8	8.0	11.4	17.5	4.3	3.7
Plot 6								
95.9	13.5	6.0	3.0	5.3	29.8	32.6	4.8	4.1
35.8	5.0	6.3	1.4	3.7	10.6	16.6	4.1	3.5
115.9	14.8	19.7	6.2	10.6	61.0	58.5	4.1	3.7
50.9	5.6	11.2	2.5	7.0	16.8	22.4	3.8	3.2
81.5	7.6	11.8	3.9	6.0	11.3	52.0	3.8	3.1
114.6	11.2	16.2	4.5	11.0	22.4	54.6	3.8	3.2
58.4	7.5	7.5	2.5	8.0	38.4	19.8	4.0	3.4
79.0	8.6	12.5	2.4	6.0	18.8	30.5	4.0	3.4
90.5	9.2	14.8	3.7	5.7	10.1	29.5	3.8	3.2
Plot 7								
16.7	5.0	20.7	1.8	5.6	29.4	9.7	4.8	4.3
22.8	5.5	12.0	1.9	2.9	16.9	11.3	4.3	3.9
28.3	8.8	18.9	1.4	6.8	48.5	14.7	4.7	4.2
20.1	4.9	14.4	0.8	3.2	13.8	9.9	4.5	4.0
25.8	5.8	13.0	1.6	3.0	7.4	15.2	4.3	3.8
20.4	4.9	11.8	1.3	4.4	19.1	10.0	4.7	4.1
20.4	4.1	16.3	1.3	9.0	68.0	10.4	5.1	4.6
18.7	4.4	9.5	1.5	6.0	25.5	8.8	4.6	4.1
33.6	5.9	12.1	1.6	6.0	22.3	17.7	4.2	3.8

Appendix 1C. part1 continued.

	N	P	K	Na	Mg	Ca	LOI	pH W.	PH $Cl^{2}Ca$
Plot 8									
	32.6	7.2	8.5	1.3	2.9	11.0	8.4	4.5	4.0
	14.4	6.0	13.0	1.4	7.0	47.1	8.8	4.9	4.4
	25.6	7.0	17.8	1.7	6.0	36.4	11.8	4.7	4.2
	16.7	6.6	16.7	1.7	4.5	26.2	11.3	4.6	4.1
	20.7	6.9	14.7	2.3	4.7	21.5	14.1	4.5	4.0
	14.4	6.6	8.1	1.3	3.7	10.9	8.4	4.5	3.9
	23.3	6.8	10.5	1.4	5.0	22.0	10.8	4.5	4.0
	12.1	5.4	11.3	1.3	5.4	15.4	6.7	4.5	3.9
	10.8	3.1	9.6	1.1	3.2	15.7	7.1	4.4	3.9
plot 9									
	27.3	7.3	8.9	2.2	3.6	7.5	13.7	4.3	3.8
	26.6	8.0	14.7	1.1	4.7	21.3	14.1	4.6	4.2
	29.5	7.3	11.2	1.4	2.8	8.1	12.7	4.4	3.9
	14.6	4.6	13.2	1.7	4.9	23.8	8.2	4.7	4.2
	10.8	5.1	10.4	1.1	1.9	6.2	10.9	4.4	4.0
	23.7	6.3	16.6	1.2	4.9	25.0	11.0	4.6	4.1
	17.1	4.3	6.7	1.4	2.8	8.7	8.7	4.3	3.8
	11.9	4.6	7.4	1.7	2.9	15.4	7.3	4.5	4.0
	18.6	3.8	12.0	1.1	3.6	14.8	11.2	4.4	3.9

Part 2). Soil profiles.

Depth (cm)	N	P	K	Na	Mg	Ca	LOI	pH W.	pH $Cl^{2}Ca$
Profile No 1a.									
A1	91.5	5.1	39.0	9.4	40.0	43.3	63.1	2.8	
2-10	70.5	5.0	35.0	9.4	26.0	18.1	85.0	2.9	
	46.4	5.1	11.4	6.6	13.0	10.5	30.0	2.9	
B1	16.2	3.1	1.9	3.3	1.6	0.9	14.1	3.3	
18-25	15.8	2.4	1.7	2.9	1.4	1.2	10.6	3.3	
	3.5	2.7	1.2	2.2	0.6	1.0	6.1	3.4	
B2	2.1	1.9	1.2	3.8	0.2	1.2	4.8	4.0	
30-40	1.5	1.9	1.3	2.2	0.2	0.8	6.2	4.0	
	1.5	1.8	1.4	2.5	0.2	0.8	4.5	4.1	
B3	0.0	1.9	0.4	2.5	0.1	0.7	1.0	4.6	
55-65	0.0	2.5	1.0	2.1	0.1	0.8	2.3	4.7	
	0.0	2.3	0.9	2.1	0.1	0.7	1.3	4.7	

Appendix 1C. part 2 continued.

	N	P	K	Na	Mg	Ca	LOI	pH W.	PH $Cl^{2}Ca$
Profile No. 2a.									
A1	115.9	4.1	15.7	3.2	17.0	20.6	68.7	2.9	
1-9	117.9	4.9	24.0	5.9	27.0	58.0	86.0	2.9	
	122.9	4.8	29.0	6.9	28.0	57.0	91.0	2.9	
B1&	16.2	2.6	3.1	2.6	1.1	1.5	16.1	3.6	
B2	6.9	2.0	2.5	2.2	0.5	1.4	8.8	3.8	
10-15	0.9	2.2	1.4	2.1	0.3	1.4	3.8	3.8	
B3	0.0	1.0	0.4	1.8	0.1	0.8	1.1	4.3	
30-40	0.0	0.7	0.9	2.6	0.2	0.9	1.1	4.3	
	0.0	1.2	0.7	3.2	0.1	1.1	1.2	4.3	
Profile No. 3b.									
A	111.5	3.8	17.8	3.0	25.0	41.5	78.2	2.8	
1-9	120.2	4.8	31.0	3.7	21.0	41.6	89.2	3.1	
	113.2	4.9	32.0	4.4	19.0	45.7	79.2	3.0	
B1	4.9	1.7	2.3	1.2	0.4	0.7	7.9	4.0	
10-17	5.4	1.7	1.9	1.4	0.3	0.6	6.4	4.1	
	2.7	2.1	3.1	1.1	0.4	0.8	7.1	3.9	
B2	2.2	1.5	1.1	0.6	0.1	0.3	4.2	4.3	
30-40	4.9	1.5	0.8	0.6	0.1	0.3	3.3	4.3	
	0.0	1.5	0.7	0.5	0.1	0.2	3.6	4.5	
Profile No. 4									
A	39.9	4.4	6.9	2.6	4.8	18.5	19.8	4.2	3.8
1-9	20.6	5.4	8.5	1.7	4.8	20.5	12.6	4.5	4.0
	33.9	6.1	9.5	2.1	4.3	19.0	16.0	4.2	3.7
B	6.0	2.1	2.5	1.9	1.4	7.7	4.0	4.7	4.2
12-20	1.7	3.4	1.5	1.5	0.7	4.0	2.2	4.8	4.3
	1.7	2.7	1.2	1.6	0.5	2.7	2.0	4.7	4.3
C	0.0	0.4	0.7	2.7	0.6	2.5	1.2	4.5	4.2
30-40	0.0	1.0	1.5	2.3	2.0	4.7	1.4	4.5	4.1
	0.0	0.5	0.6	1.8	0.6	2.2	1.3	4.5	4.2
C	0.0	0.3	1.3	1.9	1.2	3.4	1.1	4.7	4.2
40-50								4.8	4.3
								4.9	4.3

Appendix 1C. part 2 continued.

	N	P	K	Na	Mg	Ca	LOI	pH W.	PH Cl^2Ca
Profile No. 5									
A1	112.8	8.8	24.0	4.9	18.0	19.8	61.6	4.1	3.3
3-9	129.9	9.3	25.5	7.7	18.0	12.6	73.0	4.0	3.3
	116.4	9.0	22.0	6.9	13.0	8.7	59.3	4.0	3.3
B1	16.0	2.7	1.5	1.6	1.2	3.2	7.3	3.9	3.4
11-17	13.0	3.5	1.2	1.2	1.2	2.0	6.3	3.9	3.3
	17.1	1.9	1.2	2.4	1.7	2.3	7.7	3.9	3.3
B2	0.0	0.8	0.4	0.9	0.2	0.8	1.4	4.3	4.0
20-30	0.0	0.8	0.3	0.4	0.2	0.8	1.1	4.4	4.1
	0.0	0.8	0.4	1.0	0.2	1.2	1.1	4.4	4.1
C	0.0	0.4	0.4	0.5	0.2	1.0	0.8	4.6	4.3
40-50	0.0	0.7	0.3	1.1	0.1	0.9	0.7	4.5	4.2
Profile No. 6									
A	36.1	5.6	6.3	1.8	3.2	13.8	15.4	4.2	3.7
2-9	47.7	7.3	6.2	2.3	3.5	18.5	18.4	4.1	3.7
	61.9	8.8	8.4	3.3	4.8	22.1	23.4	4.1	3.7
B	7.2	2.0	1.4	1.7	0.7	5.3	5.1	4.9	4.1
15-25	0.8	1.1	1.2	1.3	0.6	4.0	3.1	4.6	4.1
	0.0	0.8	0.8	1.0	0.6	3.3	3.0	4.7	4.1
C	0.0	1.3	0.7	1.2	0.2	1.4	2.2	4.6	4.4
40-50	0.0	1.2	0.6	0.8	0.2	1.0	1.8	4.6	4.4
	0.0	1.3	0.6	1.2	0.2	1.0	1.7	4.6	4.4
Profile No. 7									
B1	17.4	4.7	19.7	1.4	4.9	28.4	9.6	4.7	4.2
2-8	17.4	4.0	16.7	1.2	5.7	30.3	10.7	4.7	4.3
	18.7	4.5	12.5	1.6	2.6	4.7	9.5	4.4	4.0
B2	3.9	2.7	3.0	1.3	0.7	2.3	4.7	4.4	4.1
30-40	3.9	2.6	3.1	1.0	0.4	1.3	4.8	4.3	4.2
	0.0	3.7	3.1	1.2	1.1	2.8	3.6	4.5	4.1
C	0.0	3.4	3.0	2.2	15.0	30.3	1.6	4.9	4.2
55-65	0.0	3.6	3.1	2.2	17.0	34.8	1.7	5.0	4.2
	0.0	2.2	2.5	1.6	7.0	13.8	1.6	4.7	4.0

Appendix 1C. part 2 continued.

	N	P	K	Na	Mg	Ca	LOI	pH W.	PH Cl^2Ca
Profile No. 8									
B1	15.1	4.4	7.5	1.6	5.0	11.6	7.5	4.4	3.9
2-10	13.1	4.8	7.6	1.8	8.0	28.9	9.0	4.6	4.1
	12.5	4.2	14.6	1.7	4.5	14.7	7.1	4.5	4.0
B2	0.0	3.4	3.0	2.1	3.1	4.6	4.0	4.6	4.1
30-40	0.0	2.8	2.5	1.6	2.5	5.8	3.4	4.6	4.1
	0.0	3.3	4.8	1.4	1.0	2.9	4.6	4.5	4.0
C	0.0	3.0	3.2	1.9	11.0	17.4	1.9	4.8	4.1
55-65	0.0	4.1	3.0	2.5	16.0	30.5	1.6	5.0	4.2
	0.0	3.3	2.7	2.4	12.0	19.9	1.8	4.9	4.1
Profile No. 9									
B1	16.3	4.7	6.7	1.6	1.5	4.4	9.2	4.3	3.9
2-8	16.5	5.2	7.9	1.8	1.5	3.7	9.1	4.4	3.9
	18.2	5.1	11.0	2.3	3.6	19.2	9.2	4.6	4.1
B2	0.0	3.1	1.6	1.7	1.0	2.2	3.8	4.7	4.2
30-40	0.0	2.9	1.8	1.7	1.3	2.8	4.0	4.6	4.1
	0.0	3.2	2.0	1.8	1.5	2.9	4.5	4.6	4.1
C	0.0	3.0	2.6	2.9	15.0	27.0	1.6	4.9	4.4
55-65	0.0	3.5	2.0	1.4	3.0	6.0	2.0	4.8	4.3
	0.0	3.6	2.0	2.4	4.0	7.7	2.0	4.8	4.3

APPENDIX 2

Appendix 2A.
The estimated percentage cover of the ground flora recorded from two 2 x 2 m random quadrats (A and B) in each of three 33.3 x33.3 m plots in each of Ross, Gartfairn and Methven woods. Species with less than 1 % cover are indicated +. Species observed within the plots but not within the quadrats are asterisked.

Plot	Ross						Gartfairn						Methven					
	1		2		3		4		5		6		7		8		9	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Acer pseudoplatanus (seedling)	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.
Agrostis capillaris	.	.	*	.	.	.	.	.	.	.	.	.	*	.	35	3	5	30
Agrostis vinealis	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ajuga reptans	.	.	.	.	+	+	.	.	10	10	*	.	30	35	5	2	.	+
Alnus glutinosa (seedling)	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.
Anemone nemorosa	.	.	.	.	.	.	.	.	*	.	.	.	20	10	.	.	50	25
Angelica sylvestris	.	.	.	.	.	.	*	.	60	50	.	.	*	.	.	.	*	.
Anthoxanthum odoratum	.	.	.	.	*	.	80	70	.	.	90	55	*	.	.	.	*	.
Athyrium filix-femina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
Betula pendula (seedling)	.	.	.	.	.	.	*	.	*	.	*	.	.	.	.	.	.	.
Betula pubescens (seedling)	*	.	*	.	*	.	*	.	*	.	*	.	*	.	.	.	*	.
Blechnum spicant	*	.	15	10	10	+	.	.	.	.	*	.	.	.	.	.	.	.
Calluna vulgaris	+	10	*	.	+	10	.	.	.	.	.	.	.	.	.	.	.	.
Caltha palustris	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.
Cardamine flexuosa	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.
Carex remota	.	.	.	.	.	.	.	10	.	+	.	+	.	.	.	.	*	.
Chrysosplenium oppositifolium	.	.	.	.	.	.	.	.	*	.	.	.	*	.	*	.	.	.
Crepis mollis	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.
Dactylis glomerata	.	.	.	.	*	.	.	.	.	.	*	.	.	.	*	.	.	.
Deschampsia cespitosa	*	.	.	.	*	.	.	.	*	.	*	.	*	.	*	.	.	.
Deschampsia flexuosa	.	+	10	10	15	10	.	.	.	.	.	.	+	.	+	.	*	.
Dicranum scoparium	.	.	.	.	+	.	+	.	+	.	*	.	.	.	.	.	.	.
Digitalis purpurea	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.
Dryopteris affinis ssp. *affinis*	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.

Appendix 2A contd.

Plot	Ross						Gartfairn						Methven					
	1		2		3		4		5		6		7		8		9	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Dryopteris affinis ssp. *borreri*	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Dryopteris dilatata	.	.	*	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.
Dryopteris filix-mas	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
Endymion non-scriptus	.	.	.	.	*	.	+	+	.	.	*	.	15	.	.	.	*	.
Equisetum fluviatile	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.
Equisetum palustre	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.
Erica cinerea	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fagus sylvatica (sapling)	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Filipendula ulmaria	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	.	*	.
Fraxinus excelsior (seedling)	*	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.
Galium palustre	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.
Hedera helix	*	.	.	.	*	.	*	.	.	.	.	.	*	.	.	.	*	.
Holcus lanatus	.	.	.	.	.	.	.	.	*	.	.	.	5	.	30	2	+	.
Hypericum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.
Hypnum cupressiforme	+	.	.	+	+	.	*	.	*	.	*	.	+	.	.	.	*	.
Ilex aquifolium (seedling)	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus conglomeratus	.	.	.	.	.	.	.	10	+	.	*	.	.	.	.	.	*	.
Lonicera periclymenum	*	.	*	.	*	.	.	.	*	.	*	.	*	.	*	.	+	+
Luzula pilosa	.	.	.	.	.	+	.	.	.	.	.	.	*	.	.	.	+	.
Luzula sylvatica	.	.	.	.	*	.	.	.	*	.	*	.	.	.	.	.	*	.
Lysimachia nemorum	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.
Matricaria matricarioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Melampyrum pratense	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.
Mnium hornum	+	+	+	2	.	2	*	.	.	.	*	.	*	.	*	.	*	.
Molinia caerulea	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oreoptris limbosperma	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.
Oxalis acetosella	*	.	*	.	.	+	10	2	*	.	*	.	20	+	*	.	25	10
Phalaris arundinacea	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.
Plantago major	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.
Poa annua	.	.	*	.	*	.	.	.	*	.	*	.	*	.	+	.	*	.
Poa pratensis	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.

Appendix 2A contd.

Plot	Ross 1 A	1 B	2 A	2 B	3 A	3 B	Gartfairn 4 A	4 B	5 A	5 B	6 A	6 B	Methven 7 A	7 B	8 A	8 B	9 A	9 B
Polypodium vulgare	*	.	+	1	.	.	.	.	.	5	.	5	*	.	.	.	*	.
Polytrichum formosum	.	+	+	.	*	.	.	.	*	.	*	.	.	+	*	.	*	.
Potentilla erecta	.	.	*	.	*	.	.	.	+	5	.	.	*	.	*	.	+	+
Primula vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.
Prunella vulgaris	.	.	.	.	*	.	.	.	*	.	*	.	*	.	.	.	*	.
Pteridium aquilinum	*	.	.	10	15	10	.	.	.	.	*	.	.	10	10	.	*	.
Qercus sp. (seedling)	*	.	*	.	*	.	.	.	*	.	*	.	*	.	*	.	*	.
Ranunculus repens	.	.	.	.	*	.	.	.	*	.	.	.	*	.	*	.	*	.
Rhytidiadelphus squarrosus	.	.	.	.	*	.	+	+	+	10	.	5	.	.	.	.	.	.
Rubus sp.	.	.	.	.	.	.	*	.	*	.	*	.	.	.	.	.	.	.
Rumex acetosa	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.
Salix sp. (seedling)	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.
Sambucus nigra (seedling)	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.
Sarothamnus scoparius	*	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.
Scrophularia nodosa	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.
Silene dioica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.
Solidago virgaurea	.	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.
Sorbus aucuparia (seedling)	*	.	*	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.
Sparganium erectum	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.
Stellaria palustris	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.
Succisa pratensis	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.
Thamnium alopecurum	+	.	2	1	2	5	*	.	*	.	*	.	.	+	.	3	*	.
Thuidium tamariscinum	+	+	2	1	3	3	+	.	*	.	+	.	.	+	.	.	.	.
Ulex europaeus	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ulmus glabra	.	.	.	.	.	.	.	.	*	.	.	.	*	.	*	.	.	.
Urtica dioica	.	.	*	.	*	.	*	.	*	.	*	.	*	.	.	.	*	.
Vaccinium myrtillus	95	85	50	55	60	75	.	.	.	.	*	.	.	.	.	.	.	.
Valeriana officinalis	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.
Veronica chymaedrys	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.
Veronica officinalis	.	.	.	.	.	.	.	.	*	.	.	.	*	.	*	.	*	.
Viola riviniana	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	+	+

Appendix 2B

Girth (cm), height (m), crown width (m) measured from two directions north-sought (N-S) and east-west (E-W), basal area (cm^2) (B.a) and crown cover (m^2) (C.cov) of tree species (sp) (Oak; 1, Birch; 2 and Rowan; 3) in 9 sub-plots (11.1 X 11.1) within each the 3 plots in each woodland. Tag No; is Tree numbers. Symbols are ↑ ↓; in multi stem trees pointing to their shared canopy, BC; broken canopy and AD; almost dead

Ross (Plot 1)

Sub plot	Tag No	sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
1	1	2	61	9.9	4.4	4.3	296	15
1	2	1	90	13.1	10.6	7.9	645	67
1	3	1	75	11.4	5.3	5.5	442	23
1	4	1	84	12.0	6.0	5.6	562	26
1	5	1	95	10.8	7.9	7.9	711	49
2	6	1	28	4.2	3.5	3.0	62	8
3	7	1	101	10.0	9.7	7.2	812	56
3	8	1	113	10.8	11.1	6.7	1016	62
3	9	1	28	4.7	2.6	2.9	62	6
3	10	1	28	5.4	2.6	2.9	62	6
4	11	1	95	12.9	7.2	6.2	718	35
4	12	1	110	13.2	9.3	7.9	963	58
4	13	1	51	9.4	1.6	2.8	207	4
5	14	1	94	11.8	9.0	7.1	696	51
5	15	1	94	12.5	7.2	6.5	703	37
5	16	1	109	11.6	11.2	9.3	946	83
5	17	1	93	11.2	7.0	6.2	688	34
6	18	1	89	10.9	11.0	8.0	630	71
6	19	1	103	10.8	9.1	6.9	844	50
6	20	3	125	9.3	8.8	6.7	1243	47
7	21	1	196	14.5	16.8	16.0	3057	211
7	22	1	98	12.5	9.7	6.0	757	48
7	23	1	96	12.9	7.6	7.8	733	47
8	24	1	88	13.0	7.5	6.3	616	37
8	25	1	82	12.5	5.2	10.5	535	48
8	26	1	103	13.6	8.3	11.0	844	73
8	27	1	80	13.7	6.8	6.8	509	36
8	28	1	67	12.2	5.3	3.8	357	16
9	29	1	73	10.3	7.5	4.5	424	28
9	30	1	72	8.7	6.1	4.7	413	23
9	31	2	53	8.9	4.3	4.2	224	14
9	32	1	86	10.7	8.5	7.1	582	48

Appendix 2B. Ross (Plot 2).

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
1	33	3	68	6.6	5.8	5.1	368	23
1	34	1	136	13.0	13.6	10.3	1472	112
1	35	1	147	15.0	13.1	10.8	1720	112
1	36	1	75	13.5	7.0	4.9	448	28
2	37	1	70	9.2	4.8	9.4	390	40
2	38	1	78	10.9	6.2	5.3	484	26
2	39	1	137	15.0	15.2	13.4	1494	161
2	40	1	99	12.0	10.1	6.1	780	52
3	41	2	27	8.2	3.8	3.5	58	11
3	42	2	26	7.8	3.3	4.4	54	12
3	43	1	76	14.2	7.1	6.6	460	37
3	44	1	103	16.0	7.7	7.0	844	42
4	45	1	71	10.5	6.4	8.1	401	41
4	46	1	127	14.5	11.4	12.4	1284	111
4	47	1	162	15.2	13.2	10.3	2088	108
6	48	1	161	17.1	11.4	18.2	2063	172
6	49	1	124	13.5	12.5	9.8	1224	98
6	50	1	109	15.6	6.2	12.6	946	69
7	51	1	145	13.0	8.7	13.6	1673	98
8	52	2	21	4.9	3.2	3.0	35	8
8	53	2	23	5.1	2.9	2.6	42	6
8	54	1	100	12.0	10.7	11.3	796	95
9	55	1	96	14.2	6.6	8.4	733	44
9	56	1	101	14.0	10.6	10.1	812	84
9	57	2	30	5.3	4.4	3.3	72	12
9	58	1	74	12.2	7.6	7.2	436	43
9	59	1	129	14.5	10.5	7.6	1324	64

Ross (PLot 3).

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
1	60	1	120	12.0	8.2	8.1	1146	52
1	61	1	72	10.0	6.0	7.4	413	35
1	62	1	93	11.9	8.5	7.7	688	52
2	63	1	65	3.9	4.3	3.2	336	11
2	64	1	102	10.7	5.7	8.9	828	42
2	65	1	66	9.9	5.9	6.0	347	28
2	66	1	79	11.1	5.2	6.1	497	25
2	67	1	82	9.5	3.2	4.1	535	11
3	68	1	86	11.6	6.9	8.0	589	44
3	69	1	63	10.9	3.9	6.0	316	19
3	70	1	95	10.5	5.5	7.8	718	35
3	71	1	86	10.9	5.7	6.1	589	27
4	72	1	81	11.8	6.0	7.8	522	37
4	73	1	82	10.7	4.5	4.0	535	14
4	74	1	78	8.0	5.8	5.0	484	23
4	75	1	93	10.0	8.4	6.2	688	42
4	76	1	64	10.8	4.9	5.3	326	20
4	77	1	79	9.6	6.8	6.5	497	35

Appendix 2B. Ross (plot 3) continued.

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
5	78	1	83	11.1	7.6	6.4	548	39
5	79	1	68	10.2	3.7	5.4	368	16
5	80	1	47	7.9	4.1	3.3	176	11
5	81	1	97	10.5	6.2	7.1	749	35
5	82	1	53	5.4	3.8	3.5	224	11
5	83	1	95	9.2	5.4	4.8	718	20
5	84	1	66	9.6	4.9	5.9	347	23
6	85	1	90	10.1	8.8	6.3	645	45
6	86	1	90	10.6	8.7	6.3	645	44
6	87	2	77	9.0	5.3	5.4	472	23
6	88	1	69	10.6	5.2	3.2	379	14
6	89	1	92	12.3	7.7	5.7	674	35
6	90	1	61	7.9	2.7	5.6	296	14
7	91	1	79	10.3	4.6	9.5	497	39
7	92	1	83	11.0	5.1	4.4	548	18
7	93	2	22	5.4	2.8	2.7	39	6
7	94	1	54	9.7	2.0	3.6	232	6
8	95	1	75	8.5	5.8	5.8	448	26
8	96	1	74	7.8	4.5	5.0	436	18
8	97	1	93	9.5	8.9	5.9	688	43
8	98	1	73	9.8	5.1	6.0	424	24
9	99	1	93	10.5	11.9	6.7	688	68
9	100	1	105	12.5	8.5	8.7	877	58
9	101	1	88	9.7	5.6	7.7	616	35
9	102	1	104	12.2	10.3	7.1	861	59
9	103	1	58	7.0	4.9	2.7	268	11

Gartfairn (Plot 4)

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
1	104	1	73	18.0	6.5	7.4	424	38
1	105	1	77	17.7	5.0	5.2	472	20
1	106	2	80	15.1	7.8	4.4	509	29
1	107	1	124	15.5	4.8	6.4	1224	25
2	108	2	83	15.5	6.4	5.5	548	28
2	109	1	79	16.5	5.6	5.1	497	23
2	110	2	46	16.0	2.2	2.6	168	5
2	111	2	71	16.3	4.3	4.7	401	16
3	112	2	58	15.5	3.4	3.1	268	8
3	113	1	119	17.0	3.5	4.2	1127	12
3	114	1	39	9.6	3.6	4.5	121	13
3	115	2	62	16.8	4.3	4.4	306	15
3	116	2	53	11.2	4.1	2.8	224	9
3	117	2	117	23.0	7.0	7.7	1089	42
3	118	2	70	17.6	6.3	5.4	390	27
3	119	2	58	16.5	2.5	3.8	268	8
3		2	38	12.2	↑		115	
4		1	75	18.0	↓		448	
4		1	38	12.0	↓		115	
4	123	1	89	13.0	7.7	6.6	630	40
4	124	1	105	18.4	8.9	6.0	877	44

Appendix 2B. Gartfairn (Plot 4) continued.

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
5	125	2	68	15.1	4.1	3.8	368	12
5	126	1	93	17.7	5.8	6.4	688	29
5	127	1	35	4.1	2.7	2.2	98	5
5	128	1	162	18.0	12.2	11.6	2088	111
5	129	1	24	4.6	3.7	3.8	46	11
6	130	1	79	18.5	6.1	5.6	497	27
6	131	1	42	7.9	5.0	4.9	140	19
6	132	2	65	16.5	6.1	7.0	336	34
6		2	51	15.5	↑		207	
6	134	1	35	8.6	3.2	4.1	98	11
6	135	2	58	19.0	3.9	4.5	268	14
6		2	41	18.7	↓		134	
6	137	2	48	16.3	5.5	4.6	183	20
6		2	47	4.9	↑		176	
7	139	1	222	17.4	14.2	13.0	3922	145
7	140	1	177	17.0	15.3	13.2	2493	160
7		1	51	4.9	↓		207	
7	142	1	72	14.1	5.0	4.9	413	19
8	143	1	78	12.1	4.9	6.8	484	27
8	144	2	41	12.7	2.8	2.1	134	5
8	145	2	50	16.0	3.0	4.6	199	11
8	146	1	154	8.7	11.4	8.3	1887	76
8	147	1	34	3.2	4.1	3.5	92	11
8		1	26	11.0	↑		54	
9	149	2	31	10.0	3.8	2.9	77	9
9	150	2	74	18.0	4.9	6.0	436	23
9	151	2	44	12.2	3.0	4.6	154	11
9	152	2	57	15.9	3.6	3.4	259	10
9	153	1	149	18.0	9.6	7.8	1767	59
9	154	1	124	18.0	9.1	11.8	1224	86

Gartfairn (Plot 5).

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
1	155	2	72	19.3	4.8	4.0	413	15
1	156	2	121	20.1	7.8	4.6	1165	30
1	157	1	42	10.5	6.6	4.3	140	23
1	158	2	62	14.4	4.2	4.9	306	16
1	159	1	63	13.3	5.6	4.5	316	20
1		1	43	7.1	↓		147	
1		1	25	3.0	↓		50	
1	162	1	50	9.9	5.0	5.2	199	20
1	163	1	86	15.2	9.2	8.1	589	59
2	164	2	29	6.9	5.5	3.6	67	16
2	165	1	150	17.6	9.8	11.5	1791	89
2	166	1	95	14.5	6.3	6.7	718	33
2	167	2	65	5.5	5.4	4.8	336	20
2	168	2	53	12.5	↑		224	
2	169	2	59	13.6	5.9	4.5	277	21
2	170	1	96	12.9	7.3	8.0	733	46
2	171	1	35	6.9	↑		98	
3	172	2	43	9.9	6.1	3.0	147	16

Appendix 2B. Gartfairn (Plot 5) continued.

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	Crown width E-W	B.a	C.cov
3	173	2	61	12.3	4.8	4.8	296	18
3	174	2	66	11.5	4.9	6.6	347	26
4	175	2	110	19.0	7.8	7.9	963	48
4	176	1	157	17.2	15.7	14.4	1962	178
4	177	1	81	14.5	6.7	5.7	522	30
4	178	1	85	17.2	5.4	4.6	575	20
4	179	1	44	10.2	↑		154	
5	180	1	192	14.7	9.8	9.5	2934	73
5	181	2	94	18.3	6.4	6.2	703	31
5	182	1	40	8.9	3.4	3.1	127	8
5	183	1	61	12.0	7.5	5.4	296	33
5	184	2	124	15.5	10.5	8.9	1224	74
5	185	2	76	16.4	5.3	4.5	460	19
5	186	1	48	11.5	4.1	3.3	183	11
6	187	1	85	14.6	5.1	7.1	575	29
6	188	1	35	3.0	4.3	5.7	98	20
6		1	34	4.0	↑		92	
6		1	87	15.5	↓		602	
6	191	1	93	15.9	6.6	7.5	688	39
6		1	50	10.1	↓		199	
6	193	1	68	13.1	4.8	4.3	368	16
7	197	1	60	4.1	2.6	4.1	287	9
7	198	2	61	15.0	4.2	5.0	296	17
7	199	2	58	15.0	4.1	8.0	268	29
7	200	2	33	11.5	3.0	6.0	87	16
7	217	2	36	9.7	2.6	2.2	103	5
8	201	1	107	18.0	7.2	8.1	911	46
8		1	71	14.4	↓		401	
8	203	1	104	17.1	7.4	8.9	861	52
8		1	85	16.5	↓		575	
8	205	1	104	18.5	6.3	6.8	861	34
8		1	57	10.7	↑		259	
8	207	1	87	16.0	5.7	8.2	602	38
9	194	1	64	5.5	4.8	4.2	326	16
9	195	1	103	15.2	7.5	5.8	844	35
9	196	2	59	12.3	3.6	4.1	277	12
9	208	1	88	19.0	5.3	4.6	616	19
9		1	66	11.0	↓		347	
9	210	1	71	14.9	7.9	9.5	401	59
9		1	106	18.0	↓		894	
9	212	1	143	18.2	11.9	12.4	1627	116
9	213	1	53	7.5	B.C		224	
9	214	1	69	13.0	4.5	3.0	379	11
9		1	39	6.9	↑		121	
9	216	1	118	13.0	4.8	6.2	1108	24

Appendix 2B. Gartfairn (Plot 6).

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
1		1	69	11.0	↓		379	
1		1	68	13.8	↓		368	
1	220	1	98	17.0	7.3	9.2	764	54
1	221	1	170	17.5	9.8	9.0	2300	69
1	222	1	77	15.1	5.0	5.0	472	20
1	223	2	68	14.7	3.9	4.9	368	15
1	224	1	113	17.9	6.8	6.9	1016	37
2	225	1	79	13.8	4.7	3.3	497	13
2	226	1	118	16.3	6.5	8.5	1108	44
3	227	1	69	17.8	2.9	3.8	379	9
3	228	1	158	18.0	11.5	13.8	1987	126
4	229	2	100	20.5	5.6	7.1	796	32
4	230	1	149	14.7	9.7	11.5	1767	88
4	231	2	115	19.0	7.5	6.4	1052	38
4	232	2	53	13.5	2.7	3.9	224	9
4	233	1	59	13.5	4.0	4.2	277	13
5	234	1	182	18.4	14.8	13.8	2636	161
6		2	60	13.2	↓		287	
6	236	2	87	17.2	6.3	6.8	602	34
6	237	1	128	16.2	11.1	8.5	1304	75
6	238	1	60	15.0	6.0	4.7	287	23
7	239	1	51	13.7	3.1	3.7	207	9
7	240	1	66	13.7	4.3	4.4	347	15
7	241	1	133	20.5	7.2	8.6	1408	49
7	242	1	97	16.5	6.0	5.7	749	27
7	243	1	53	11.7	4.5	7.3	224	27
7	244	1	78	16.0	4.7	4.9	484	18
8	245	1	131	17.4	10.2	7.0	1366	58
8	246	1	92	17.3	6.8	4.9	674	27
8	247	1	73	15.0	5.3	3.8	424	16
9		1	61	15.8	↓		296	
9	249	1	76	16.2	8.1	9.7	460	62
9	250	1	71	16.1	5.5	5.4	401	23
9	251	2	96	16.1	7.3	7.8	733	45
9	252	1	136	17.7	11.6	10.2	1472	93

Methven (Plot7).

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
1	255	1	112	18.2	9.9	10.3	998	80
1		1	107	17.3	↑		911	
1	257	1	96	14.5	11.5	6.1	733	61
1		1	87	14.2	↑		602	
1		1	68	14.0	↓		368	
1	260	1	128	18.0	6.7	13.2	1304	78
1	261	1	97	12.5	6.3	5.4	749	27
2		1	128	17.5	↓		1304	
2	263	1	141	18.0	16.4	12.9	1582	169
2		1	78	10.0	↑		484	
2		1	120	17.5	↑		1146	

Appendix 2B. Methven (Plot 7) continued.

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
2	266	1	105	15.8	10.5	8.9	877	74
3		1	91	10.0	↑		659	
3	267	1	84	13.5	4.9	4.0	562	16
3	269	1	127	15.9	12.2	10.9	1284	105
3	270	2	58	8.7	7.8	4.3	268	29
4		1	85	16.1	↓		575	
4		1	91	16.0	↓		659	
4	273	1	115	16.2	11.1	13.0	1052	114
4		1	111	18.5	↓		981	
4	275	1	133	19.0	11.4	12.0	1408	108
4	276	1	88	16.7	12.6	10.3	616	103
4		1	87	13.7	↑		602	
5	278	1	127	15.9	6.4	7.6	1284	39
5	279	1	127	15.5	10.0	10.6	1284	83
5	280	1	144	16.3	11.5	15.1	1650	139
5		1	62	13.7	↑		306	
6	282	1	123	18.5	10.4	11.1	1204	91
7	283	2	56	15.1	5.7	4.0	250	19
7	284	1	133	19.5	9.9	6.3	1408	52
7		1	70	15.4	↓		390	
7	286	1	112	16.9	5.2	6.5	998	27
7	287	1	124	19.0	6.6	8.6	1224	45
8	288	1	84	11.5	5.7	4.0	562	19
8	289	1	109	18.4	7.3	5.8	946	34
8	290	1	111	19.0	4.9	7.1	981	28
8	291	1	108	17.0	6.6	5.7	928	30
9	292	1	71	11.3	3.8	5.1	401	16
9	293	1	86	13.5	8.7	6.6	589	46
9	294	1	161	16.4	12.6	12.0	2063	119
9	295	1	90	16.9	4.9	6.1	645	24

Methven (Plot 8)

Sub plot	Tag	No sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
1	296	2	90	10.0	5.5	4.8	645	21
1	297	1	226	20.0	15.1	15.5	4065	184
2		1	97	13.0	↓		749	
2	299	1	116	7.5	7.8	10.8	1071	68
2	300	1	77	10.3	4.3	4.0	472	14
2	301	1	127	15.5	8.2	5.7	1284	38
2	302	1	74	13.2	2.7	2.8	436	6
3	303	1	132	14.5	9.3	11.1	1387	82
3		1	120	18.5	↑		1146	
3	305	1	97	12.0	2.9	2.2	749	5
3	306	2	53	11.0	5.0	4.8	224	19
3	307	1	106	17.4	8.7	11.7	894	82
3	308	1	125	14.4	7.0	7.9	1243	44
4		1	85	18.1	↓		575	
4	310	1	127	18.0	11.3	10.0	1284	89
4		1	124	18.0	↑		1224	
4	312	1	76	12.8	2.0	1.5	460	2
5		1	55	12.0	↓		241	

Appendix 2B. Methven (Plot 8) continued.

Sub plot	Tag No	sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
5	314	1	114	18.1	8.1	7.8	1034	50
5		1	93	19.1	↓		688	
5	316	1	126	18.0	12.2	13.3	1263	132
5		1	110	18.1	↑		963	
5		1	113	17.0	↑		1016	
5	317	1	83	15.9	3.6	2.3	548	7
6	320	1	138	18.5	8.2	6.7	1516	44
6	321	1	80	12.2	2.7	2.8	509	6
6	322	1	130	18.0	13.8	7.7	1345	91
6	323	1	95	17.5	5.5	6.3	718	27
6		1	78	15.5	↑		484	
6	325	1	91	13.1	6.9	4.7	659	26
7	326	1	111	15.0	6.4	10.2	981	54
7		1	93	15.5	↑		688	
7	328	2	47	10.8	4.0	3.2	176	10
7	329	1	96	15.4	7.5	9.3	733	55
7		1	95	15.7	↑		718	
8		1	81	17.1	↓		522	
8	332	1	111	18.0	9.9	8.4	981	66
8	333	1	98	17.8	10.9	8.2	764	72
8		1	87	14.8	↑		602	
8	335	1	153	16.9	8.4	10.2	1863	68
8	336	1	69	12.3	5.9	3.8	379	19
9	337	2	126	17.2	8.6	8.5	1263	57
9		1	62	8.2	↓		306	
9		1	62	12.8	↓		306	
9	340	1	77	15.2	5.6	5.2	472	23
9	341	1	130	17.5	9.6	16.0	1345	129
9		1	103	11.4	↑		844	
9		1	118	14.2	↑		1108	
9	344	2	82	16.8	3.6	7.1	535	23

Methven (Plot 9).

Sub plot	Tag No	sp	Girth	Height	Crown width N-S	E-W	B.a	C.cov
1	345	1	132	21.1	10.2	8.0	1387	65
1	346	1	92	17.3	6.9	6.7	674	36
1		1	84	14.6	↑		562	
2		1	92	18.9	↓		674	
2	349	1	119	19.0	8.8	6.7	1127	47
2		1	90	16.5	↓		645	
2	351	1	110	15.6	8.2	7.5	963	48
2	352	1	159	20.0	12.8	14.2	2012	143
2		1	145	16.3	↑		1673	
3	354	1	127	17.0	10.2	8.0	1284	65
4	355	1	135	18.0	12.2	11.2	1450	108
4		1	108	13.3	↑		928	
4	358	1	104	11.0	4.1	5.0	861	16
4	359	1	118	16.8	8.0	10.8	1108	69
5	360	1	110	16.6	4.4	5.5	963	19
5	361	1	165	17.8	8.2	9.8	2167	64
5	362	2	63	14.9	3.1	2.9	316	7

Appendix 2B. Methven (Plot 9) continued.

Sub plot	Tag No	sp	Girth	Height	Crown width N-S	Crown width E-W	B.a	C.cov
6		1	82	12.0	2.2	1.9	535	3 AD
6		1	88	15.4	↓		616	
6	365	1	124	17.5	12.5	14.0	1224	138
6		1	115	18.5	↑		1052	
6		1	86	17.0	↑		589	
6		1	116	18.0	↑		1071	
6	369	1	128	17.5	7.4	8.8	1304	52
7	370	1	120	17.0	6.7	8.9	1146	48
8	371	1	98	16.2	5.1	6.0	764	24
8	372	1	141	15.5	11.4	9.5	1582	86
8	373	1	80	16.1	4.4	5.2	509	18
9	374	1	113	18.2	6.5	7.8	1016	40
9	375	1	100	18.7	6.0	7.0	796	33
9	376	1	84	15.6	4.0	6.7	562	23
9	377	1	106	19.3	6.3	7.6	894	38
9	378	2	61	15.8	5.1	6.6	296	27
9		2	54	9.8	↑		232	

Appendix 2C

Average height, basal area, Crown cover, biomass and density of Oak and Birch trees and the totals for three plots within each of the woodlands.

Wood	Ross			Gartfairn			Methven		
Plot	1	2	3	4	5	6	7	8	9
Average height (m)									
Oak	11.1	13.6	9.9	13.3	12.5	15.8	15.8	15.3	16.8
Birch	9.4	6.3	7.2	15.3	13.6	16.3	11.9	13.2	13.5
Basal area (m^2 h^{-1})									
Oak	19.6	21.9	22.4	22.1	25.8	24.0	36.3	40.6	32.1
Birch	0.5	0.3	0.5	7.2	8.0	4.1	0.5	2.8	0.8
Crown cover (m^2 h^{-1})									
Oak	13000	16000	13000	10000	12000	12000	17000	15000	12000
Birch	290	470	280	3400	4300	1700	470	1300	340
Biomass (t ha^{-1})									
Oak	76	103	78	103	112	133	200	217	188
Birch	1.6	0.5	1.2	36	36	22	2.0	12	3.8
Total	82	105	79	139	148	155	202	229	192
Density (ha^{-1})									
Oak	290	210	420	230	310	250	260	270	220
Birch	20	50	20	200	180	60	20	50	20
Total	320	270	440	430	490	310	280	320	240

The difference between the totals and sums for Oak and Birch in plots 1 and 2 is for one Rowan in each of these plots.

APPENDIX 3

Appendix 3 A.

Oven-dried (85 °C) masses of; (OL) oak leaves, (BL) birch leaves, (SW) small wood, (F) fruit, and (Mis) miscellaneous litterfall produced during between each sampling period in each of the eighteen litter traps in each of the of the three plots in **Ross**. Asterisk indicate missed sample.

22 Sep to 17 Oct 1987

Trap No	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	3.22	0.52	2.72	1.70	0.08	1.14	1.41	0.60	0.00	0.15	0.82	0.00	0.00	0.11	0.07
2	3.36	0.09	3.43	1.68	0.24	0.96	0.06	0.37	0.00	0.06	1.06	0.06	0.32	0.51	0.05
3	1.77	0.04	0.00	1.38	0.08	1.78	0.00	2.94	0.00	0.32	0.86	0.00	0.57	0.00	0.07
4	2.04	0.08	0.58	0.00	0.18	2.04	0.18	2.43	0.00	0.42	1.07	0.00	1.45	0.00	0.08
5	3.83	0.00	2.67	0.84	0.36	1.68	0.37	3.44	0.00	0.17	1.30	0.15	2.42	0.16	0.09
6	2.22	0.07	0.57	0.00	0.07	1.16	0.00	4.93	0.00	0.21	1.64	0.35	0.00	0.00	0.08
7	3.07	0.09	0.57	0.00	0.14	1.78	0.00	0.42	0.00	0.13	1.62	0.07	2.17	0.00	0.07
8	3.86	0.13	0.37	0.82	0.20	2.05	0.13	0.45	0.00	0.27	1.36	0.86	0.45	0.04	0.12
9	3.31	0.21	2.20	0.12	0.24	1.15	0.00	0.52	0.00	0.13	1.07	0.05	0.38	0.00	0.00
10	4.20	2.18	3.25	0.00	0.18	1.73	0.00	4.05	0.00	0.30	1.24	0.03	0.68	0.00	0.03
11	1.66	0.33	0.04	0.48	0.27	2.28	0.00	0.89	0.00	0.13	1.47	0.00	0.63	0.84	0.07
12	2.66	1.00	0.00	0.14	0.15	1.99	0.00	0.66	0.00	0.18	1.01	0.02	0.43	0.76	0.06
13	3.13	0.00	1.33	3.42	0.12	1.31	0.34	4.23	0.00	0.32	1.88	1.33	0.00	0.00	0.09
14	2.76	0.01	1.18	2.05	0.68	3.30	0.23	4.68	0.10	0.43	0.81	0.90	0.48	0.00	0.06
15	3.27	0.11	4.02	0.00	0.57	1.14	0.24	4.49	0.00	0.26	1.52	0.42	0.49	0.10	0.04
16	2.48	0.07	2.47	2.10	0.30	1.24	0.00	0.74	0.00	0.27	1.10	0.44	1.68	0.70	0.10
17	2.28	0.71	0.13	0.47	0.13	1.90	0.00	1.27	0.00	0.16	1.80	0.03	0.31	0.00	0.00
18	3.09	0.40	1.54	2.01	0.30	1.32	0.40	0.36	0.00	0.18	1.14	0.00	1.36	3.37	0.00

18 Oct to 4 Nov 1987

1	3.73	1.02	0.29	0.76	0.00	3.16	0.00	0.00	0.00	0.00	1.88	0.00	0.00	0.28	0.00
2	5.10	0.13	0.58	3.82	0.00	3.41	0.00	0.44	0.00	0.00	2.77	0.00	0.00	0.67	0.00
3	2.33	0.14	0.00	0.00	0.00	2.68	0.00	0.00	0.00	0.00	2.98	0.00	0.00	0.00	0.00
4	13.30	0.21	2.62	5.38	0.00	1.82	0.00	0.24	0.00	0.00	3.52	0.17	0.30	0.00	0.00
5	9.37	0.00	0.85	0.85	0.00	2.34	0.18	0.00	0.00	0.00	2.24	0.00	0.21	0.00	0.00
6	6.85	0.00	0.00	0.00	0.00	2.44	0.00	0.00	0.00	0.00	2.73	1.04	0.00	0.00	0.00
7	5.97	0.03	0.11	0.27	0.00	4.41	0.00	0.36	0.00	0.00	6.31	0.11	0.00	0.00	0.00
8	9.50	0.06	0.00	0.00	0.00	3.68	0.00	0.00	0.00	0.00	4.44	0.76	0.15	1.02	0.00
9	14.39	0.16	0.41	4.09	0.00	1.42	0.00	0.53	0.00	0.00	4.84	0.00	0.00	0.00	0.00
10	13.68	0.98	3.78	0.94	0.00	2.78	0.11	0.00	0.00	0.00	4.01	0.00	0.00	0.70	0.00
11	10.54	0.72	4.06	4.07	0.00	2.31	0.00	0.00	0.00	0.00	4.10	0.24	0.00	0.00	0.00
12	15.62	1.45	0.00	2.51	0.00	2.04	0.00	0.54	0.00	0.00	4.75	0.00	0.35	0.00	0.00
13	4.14	0.00	0.37	2.74	0.00	3.91	0.00	0.00	0.00	0.00	2.75	0.80	0.00	0.00	0.00
14	5.26	0.04	0.00	1.44	0.00	2.49	0.00	0.00	0.00	0.00	2.97	1.62	1.10	0.30	0.00
15	8.31	0.04	0.65	4.75	0.00	2.45	0.34	0.00	0.00	0.00	2.78	0.19	0.64	1.41	0.00
16	5.50	0.16	0.00	4.48	0.00	2.77	0.00	0.46	0.00	0.00	4.07	0.12	0.20	0.00	0.00
17	6.00	0.98	0.00	2.36	0.00	13.00	0.00	0.00	0.00	0.00	6.80	0.00	0.00	0.00	0.00
18	8.69	1.14	0.28	0.00	0.00	5.75	0.00	0.00	0.00	0.00	5.62	0.00	0.00	0.33	0.00

Appendix 3 A. Continued.

5 Nov to 21 Nov 1987

Trap No	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	22.73	0.02	5.78	0.74	0.09	16.69	0.00	13.63	0.00	0.14	18.10	0.00	0.63	1.63	0.20
2	21.17	0.05	0.33	2.74	0.19	24.06	0.00	4.04	0.00	0.14	22.21	0.00	13.88	0.35	0.13
3	19.00	0.05	0.00	0.54	0.00	23.79	0.00	0.09	0.00	0.22	14.20	0.00	0.00	0.00	0.16
4	17.42	0.16	0.67	1.37	0.06	19.82	0.00	0.96	0.00	0.44	20.09	0.00	0.28	0.00	0.15
5	28.06	0.00	0.17	0.72	0.07	27.90	1.14	1.69	0.00	0.37	16.82	0.00	0.63	0.95	0.15
6	22.77	0.00	0.23	0.00	0.11	19.90	0.81	0.09	0.00	0.16	23.84	0.13	0.32	0.08	0.17
7	18.22	0.00	2.66	3.95	0.15	22.67	0.00	0.67	0.00	0.07	26.17	0.00	1.14	0.00	0.22
8	23.15	0.00	4.24	5.02	0.20	29.94	0.00	0.34	0.00	0.17	21.86	0.00	0.77	1.35	0.18
9	20.30	0.00	0.84	0.64	0.14	22.14	0.00	0.00	0.00	0.33	22.18	0.00	0.21	0.00	0.09
10	18.15	0.28	0.40	0.14	0.00	23.62	0.00	0.28	0.00	0.20	19.65	0.00	0.88	0.20	0.06
11	14.07	0.07	0.00	0.94	0.11	16.65	0.40	0.88	0.00	0.14	21.50	0.00	0.05	1.44	0.09
12	14.46	0.00	0.17	1.10	0.02	18.26	0.00	0.13	0.00	0.22	20.78	0.00	0.92	0.78	0.20
13	28.42	0.00	0.48	1.12	0.11	31.13	0.00	0.35	0.00	0.12	9.19	0.00	0.00	0.00	0.07
14	25.87	0.00	2.33	1.43	0.22	31.01	0.00	0.15	0.00	0.12	7.36	0.52	0.12	0.29	0.43
15	21.22	0.02	0.52	1.80	0.23	30.28	0.00	1.02	0.00	0.15	15.70	0.00	0.10	0.78	0.08
16	24.28	0.00	1.73	5.46	0.30	28.88	0.00	0.59	0.00	0.28	11.84	0.00	0.37	1.02	0.10
17	20.31	0.00	0.13	0.00	0.00	16.88	0.00	0.59	0.12	0.14	21.30	0.00	0.35	0.00	0.06
18	20.66	0.29	0.47	13.07	0.14	26.68	0.00	0.12	0.00	0.12	14.00	0.00	0.15	3.33	0.09

22 Nov to 12 Dec 1987

1	3.16	0.00	1.81	0.00	0.00	0.85	0.00	0.00	0.00	0.00	3.85	0.00	0.00	0.00	0.00
2	3.70	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	4.18	0.00	0.00	0.00	0.00
3	0.76	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	4.44	0.00	0.00	0.00	0.00
4	0.58	0.00	0.00	0.00	0.00	0.92	0.00	0.00	0.00	0.00	4.73	0.00	0.00	0.00	0.00
5	2.75	0.00	0.12	0.00	0.00	1.53	0.00	0.00	0.00	0.00	4.54	0.00	0.00	0.00	0.00
6	2.96	0.00	0.00	0.00	0.00	1.50	0.00	0.21	0.00	0.00	2.33	0.00	0.00	0.00	0.00
7	6.11	0.00	0.00	0.64	0.07	0.73	0.00	0.00	0.00	0.00	2.28	0.00	0.00	0.00	0.00
8	2.81	0.00	0.00	0.21	0.00	0.75	0.00	0.00	0.00	0.00	3.19	0.00	0.00	0.00	0.00
9	2.89	0.00	0.10	0.00	0.00	2.12	0.00	0.00	0.00	0.00	3.03	0.00	0.00	0.00	0.00
10	0.58	0.00	0.00	0.00	0.00	1.93	0.00	0.00	0.00	0.00	4.16	0.00	0.00	0.00	0.00
11	1.17	0.00	0.00	0.00	0.00	1.10	0.00	0.00	0.00	0.00	2.09	0.00	0.00	0.00	0.00
12	0.87	0.00	0.23	0.00	0.00	1.31	0.00	0.00	0.00	0.00	1.90	0.00	0.00	0.00	0.00
13	5.51	0.00	0.00	0.00	0.06	1.72	0.00	0.00	0.00	0.00	3.43	0.00	0.00	0.00	0.00
14	4.67	0.00	0.00	0.00	0.00	2.01	0.00	0.00	0.00	0.00	1.48	0.00	0.00	0.00	0.00
15	2.67	0.00	0.00	0.00	0.00	1.84	0.00	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00
16	4.01	0.00	0.21	1.08	0.02	1.78	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00
17	2.37	0.00	0.16	0.00	0.00	0.30	0.00	0.09	0.00	0.04	3.96	0.00	0.00	0.00	0.00
18	1.98	0.00	0.83	0.00	0.05	0.73	0.00	0.00	0.00	0.00	2.38	0.00	0.00	1.16	0.00

Appendix 3 A. Continued.

13 Dec 1987 to 13 Jan 1988

Trap No	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	1.56	0.00	0.04	0.00	0.11	0.34	0.00	0.08	0.00	0.05	1.81	0.00	0.00	0.00	0.09
2	1.45	0.00	0.00	0.00	0.32	0.21	0.00	0.05	0.00	0.09	0.70	0.00	1.76	0.00	0.08
3	0.36	0.00	0.00	0.00	0.08	0.18	0.00	0.00	0.00	0.17	2.40	0.00	0.10	0.00	0.05
4	0.76	0.00	0.14	0.00	0.14	0.00	0.00	0.00	0.00	0.11	1.47	0.00	0.05	0.00	0.09
5	0.16	0.00	0.21	0.00	0.09	0.08	0.00	0.00	0.00	0.15	1.33	0.00	0.08	0.00	0.06
6	0.91	0.00	0.00	0.00	0.31	1.47	0.00	0.23	0.00	0.15	1.30	0.00	0.34	0.00	0.15
7	1.01	0.00	0.46	0.00	0.10	0.40	0.00	0.09	0.00	0.06	1.02	0.00	0.00	0.00	0.15
8	1.82	0.00	0.11	0.00	0.10	0.13	0.00	0.09	0.00	0.15	0.51	0.00	0.00	0.00	0.10
9	1.12	0.00	0.00	0.00	0.34	0.64	0.00	0.00	0.00	0.22	0.37	0.00	0.00	0.00	0.16
10	1.45	0.00	0.06	0.00	0.08	0.31	0.00	0.09	0.00	0.09	1.11	0.00	0.21	0.00	0.04
11	0.47	0.00	0.00	0.00	0.10	0.65	0.00	0.08	0.00	0.17	1.17	0.00	0.00	0.00	0.13
12	0.16	0.00	0.00	0.00	0.09	0.17	0.00	0.00	0.00	0.10	1.24	0.00	0.00	0.00	0.16
13	0.36	0.00	0.19	0.00	0.11	0.25	0.00	0.05	0.00	0.15	0.42	0.00	0.09	0.00	0.13
14	1.19	0.00	0.26	0.00	0.12	0.20	0.00	0.11	0.00	0.14	0.43	0.00	0.00	0.00	0.13
15	0.36	0.00	0.46	0.00	0.12	0.27	0.00	0.06	0.00	0.24	0.39	0.00	0.00	0.00	0.09
16	1.38	0.00	0.00	0.00	1.37	0.31	0.00	0.19	0.00	0.21	0.22	0.00	0.86	0.00	0.10
17	0.68	0.00	0.98	0.00	0.13	0.12	0.00	0.17	0.00	0.17	1.14	0.00	0.00	0.00	0.14
18	1.86	0.00	2.57	0.00	0.48	0.00	0.00	0.00	0.00	0.15	1.49	0.00	0.00	0.00	0.08

14 Jan to 13 Feb 1988

Trap No	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	0.01	0.00	0.00	0.00	0.11	0.00	0.00	0.06	0.00	0.11	0.00	0.00	0.00	0.00	0.14
2	0.00	0.00	0.09	0.00	0.12	0.00	0.00	1.47	0.00	0.14	0.00	0.00	0.00	0.00	0.09
3	0.00	0.00	0.50	0.00	0.04	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.15
4	0.01	0.00	0.75	0.00	0.10	0.08	0.00	3.50	0.00	0.04	0.00	0.00	0.05	0.00	0.08
5	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.05
6	0.15	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.10
7	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.55	0.00	0.08
8	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.22	0.00	0.09	0.00	0.00	0.00	0.00	0.10
9	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.17	0.00	0.11	0.00	0.00	0.00	0.00	0.12
10	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.07
11	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.15
12	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.23	0.00	0.05	0.00	0.00	0.00	0.00	0.12
13	0.05	0.00	0.00	0.00	0.09	0.00	0.00	0.38	0.00	0.18	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.58	0.00	0.11	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.07
15	0.00	0.00	0.49	0.00	0.05	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.03
16	0.17	0.00	0.13	0.00	0.40	0.00	0.00	0.17	0.00	0.11	0.00	0.00	0.19	0.00	0.10
17	0.02	0.00	0.10	0.00	0.06	0.00	0.00	0.16	0.00	0.19	0.00	0.00	0.00	0.00	0.10
18	0.00	0.00	1.57	0.00	0.11	0.00	0.00	0.10	0.00	0.05	0.00	0.00	0.00	0.00	0.15

14 Feb to 13 Mar 1988. Sum for the 18 traps.

	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.43	0.00	0.43	0.00	0.00	0.54	0.00	0.23

14 Mar to 13 Apr 1988. Sum for the 18 traps

	0.31	0.00	0.95	0.25	1.03	0.02	0.00	18.14	0.00	1.15	0.23	0.00	2.81	0.00	0.70

Appendix 3 A. Continued.

14 Apr to 12 May 1988. Sum for the 18 traps.

Plot 1					Plot 2					Plot 3				
OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
0.65	0.00	0.50	0.00	1.85	0.25	0.00	1.10	0.00	2.68	0.14	0.00	0.16	0.00	0.58

13 May to 12 Jun 1988

Trap No	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	0.27	0.00	0.56	0.00	2.91	0.44	0.00	0.28	0.00	2.38	0.12	0.00	0.50	0.00	1.34
2	0.51	0.00	1.67	0.00	3.76	0.63	0.00	1.19	0.00	2.80	0.08	0.00	0.50	0.00	1.77
3	0.16	0.00	0.06	0.00	1.92	0.20	0.00	1.02	0.00	2.48	0.15	0.00	0.68	0.00	1.82
4	0.13	0.00	0.07	0.00	2.17	0.41	0.00	0.33	0.00	2.35	0.00	0.00	0.42	0.00	2.36
5	0.29	0.00	0.76	0.00	3.33	0.40	0.00	0.28	0.00	1.70	0.27	0.00	0.19	0.00	1.63
6	0.20	0.00	0.12	0.00	2.07	0.29	0.00	0.68	0.00	2.14	0.18	0.00	1.37	0.00	2.92
7	0.34	0.00	0.05	0.00	3.05	0.68	0.00	1.38	0.00	3.03	0.04	0.00	0.05	0.00	2.99
8	0.33	0.00	0.41	0.00	3.77	0.28	0.00	6.65	0.00	2.80	0.00	0.00	2.62	0.00	3.90
9	0.20	0.00	0.74	0.00	3.04	0.55	0.00	1.86	0.00	4.83	0.24	0.00	0.00	0.00	1.06
10	0.31	0.00	0.71	0.00	3.21	0.32	0.00	0.44	0.00	3.96	0.29	0.00	0.93	0.00	2.47
11	0.21	0.00	0.31	0.00	1.46	0.30	0.00	0.80	0.00	3.26	0.32	0.00	1.36	0.00	2.63
12	0.18	0.00	0.07	0.00	2.84	0.57	0.00	0.95	0.00	3.25	0.16	0.00	0.17	0.00	2.16
13	0.20	0.00	0.33	0.00	2.92	0.32	0.00	0.64	0.00	2.62	0.40	0.00	0.03	0.00	0.60
14	0.41	0.00	1.65	0.00	7.10	0.18	0.00	1.45	0.00	3.65	0.25	0.00	0.05	0.00	1.67
15	0.33	0.00	0.93	0.00	2.75	0.39	0.00	1.98	0.00	7.20	0.16	0.00	0.00	0.00	0.89
16	0.40	0.00	1.24	0.00	2.93	0.25	0.00	3.37	0.00	6.67	0.18	0.00	0.20	0.00	1.21
17	0.32	0.00	0.59	0.00	1.73	0.36	0.00	1.46	0.00	3.18	0.17	0.00	0.20	0.00	2.84
18	0.11	0.00	0.21	0.00	1.57	0.29	0.00	1.71	0.00	3.97	0.12	0.00	0.37	0.00	1.94

13 Jun to 14 Jul 1988

1	0.10	0.00	2.32	0.00	0.93	0.36	0.00	1.88	0.00	1.38	0.18	0.00	2.21	0.00	1.26
2	0.21	0.00	1.30	0.00	2.38	0.29	0.00	2.31	0.00	1.00	0.69	0.00	2.16	0.00	1.51
3	0.11	0.00	0.00	0.00	0.44	0.37	0.00	1.12	0.00	1.18	0.13	0.00	0.27	0.00	1.41
4	0.14	0.00	0.65	0.00	0.65	0.36	0.00	0.43	0.00	1.20	0.11	0.00	1.17	0.00	1.80
5	0.28	0.00	0.88	0.00	0.90	0.15	0.00	3.62	0.00	1.88	0.36	0.00	5.27	0.00	1.45
6	0.74	0.00	1.38	0.00	1.41	0.24	0.00	1.41	0.00	0.51	0.18	0.00	1.15	0.00	1.15
7	0.45	0.00	1.23	0.00	2.05	0.41	0.00	0.77	0.00	1.25	0.17	0.00	0.85	0.00	1.78
8	0.92	0.00	2.65	0.00	2.41	0.31	0.00	0.19	0.00	0.56	0.09	0.00	2.49	0.00	2.48
9	0.55	0.00	0.81	0.00	1.26	0.50	0.00	0.82	0.00	1.61	0.11	0.00	0.29	0.00	0.75
10	0.26	0.00	0.51	0.00	0.45	0.21	0.00	0.89	0.00	0.76	0.15	0.00	1.35	0.00	1.76
11	0.14	0.00	0.87	0.00	0.83	0.12	0.00	0.69	0.00	0.69	0.34	0.00	1.33	0.00	1.94
12	0.12	0.00	0.10	0.00	0.69	0.33	0.00	1.15	0.00	0.81	0.28	0.00	0.40	0.00	0.80
13	0.27	0.00	0.67	0.00	1.17	0.28	0.00	0.46	0.00	0.78	0.06	0.00	0.05	0.00	0.15
14	0.38	0.00	0.64	0.00	0.83	0.45	0.00	0.78	0.00	0.75	0.16	0.00	0.67	0.00	0.64
15	0.50	0.00	0.84	0.00	1.32	0.26	0.00	1.63	0.00	1.30	0.12	0.00	0.73	0.00	0.55
16	0.52	0.00	2.31	0.00	1.29	0.24	0.00	1.48	0.00	1.75	0.15	0.00	0.43	0.00	0.69
17	0.25	0.00	0.96	0.00	0.48	0.33	0.00	0.39	0.00	0.93	0.33	0.00	0.37	0.00	1.08
18	0.44	0.00	1.48	0.00	1.24	0.34	0.00	0.43	0.00	0.97	0.67	0.00	5.04	0.00	1.34

Appendix 3 A. Continued.

15 Jul to 9 Aug 1988

Trap No	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	1.18	0.04	0.48	0.85	0.61	1.03	0.00	0.07	0.68	1.13	0.91	0.00	0.76	0.04	0.72
2	1.04	0.24	1.69	0.00	1.30	1.10	0.00	1.43	0.03	0.78	1.14	0.00	2.40	0.09	1.11
3	0.40	0.01	0.32	0.00	0.30	2.70	0.00	5.63	0.00	1.43	1.32	0.00	0.11	0.00	0.92
4	2.19	0.01	0.68	0.00	0.69	0.86	0.00	1.94	0.25	1.13	2.73	0.01	0.53	0.00	0.91
5	2.19	0.00	6.30	0.21	1.31	0.88	0.00	0.49	0.28	1.14	2.16	0.00	0.91	0.11	1.14
6	0.42	0.00	0.73	0.09	0.68	0.98	0.00	2.01	0.00	0.92	3.40	0.00	0.64	0.00	0.92
7	2.67	0.06	4.60	0.00	0.87	0.91	0.00	4.89	0.00	1.03	1.64	0.03	0.38	0.00	1.35
8	1.78	0.00	2.50	0.45	0.98	0.85	0.00	13.14	0.00	0.93	0.86	0.03	1.23	0.00	1.24
9	2.92	0.00	0.97	0.08	0.97	1.05	0.00	1.30	0.28	1.02	0.98	0.00	0.71	0.00	0.49
10	0.89	0.14	0.36	0.14	0.79	1.28	0.00	0.43	0.00	1.38	2.22	0.00	1.53	0.00	0.93
11	1.90	0.36	0.87	0.07	0.63	0.71	0.00	2.00	0.06	0.59	2.02	0.00	1.00	0.10	0.94
12	0.72	0.11	2.09	0.00	0.79	1.02	0.00	3.17	0.00	0.72	1.90	0.00	2.13	0.00	0.80
13	5.03	0.00	5.98	1.88	1.19	3.95	0.00	1.94	0.67	1.21	0.70	0.05	0.06	0.00	0.34
14	1.27	0.00	12.02	0.26	1.35	0.54	0.00	3.73	0.00	0.78	1.16	0.05	3.33	0.00	0.60
15	2.36	0.02	5.50	0.10	1.03	0.90	0.00	1.29	0.00	2.04	0.74	0.01	0.22	0.21	0.63
16	2.64	0.00	0.69	0.20	0.92	1.23	0.00	7.76	0.15	1.90	0.35	0.00	0.64	0.16	0.78
17	1.08	0.34	0.11	0.17	0.38	0.63	0.00	0.84	0.00	0.78	0.73	0.00	0.09	0.03	0.49
18	1.82	0.10	0.43	0.00	1.14	0.52	0.00	4.92	0.00	1.16	0.76	0.00	0.21	0.00	0.17

10 Aug to 10 Sep 1988

Trap No	Plot 1 OL	Plot 1 BL	Plot 1 SW	Plot 1 F	Plot 1 Mis	Plot 2 OL	Plot 2 BL	Plot 2 SW	Plot 2 F	Plot 2 Mis	Plot 3 OL	Plot 3 BL	Plot 3 SW	Plot 3 F	Plot 3 Mis
1	1.46	0.03	2.72	0.32	0.11	1.59	0.02	0.74	0.98	0.27	1.74	0.00	3.51	0.30	0.46
2	2.25	0.00	1.71	0.30	0.48	0.73	0.00	0.32	0.13	0.26	1.02	0.00	0.13	0.04	0.13
3	0.20	0.00	0.00	0.09	0.10	1.33	0.00	1.25	0.00	0.35	0.54	0.00	0.00	0.00	0.21
4	1.62	0.00	2.28	0.00	0.23	1.65	0.00	4.00	0.04	0.29	0.67	0.00	0.38	0.00	0.24
5	3.08	0.00	2.12	0.78	0.27	1.20	0.01	3.63	0.13	0.41	1.34	0.00	0.72	0.00	0.36
6	0.82	0.00	0.38	0.13	0.08	1.48	0.00	1.86	0.00	0.30	0.65	0.01	1.24	0.00	0.32
7	1.78	0.01	0.30	0.18	0.24	0.41	0.00	0.10	0.00	0.20	1.47	0.00	1.25	0.00	0.27
8	1.84	0.01	1.05	0.10	0.20	0.48	0.00	1.12	0.00	0.35	0.94	0.14	0.47	0.00	0.39
9	2.89	0.00	4.14	0.00	0.57	2.74	0.00	5.82	0.05	0.23	0.54	0.00	0.00	0.01	0.13
10	1.02	0.16	0.00	0.26	0.13	0.91	0.00	0.05	0.10	0.20	0.82	0.00	0.40	0.11	0.31
11	1.35	0.09	1.07	0.10	0.25	4.49	0.00	6.76	0.00	0.21	0.99	0.00	1.85	0.02	0.31
12	0.70	0.17	0.16	0.14	0.15	1.36	0.00	1.70	0.10	0.13	1.03	0.00	0.70	0.18	0.35
13	2.23	0.00	2.57	0.59	0.62	0.36	0.00	0.35	0.11	0.36	0.60	0.26	0.04	0.00	0.04
14	1.30	0.00	0.23	0.31	0.15	1.75	0.00	2.10	1.00	0.22	0.80	0.09	0.13	0.00	0.13
15	1.42	0.02	1.10	0.09	0.16	0.84	0.02	0.23	0.12	0.43	0.55	0.00	0.01	0.05	0.14
16	0.95	0.02	0.16	0.00	0.15	1.07	0.03	0.81	0.30	0.47	1.16	0.12	0.07	0.00	0.15
17	1.08	0.22	0.16	0.49	0.10	1.09	0.00	0.96	0.00	0.22	0.87	0.00	0.23	0.00	0.15
18	1.13	0.08	0.20	0.07	0.10	1.17	0.00	0.29	0.07	0.21	1.07	0.00	0.47	0.09	0.11

Appendix 3 A. Continued.

11 Sep to 12 Oct 1988

Trap No	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	8.09	0.84	6.84	1.91	0.53	5.93	0.96	8.22	0.55	0.74	6.73	0.22	11.06	0.10	0.80
2	9.05	0.30	5.50	0.20	0.94	4.82	0.05	4.16	0.00	0.34	4.32	0.38	3.99	0.00	0.44
3	5.39	0.14	2.27	0.00	0.32	5.45	0.11	7.56	0.00	1.07	3.94	0.08	3.64	0.00	0.46
4	7.41	0.30	12.23	0.16	0.78	4.80	0.01	1.88	0.00	0.68	5.72	0.00	3.03	0.00	0.47
5	12.62	0.07	13.12	1.10	0.89	2.06	1.13	0.90	0.00	0.54	5.15	0.07	3.18	0.00	0.27
6	6.16	0.07	1.52	0.09	0.40	3.37	0.30	5.72	0.00	0.51	3.71	0.17	5.50	0.00	0.56
7	8.66	0.02	3.65	0.23	0.42	5.46	0.06	2.36	0.03	0.37	5.86	0.05	7.53	0.00	0.68
8	11.08	0.06	11.59	0.00	1.16	4.61	0.09	0.40	0.00	0.32	7.31	0.64	9.77	0.00	1.15
9	10.97	0.11	3.66	0.00	0.76	4.12	0.06	1.13	0.00	0.48	1.60	0.00	0.89	0.04	0.22
10	10.50	0.86	4.37	0.00	0.42	4.91	0.11	1.70	0.00	0.51	5.60	0.01	4.21	0.00	0.52
11	5.26	0.76	2.74	0.14	0.43	2.42	0.09	0.47	0.00	0.23	3.18	0.03	2.10	0.00	0.60
12	6.53	0.52	9.70	0.02	0.96	3.29	0.03	4.14	0.08	0.96	6.18	0.04	1.01	0.00	0.87
13	8.79	0.06	9.48	0.98	1.01	5.89	0.29	2.92	0.09	0.34	2.15	2.21	0.13	0.00	0.18
14	8.57	0.25	1.52	0.05	0.38	9.33	0.04	2.27	0.42	0.46	3.33	0.84	0.58	0.03	0.27
15	8.38	0.15	9.34	0.35	0.87	7.23	0.29	7.46	0.10	1.02	3.70	0.18	0.06	0.00	0.27
16	8.99	0.22	5.78	0.00	0.61	7.82	0.14	4.20	0.20	1.11	5.74	0.66	2.44	0.00	0.49
17	8.86	1.18	10.79	0.00	0.32	4.33	0.42	0.60	0.00	0.27	5.79	0.03	9.91	0.00	0.40
18	9.18	0.49	10.05	0.41	0.47	7.05	0.04	3.38	0.00	0.53	3.84	0.08	7.60	0.00	0.44

APPENDIX 3

Appendix 3 B.

Oven-dried (85 °C) masses of; (OL) oak leaves, (BL) birch leaves, (SW) small wood, (F) fruit, and (Mis) miscellaneous litterfall produced during between each sampling period in each of the eighteen litter traps in each of the of the three plots in Gartfairn. Asterisk indicate missed sample.

17 Oct to 6 Nov 1987

Trap No	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	3.51	4.45	0.33	0.00	0.18	5.44	4.38	2.07	0.00	0.11	9.07	2.58	0.42	0.09	0.13
2	2.83	5.14	0.61	0.00	0.46	7.07	3.47	0.37	0.00	0.08	9.36	2.74	2.44	0.00	0.10
3	2.45	2.57	0.18	0.00	0.16	1.91	5.12	0.00	0.00	0.08	7.69	1.28	0.73	2.09	0.00
4	1.98	4.85	0.00	0.00	0.14	9.30	2.37	0.17	0.65	0.06	4.63	1.09	0.04	0.00	0.14
5	2.87	4.96	0.11	0.00	0.45	12.05	2.52	0.00	0.00	0.08	5.31	1.55	0.61	3.90	0.48
6	1.98	4.48	0.00	0.00	0.32	9.45	1.49	0.93	0.00	0.16	4.46	0.56	2.78	0.41	0.18
7	5.08	1.46	0.31	0.11	0.11	2.29	4.90	0.08	0.11	0.09	4.83	4.16	0.00	0.00	0.10
8	2.95	0.78	0.32	0.00	0.06	6.59	3.16	0.13	0.00	0.25	11.53	2.30	2.75	0.00	0.06
9	6.90	2.39	0.64	0.00	0.20	7.37	2.93	0.00	0.00	0.13	4.12	2.28	0.00	0.30	0.06
10	12.00	0.95	1.52	1.14	0.17	5.63	5.13	0.00	0.00	0.17	4.61	1.59	0.27	0.06	0.07
11	3.21	3.05	1.55	0.00	0.38	6.72	2.22	0.22	1.10	0.12	2.62	2.44	0.00	0.08	0.14
12	4.62	4.55	0.60	0.00	0.30	6.56	3.12	0.00	0.00	0.12	6.16	1.48	0.00	0.29	0.15
13	2.87	1.10	0.51	0.00	0.10	7.75	2.83	0.00	0.00	0.12	12.46	1.09	0.75	0.68	0.13
14	7.26	0.95	0.65	0.51	0.20	5.80	2.43	0.56	0.54	0.12	9.31	5.05	0.73	0.00	0.10
15	6.57	0.83	1.24	2.68	0.31	9.31	2.44	0.81	0.00	0.22	8.33	0.64	0.72	1.77	0.10
16	5.86	2.46	0.48	0.00	0.47	7.78	3.03	0.90	0.29	0.20	1.87	3.43	0.74	0.00	0.33
17	1.43	4.56	0.00	0.57	0.28	12.23	1.26	0.38	0.00	0.11	4.15	1.50	0.30	0.15	0.14
18	0.00	2.14	1.22	0.64	0.44	11.66	2.54	3.63	0.00	0.22	3.30	1.48	0.07	1.05	0.06

7 Nov to 22 Nov 1987

1	20.07	3.82	0.22	0.00	0.27	15.52	2.21	0.11	0.00	0.20	22.19	0.30	2.14	0.23	0.32
2	12.12	9.34	0.07	0.00	0.31	13.94	4.54	0.42	0.00	0.24	26.00	2.30	1.77	0.21	0.23
3	17.37	1.33	2.57	0.00	0.26	21.46	1.33	0.33	0.50	0.28	18.42	0.47	9.85	1.50	0.45
4	16.86	2.62	0.22	0.05	0.22	20.72	1.43	1.10	0.00	0.42	17.10	0.59	0.44	0.41	0.51
5	14.80	2.61	0.03	0.00	0.45	13.99	1.14	0.87	0.00	0.35	21.14	1.12	1.37	3.84	0.61
6	16.09	1.46	0.64	0.00	0.46	23.84	0.98	2.58	0.56	0.36	12.26	0.33	1.20	1.70	0.23
7	27.15	0.61	0.48	0.71	0.24	12.44	2.16	1.28	0.00	0.18	12.51	2.06	0.47	0.72	0.08
8	17.57	0.26	1.29	0.00	0.29	16.12	1.86	0.65	0.00	0.34	25.38	0.35	0.63	0.90	0.18
9	23.14	0.83	0.18	0.32	0.27	20.99	1.01	0.31	0.65	0.17	23.47	0.21	0.42	0.44	0.33
10	26.84	0.70	1.24	2.22	0.37	19.51	3.45	0.64	0.00	0.23	19.39	0.49	0.24	0.41	0.14
11	19.00	1.72	3.91	0.00	0.49	13.82	1.63	0.36	1.09	0.18	17.89	1.70	1.05	0.14	0.32
12	23.86	2.12	0.10	0.16	0.37	23.27	1.20	0.33	0.00	0.21	22.26	0.73	0.91	0.70	0.32
13	19.72	0.13	4.52	0.23	0.27	23.02	1.87	0.12	0.00	0.36	12.79	0.14	0.45	0.81	0.15
14	21.09	1.21	0.38	0.47	0.30	25.51	1.92	0.10	0.00	0.34	11.15	3.23	1.76	0.46	0.10
15	21.38	0.90	1.60	1.30	0.32	24.80	3.02	1.31	0.00	0.54	15.48	0.34	0.92	2.95	0.22
16	22.40	0.61	3.56	1.29	0.47	24.85	1.09	1.86	0.24	0.33	9.55	2.78	0.37	0.00	0.28
17	17.03	1.76	0.00	0.39	0.49	25.39	2.50	1.68	0.00	0.34	21.57	0.31	0.31	1.20	0.18
18	25.69	1.12	1.07	0.90	0.45	27.80	1.82	1.73	0.04	0.67	17.81	0.78	0.56	0.00	0.41

Appendix 3 B. Continued

23 Nov to 13 Dec 1987

Trap No	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	4.40	0.00	0.07	0.00	0.00	0.35	0.00	0.00	0.00	0.00	4.24	0.00	0.27	0.00	0.05
2	5.02	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	2.97	0.00	0.21	0.00	0.04
3	4.58	0.00	0.00	0.00	0.03	1.51	0.00	0.00	0.00	0.02	6.49	0.00	0.00	0.37	0.12
4	6.26	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	5.80	0.00	0.26	0.63	0.08
5	4.31	0.00	0.08	0.00	0.00	0.84	0.00	0.00	0.00	0.00	6.90	0.00	0.00	0.10	0.10
6	9.61	0.00	0.00	0.00	0.15	0.42	0.00	0.00	0.00	0.00	2.69	0.00	0.00	0.00	0.00
7	1.98	0.00	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	1.85	0.00	0.00	0.00	0.10
8	5.30	0.00	0.00	0.11	0.03	3.12	0.00	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.03
9	10.05	0.00	0.00	0.00	0.07	0.19	0.00	0.00	0.00	0.00	4.35	0.00	0.00	0.00	0.05
10	3.38	0.00	0.00	0.00	0.06	0.53	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.07
11	6.36	0.00	0.00	0.00	0.05	0.31	0.00	0.00	0.00	0.00	1.11	0.00	0.06	0.27	0.02
12	6.08	0.00	0.00	0.00	0.08	0.66	0.00	0.00	0.00	0.00	1.38	0.00	0.05	0.00	0.04
13	5.46	0.00	0.02	0.00	0.05	3.78	0.00	0.00	0.03	0.00	2.47	0.00	0.00	0.82	0.00
14	1.92	0.00	0.06	0.00	0.03	1.63	0.00	0.00	0.00	0.00	1.34	0.00	0.17	0.00	0.05
15	2.90	0.00	0.00	0.00	0.05	1.90	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00	0.02
16	3.70	0.00	0.00	0.00	0.07	0.46	0.00	0.00	0.00	0.00	2.20	0.00	0.00	0.55	0.02
17	8.46	0.00	0.00	0.00	0.13	0.57	0.00	0.00	0.00	0.00	2.03	0.00	0.00	0.00	0.00
18	8.16	0.00	0.00	0.00	0.08	0.96	0.10	0.00	0.00	0.09	3.19	0.00	0.18	0.00	0.02

14 Dec 1987 to 12 Jan 1988

Trap No	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	1.10	0.00	0.51	0.00	0.33	0.27	0.00	0.84	0.00	0.13	0.45	0.00	0.13	0.00	0.15
2	1.33	0.00	0.00	0.00	0.25	0.09	0.00	1.76	0.00	0.14	0.48	0.00	0.50	0.00	0.20
3	1.48	0.00	0.00	0.00	0.36	0.13	0.00	0.33	0.00	0.14	1.62	0.00	0.07	0.00	0.31
4	0.89	0.00	12.28	0.00	0.20	0.29	0.00	1.11	0.00	0.20	0.32	0.00	0.20	0.00	0.12
5	1.13	0.00	0.00	0.00	0.47	0.12	0.00	3.96	0.00	0.15	1.41	0.00	1.02	0.00	0.83
6	1.56	0.00	0.00	0.00	0.39	0.14	0.00	0.15	0.00	0.22	0.00	0.00	0.47	0.00	0.76
7	1.53	0.00	0.90	0.00	0.27	0.67	0.00	0.34	0.00	0.09	0.21	0.00	0.17	0.00	0.86
8	2.29	0.00	0.00	0.00	0.22	0.30	0.00	0.14	0.00	0.19	0.25	0.00	1.44	0.00	0.12
9	1.09	0.00	1.62	0.00	0.37	0.41	0.00	0.32	0.00	0.22	0.72	0.00	0.00	0.00	0.16
10	0.64	0.00	0.04	0.00	0.36	0.00	0.00	0.47	0.00	0.08	0.41	0.00	0.00	0.00	0.52
11	1.61	0.00	0.09	0.00	0.32	0.07	0.00	0.38	0.00	0.12	0.00	0.00	0.00	0.00	0.30
12	1.21	0.00	1.50	0.00	0.29	0.81	0.00	0.00	0.00	0.44	0.31	0.00	0.66	0.00	0.12
13	1.18	0.00	0.13	0.00	0.31	0.23	0.00	0.00	0.00	0.13	0.37	0.00	0.32	0.00	0.14
14	0.76	0.00	0.00	0.00	0.40	0.71	0.00	0.00	0.00	0.16	0.41	0.00	0.07	0.00	0.05
15	1.10	0.00	0.00	0.00	0.48	1.15	0.00	0.11	0.00	0.44	0.44	0.00	0.11	0.00	0.34
16	1.02	0.00	1.88	0.00	0.27	0.85	0.00	0.00	0.00	0.20	0.72	0.00	0.00	0.00	0.09
17	1.06	0.00	0.28	0.00	0.44	0.60	0.00	0.07	0.00	0.14	0.54	0.00	0.46	0.00	0.11
18	0.81	0.00	0.77	0.00	0.40	0.39	0.00	0.03	0.00	0.21	0.18	0.00	0.42	0.00	0.18

Appendix 3 B. Continued

13 Jan to 12 Feb 1988

Trap No	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	0.20	0.00	3.93	0.00	0.15	0.00	0.00	3.49	0.00	0.10	0.00	0.00	0.47	0.00	0.15
2	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.26	0.00	0.10	0.16	0.00	0.21	0.00	0.12
3	0.00	0.00	1.62	0.00	0.15	0.00	0.00	0.20	0.00	0.15	0.00	0.00	0.23	0.00	0.09
4	0.00	0.00	0.90	0.00	0.21	0.06	0.00	0.30	0.00	0.08	0.00	0.00	1.18	0.00	0.24
5	0.04	0.00	17.16	0.00	0.35	0.02	0.00	1.01	0.00	0.20	0.02	0.00	0.80	0.00	0.14
6	0.00	0.00	1.08	0.00	0.13	0.00	0.00	1.31	0.00	0.06	0.00	0.00	0.00	0.00	0.10
7	0.18	0.00	1.06	0.00	0.30	0.00	0.00	1.69	0.00	0.07	0.15	0.00	0.64	0.00	0.09
8	0.04	0.00	0.21	0.00	0.14	0.00	0.00	0.65	0.00	0.03	0.00	0.00	0.15	0.00	0.35
9	0.11	0.00	0.44	0.00	0.18	0.00	0.00	0.44	0.00	0.15	0.00	0.00	1.50	0.00	0.22
10	0.05	0.00	0.28	0.00	0.11	0.00	0.00	0.14	0.00	0.11	0.01	0.00	1.52	0.00	0.10
11	0.03	0.00	0.70	0.00	0.20	0.00	0.00	1.10	0.00	0.04	0.01	0.00	0.10	0.00	0.07
12	0.00	0.00	1.21	0.00	0.15	0.00	0.00	1.47	0.00	0.19	0.00	0.00	2.87	0.00	0.10
13	0.03	0.00	5.76	0.00	0.14	0.00	0.00	5.78	0.00	0.28	0.00	0.00	0.51	0.00	0.11
14	0.06	0.00	0.10	0.00	0.10	0.00	0.00	1.00	0.00	0.13	0.07	0.00	1.48	0.00	0.12
15	0.03	0.00	0.26	0.00	0.12	0.00	0.00	1.40	0.00	0.27	0.00	0.00	0.23	0.00	0.08
16	0.18	0.00	0.40	0.00	0.32	0.03	0.00	0.39	0.00	0.20	0.01	0.00	0.41	0.00	0.16
17	0.00	0.00	0.40	0.00	0.11	0.02	0.00	0.12	0.00	0.14	0.19	0.00	1.82	0.00	0.10
18	0.07	0.00	0.17	0.00	0.16	0.02	0.00	0.78	0.00	0.16	0.00	0.00	0.13	0.00	0.18

13 Feb to 14 Mar 1988. Sum for the 18 traps.

0.61	0.00	1.57	0.00	0.90	0.47	0.00	5.18	0.00	0.52	0.74	0.00	0.97	0.00	0.83

15 Mar to 13 Apr 1988. Sum for the 18 traps.

1.40	0.00	2.02	0.00	1.22	0.50	0.00	3.62	0.00	1.24	0.34	0.00	2.54	0.00	1.28

14 Apr 1988 to 12 May 1988. Sum for the 18 traps.

0.34	0.34	2.56	0.00	5.00	0.45	0.25	8.24	0.00	7.72	1.10	0.11	7.33	0.00	9.90

Appendix 3 B. Continued

13 May to 12 Jun 1988

Trap No	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	0.22	0.00	0.97	0.00	1.30	0.54	0.00	0.75	0.00	0.89	0.18	0.00	0.65	0.00	1.80
2	0.12	0.00	0.45	0.00	1.99	0.05	0.00	1.03	0.00	1.11	0.09	0.00	1.52	0.00	2.45
3	0.60	0.00	0.61	0.00	2.42	0.11	0.00	0.26	0.00	1.28	0.90	0.00	3.56	0.00	2.28
4	0.27	0.00	0.18	0.00	1.77	0.00	0.00	0.00	0.00	1.11	0.51	0.00	2.31	0.00	2.49
5	0.09	0.00	1.96	0.00	1.63	0.00	0.00	0.14	0.00	1.08	0.61	0.00	1.01	0.00	3.18
6	0.19	0.00	0.95	0.00	1.77	0.09	0.00	1.13	0.00	1.59	0.47	0.00	2.81	0.00	2.59
7	0.13	0.00	1.45	0.00	2.20	0.05	0.00	0.08	0.00	1.19	0.16	0.00	0.21	0.00	1.48
8	0.67	0.00	0.31	0.00	1.37	0.15	0.00	1.37	0.00	2.36	0.31	0.00	0.17	0.00	2.92
9	0.11	0.00	2.85	0.00	1.80	0.07	0.00	0.24	0.00	0.77	0.11	0.00	3.17	0.00	3.34
10	0.25	0.00	1.66	0.00	1.77	0.14	0.00	0.00	0.00	1.27	0.89	0.00	2.11	0.00	3.39
11	0.52	0.00	0.53	0.00	1.57	0.07	0.00	0.91	0.00	1.97	0.21	0.00	1.49	0.00	2.15
12	0.20	0.00	0.32	0.00	1.32	0.10	0.00	0.30	0.00	1.77	0.05	0.00	6.77	0.00	3.34
13	0.38	0.00	0.63	0.00	1.99	0.11	0.00	3.76	0.00	2.09	0.85	0.00	2.11	0.00	2.47
14	0.35	0.00	0.85	0.00	2.41	0.18	0.00	1.52	0.00	1.16	0.10	0.00	0.64	0.00	1.81
15	0.30	0.00	0.65	0.00	1.68	0.23	0.00	2.21	0.00	2.14	0.48	0.00	1.29	0.00	1.75
16	0.10	0.00	0.96	0.00	1.67	0.10	0.00	5.64	0.00	2.44	0.39	0.00	0.41	0.00	2.01
17	0.17	0.00	2.39	0.00	1.68	0.81	0.00	0.21	0.00	1.66	0.12	0.00	2.45	0.00	3.21
18	0.28	0.00	6.44	0.00	2.45	0.04	0.00	0.81	0.00	2.72	0.07	0.00	3.63	0.00	2.98

13 Jun to 13 Jul 1988

Trap No	Plot 4 OL	Plot 4 BL	Plot 4 SW	Plot 4 F	Plot 4 Mis	Plot 5 OL	Plot 5 BL	Plot 5 SW	Plot 5 F	Plot 5 Mis	Plot 6 OL	Plot 6 BL	Plot 6 SW	Plot 6 F	Plot 6 Mis
1	0.38	0.00	1.12	0.00	1.06	0.72	0.00	1.91	0.00	0.96	0.70	0.00	2.69	0.00	1.05
2	0.89	0.00	1.72	0.00	1.26	0.77	0.00	1.87	0.00	0.56	1.18	0.00	0.54	0.00	1.09
3	0.46	0.00	1.93	0.00	1.70	0.28	0.00	1.69	0.00	1.10	0.50	0.00	3.88	0.00	1.76
4	0.50	0.00	0.00	0.00	0.47	0.26	0.00	0.26	0.00	1.17	0.97	0.00	2.44	0.00	1.36
5	0.51	0.00	0.68	0.00	0.67	0.34	0.00	0.00	0.00	0.65	1.86	0.00	6.75	0.00	2.29
6	0.48	0.00	2.10	0.00	0.67	0.14	0.00	0.89	0.00	1.73	0.67	0.00	2.14	0.00	2.06
7	0.90	0.00	1.06	0.00	1.27	0.56	0.00	0.14	0.00	0.69	0.60	0.00	0.12	0.00	0.65
8	1.05	0.00	2.38	0.00	1.35	0.67	0.00	1.08	0.00	1.80	1.52	0.00	0.41	0.00	1.30
9	1.02	0.00	1.85	0.00	1.44	0.09	0.00	0.97	0.00	0.71	0.70	0.00	1.95	0.00	1.90
10	0.67	0.00	3.02	0.00	1.78	0.65	0.00	0.20	0.00	0.65	0.88	0.00	0.97	0.00	1.55
11	0.43	0.00	1.62	0.00	0.88	0.42	0.00	1.26	0.00	1.16	0.46	0.00	1.66	0.00	1.03
12	0.50	0.00	0.47	0.00	0.66	1.20	0.00	0.93	0.00	1.73	1.24	0.00	1.30	0.00	1.48
13	0.83	0.00	1.97	0.00	1.52	0.85	0.00	7.81	0.00	1.27	1.41	0.00	6.17	0.00	0.98
14	0.65	0.00	1.22	0.00	1.57	0.70	0.00	0.76	0.00	1.02	1.62	0.00	0.44	0.00	1.12
15	0.73	0.00	1.46	0.00	1.56	1.22	0.00	1.61	0.00	1.90	0.96	0.00	1.73	0.00	1.50
16	0.37	0.00	1.08	0.00	1.24	0.83	0.00	1.49	0.00	0.84	0.70	0.00	1.00	0.00	0.60
17	0.61	0.00	2.18	0.00	0.78	0.72	0.00	3.36	0.00	1.29	0.95	0.00	0.77	0.00	0.86
18	0.51	0.00	1.04	0.00	1.21	0.93	0.00	2.30	0.00	1.37	1.02	0.00	1.15	0.00	1.54

Appendix 3 B. Continued

14 Jul to 9 Aug 1988

Trap No	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	1.90	0.21	0.60	0.14	0.71	0.41	0.46	0.92	0.14	1.15	0.19	0.23	1.44	0.12	0.54
2	2.83	0.46	2.42	0.00	0.60	0.60	0.13	3.47	0.44	0.84	0.89	0.20	3.27	0.11	0.66
3	2.72	0.32	1.17	0.53	0.73	0.82	0.40	2.00	0.25	0.64	1.51	0.19	1.01	0.42	0.83
4	1.22	0.14	0.36	0.07	0.51	0.21	0.25	0.72	0.25	0.66	0.87	0.36	1.82	0.23	0.67
5	0.51	0.46	0.82	0.26	0.61	0.20	0.52	0.38	0.05	0.65	3.42	0.15	1.81	1.39	0.87
6	0.70	0.26	1.14	0.00	0.84	0.26	0.18	0.48	0.35	1.00	0.42	0.02	0.31	1.66	0.68
7	1.75	0.18	2.48	0.11	0.95	0.41	0.26	1.61	0.06	0.71	0.39	0.71	0.77	0.05	0.71
8	1.10	0.28	0.73	0.00	0.65	0.56	0.28	0.12	0.20	0.65	2.38	0.89	1.44	0.24	0.72
9	1.64	0.20	0.84	0.21	0.74	0.18	0.13	0.60	0.00	0.60	1.17	0.28	0.80	0.21	0.79
10	2.30	0.15	0.42	0.41	0.76	0.61	0.73	1.22	0.00	0.93	0.52	0.13	0.19	0.16	0.44
11	1.19	0.56	1.33	0.15	0.70	0.90	0.06	1.10	0.06	0.76	0.74	0.12	1.54	0.38	0.76
12	1.35	0.57	0.51	0.00	0.87	1.38	0.11	0.92	0.16	0.85	1.07	0.11	2.80	0.04	1.00
13	0.86	0.31	0.82	0.12	0.63	0.53	0.15	0.93	0.00	0.35	1.16	0.13	1.11	0.15	0.48
14	1.40	0.14	2.72	0.04	0.71	1.84	0.18	0.80	0.33	0.60	0.66	0.25	0.81	0.00	0.41
15	0.98	0.16	0.80	0.16	0.74	1.23	0.26	13.04	0.10	1.03	0.72	0.02	0.00	0.43	0.17
16	1.16	0.15	3.29	0.64	1.14	0.35	0.15	1.44	0.37	0.91	0.68	0.30	2.02	0.18	0.53
17	1.04	0.39	1.11	0.35	0.59	0.74	0.14	0.87	0.21	0.90	1.14	0.14	0.96	0.14	0.51
18	1.68	0.37	7.66	0.53	0.95	0.51	0.24	16.22	0.44	0.87	7.31	0.11	5.05	1.76	0.81

10 Aug to 10 Sep 1988

Trap No	Plot 4 OL	Plot 4 BL	Plot 4 SW	Plot 4 F	Plot 4 Mis	Plot 5 OL	Plot 5 BL	Plot 5 SW	Plot 5 F	Plot 5 Mis	Plot 6 OL	Plot 6 BL	Plot 6 SW	Plot 6 F	Plot 6 Mis
1	0.64	0.82	0.55	0.00	0.28	0.33	1.10	0.18	0.00	1.02	0.31	0.58	0.62	0.17	0.61
2	0.56	0.66	0.63	0.27	0.23	0.31	0.43	0.61	0.28	0.70	0.82	0.58	0.14	0.07	0.47
3	0.32	1.02	0.09	1.67	0.40	0.34	0.73	0.31	0.48	0.43	0.92	0.70	1.27	0.10	0.55
4	0.47	0.60	0.01	0.00	0.30	0.30	0.73	0.17	0.55	0.36	0.43	0.66	0.04	0.09	0.42
5	0.38	0.60	0.00	0.06	0.37	0.25	1.40	0.05	0.06	0.20	0.78	0.40	2.12	0.75	0.41
6	0.60	1.10	1.49	0.09	0.45	0.32	0.37	0.36	0.87	0.43	0.64	0.11	0.49	0.91	0.49
7	1.01	0.40	0.20	0.00	0.31	0.12	0.84	2.25	0.22	1.74	0.45	0.84	0.05	0.00	0.27
8	1.02	0.69	0.22	0.00	0.17	0.23	0.45	0.37	1.36	0.93	0.29	0.92	0.48	0.00	0.49
9	0.96	0.41	0.07	0.09	0.36	0.24	0.34	1.53	0.00	0.53	1.07	1.04	0.25	0.05	0.44
10	0.55	0.26	0.37	0.26	0.32	0.24	2.51	0.66	0.00	0.91	0.91	0.46	0.62	0.41	0.32
11	0.31	0.88	0.82	0.30	0.32	1.41	0.32	1.24	0.00	0.62	0.64	0.18	0.02	0.03	0.93
12	1.22	0.80	0.30	0.00	0.30	0.50	2.17	0.26	0.00	0.69	0.77	0.42	4.41	0.72	0.63
13	0.67	0.88	0.16	0.01	0.21	1.13	0.24	0.40	0.14	0.42	0.34	0.56	0.62	0.24	0.18
14	0.72	0.13	2.17	0.00	0.31	0.48	0.36	1.86	0.78	0.49	0.94	0.46	0.25	0.00	0.33
15	1.47	0.16	1.60	0.00	0.43	1.30	0.45	0.78	0.28	0.60	1.00	0.27	0.89	1.35	0.34
16	1.08	0.21	0.41	0.20	0.18	1.09	1.00	0.47	0.51	0.31	0.25	1.03	0.26	0.18	0.65
17	0.41	1.82	0.33	0.21	0.32	1.36	0.42	0.28	0.18	0.43	3.67	0.67	0.97	0.00	0.54
18	0.93	0.46	0.64	1.14	0.24	0.70	0.49	0.99	0.50	0.52	1.18	0.51	0.22	0.50	0.36

Appendix 3 B. Continued

11 Sep to 13 Oct 1988

Trap No	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	2.54	3.27	7.74	1.83	0.81	2.12	3.00	1.40	0.00	0.55	5.05	1.76	11.75	0.00	1.04
2	1.84	3.25	1.09	0.00	1.93	2.52	1.89	2.56	0.00	0.54	9.83	1.73	4.66	0.37	1.09
3	3.04	3.30	2.96	0.47	0.74	3.40	2.17	6.34	0.23	0.95	6.08	2.06	3.78	0.00	0.66
4	6.53	3.38	1.65	0.00	0.71	2.57	2.07	1.63	0.11	0.61	6.26	2.71	4.40	0.07	1.50
5	1.62	3.04	0.59	0.00	0.37	4.69	3.56	0.91	0.00	0.56	8.85	2.78	5.08	0.11	1.18
6	1.95	4.46	0.65	0.06	0.69	4.15	1.43	3.05	1.03	1.17	4.66	0.75	3.95	0.37	1.14
7	3.18	2.60	3.85	0.07	0.42	2.30	3.51	0.95	0.00	0.70	3.75	2.64	1.67	0.11	0.58
8	4.63	2.65	3.70	0.00	0.53	7.87	2.69	18.47	0.13	1.01	3.71	2.89	1.36	0.00	1.02
9	2.99	2.79	3.34	0.00	0.66	2.78	2.36	0.49	0.00	0.65	4.40	2.08	5.46	0.00	0.57
10	4.49	1.94	4.78	0.10	0.94	1.90	5.03	1.04	0.00	1.02	3.99	2.42	3.87	0.00	0.63
11	3.06	5.04	8.36	0.43	2.04	6.67	2.04	9.32	0.00	0.79	2.13	2.28	0.86	0.00	0.79
12	4.93	4.01	1.48	0.00	0.96	2.92	3.74	5.41	0.00	0.56	3.80	2.84	1.77	0.00	0.65
13	3.06	2.01	3.10	0.05	0.44	4.57	2.15	0.68	1.78	0.61	1.80	1.29	1.74	0.35	0.40
14	4.53	0.95	10.32	0.00	0.63	4.04	2.18	1.40	0.05	0.58	4.36	1.35	3.90	0.00	0.50
15	6.07	1.25	3.04	1.09	0.69	15.25	1.54	7.05	0.49	1.27	4.55	1.49	2.52	0.61	0.56
16	4.10	1.26	7.05	0.00	1.21	6.33	3.18	8.34	0.08	0.96	2.20	2.88	1.34	0.00	0.72
17	5.12	4.72	7.50	0.09	1.19	6.65	2.32	11.99	0.14	1.13	3.40	3.04	0.38	0.04	0.78
18	4.98	2.31	4.70	1.14	0.73	6.67	3.28	2.85	1.32	1.02	2.97	2.74	6.72	0.00	1.29

Appendix 3 C.

Oven-dried (85 °C) masses of; (OL) oak leaves, (BL) birch leaves, (SW) small wood, (F) fruit, and (Mis) miscellaneous litterfall produced during between each sampling period in each of the eighteen litter traps in each of the of the three plots in Gartfairn. Asterisk indicate missed sample.

Trap No	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 Apr to 18 May 1988. Sum for the 18 traps															
0	0.11	0.00	4.73	0.00	5.54	0.36	0.00	14.89	0.00	8.21	0.09	0.00	2.45	0.00	2.66
19 May to 17 Jun 1988															
1	0.17	0.00	0.92	0.00	15.61	0.16	0.00	0.75	0.00	3.53	0.35	0.00	3.54	0.00	3.82
2	0.39	0.00	0.40	0.00	9.71	0.03	0.00	0.29	0.00	4.22	0.36	0.00	4.77	0.00	3.40
3	0.23	0.00	0.36	0.00	6.57	0.30	0.00	1.20	0.00	5.63	0.04	0.00	2.16	0.00	3.81
4	0.29	0.00	1.51	0.00	5.07	0.16	0.00	1.31	0.00	4.16	0.11	0.00	0.00	0.00	2.72
5	0.68	0.00	1.14	0.00	5.60	0.09	0.00	0.61	0.00	5.28	0.25	0.00	0.32	0.00	2.11
6	0.18	0.00	0.53	0.00	4.87	1.30	0.00	2.72	0.00	6.49	0.14	0.00	0.68	0.00	3.44
7	0.38	0.00	3.80	0.00	3.96	0.05	0.00	0.27	0.00	2.89	0.52	0.00	0.73	0.00	3.18
8	1.08	0.00	4.04	0.00	3.99	0.06	0.00	1.05	0.00	4.64	0.54	0.00	0.82	0.00	2.91
9	0.32	0.00	0.84	0.00	3.48	0.28	0.00	0.74	0.00	4.40	0.10	0.00	0.54	0.00	3.17
10	0.50	0.00	1.99	0.00	4.19	0.23	0.00	0.76	0.00	4.76	0.17	0.00	0.46	0.00	3.38
11	0.50	0.00	0.20	0.00	3.76	0.14	0.00	0.34	0.00	4.03	0.21	0.00	1.79	0.00	5.41
12	0.28	0.00	1.13	0.00	2.96	0.12	0.00	0.55	0.00	5.08	0.18	0.00	2.60	0.00	4.58
13	0.17	0.00	2.05	0.00	4.01	0.10	0.00	0.33	0.00	2.38	0.04	0.00	0.66	0.00	3.89
14	0.34	0.00	0.31	0.00	4.53	0.14	0.00	0.66	0.00	3.26	0.06	0.00	0.02	0.00	0.98
15	0.14	0.00	1.33	0.00	3.20	0.33	0.00	0.51	0.00	4.45	0.14	0.00	0.54	0.00	3.93
16	0.26	0.00	0.07	0.00	4.31	0.33	0.00	1.47	0.00	4.18	0.34	0.00	1.10	0.00	3.10
17	0.56	0.00	2.07	0.00	3.64	0.53	0.00	0.28	0.00	4.36	0.67	0.00	0.56	0.00	3.94
18	0.25	0.00	0.67	0.00	4.65	0.36	0.00	0.72	0.00	6.17	0.07	0.00	1.40	0.00	2.78

Appendix 3C. Continued.

18 Jun to 19 Jul 1988

Trap No	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	1.26	0.00	2.12	0.00	4.20	0.55	0.00	3.35	0.00	2.43	0.63	0.00	5.41	0.00	2.42
2	0.60	0.00	2.07	0.00	3.87	0.67	0.00	3.29	0.00	3.51	0.92	0.00	1.64	0.00	2.10
3	2.65	0.00	3.96	0.00	3.57	0.90	0.00	2.07	0.00	2.54	1.23	0.00	1.33	0.00	2.69
4	1.36	0.00	2.21	0.00	3.10	0.72	0.00	4.00	0.00	3.14	0.58	0.00	2.33	0.00	3.32
5	2.61	0.00	5.77	0.00	5.61	1.65	0.00	2.93	0.00	2.81	0.86	0.00	0.74	0.00	2.23
6	2.33	0.00	1.31	0.00	4.28	1.45	0.00	4.70	0.00	3.40	0.95	0.00	1.80	0.00	2.68
7	2.43	0.00	2.27	0.00	2.31	0.94	0.00	1.21	0.00	2.70	0.86	0.00	2.95	0.00	1.46
8	1.66	0.00	1.15	0.00	1.88	0.58	0.00	2.45	0.00	1.71	0.56	0.00	1.11	0.00	2.17
9	1.41	0.00	2.05	0.00	2.41	0.92	0.00	0.98	0.00	3.67	1.45	0.00	2.80	0.00	3.72
10	1.56	0.00	2.77	0.00	3.51	0.74	0.00	1.61	0.00	1.85	1.54	0.00	1.41	0.00	3.27
11	1.05	0.00	0.73	0.00	2.24	1.92	0.00	0.53	0.00	2.06	1.21	0.00	2.96	0.00	2.86
12	1.21	0.00	0.55	0.00	2.37	0.92	0.00	2.48	0.00	3.53	1.95	0.00	4.03	0.00	3.75
13	1.31	0.00	0.86	0.00	2.04	0.73	0.00	0.96	0.00	1.88	0.61	0.00	0.10	0.00	0.81
14	1.68	0.00	2.31	0.00	2.63	0.43	0.00	1.01	0.00	2.24	1.36	0.00	2.01	0.00	2.90
15	0.77	0.00	2.10	0.00	1.62	0.95	0.00	0.89	0.00	2.63	1.30	0.00	0.96	0.00	2.34
16	0.91	0.00	0.30	0.00	2.47	1.40	0.00	0.76	0.00	2.16	1.05	0.00	1.16	0.00	2.09
17	0.47	0.00	1.15	0.00	2.03	0.66	0.00	0.64	0.00	3.74	0.63	0.00	1.21	0.00	3.47
18	0.91	0.00	1.21	0.00	3.80	1.06	0.00	5.11	0.00	2.38	0.87	0.00	3.61	0.00	2.91

20 Jul to 19 Aug 1988

Trap No	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	3.86	0.23	4.79	0.60	2.51	4.11	0.00	4.59	0.94	0.42	2.41	0.00	2.37	0.26	1.16
2	3.00	0.07	8.49	0.38	2.41	6.20	0.00	2.00	3.02	0.45	9.42	0.04	6.49	0.40	1.04
3	3.28	0.10	4.96	0.89	2.35	1.33	0.00	13.04	0.59	0.62	2.34	0.00	17.54	0.78	1.63
4	4.15	0.07	2.03	1.05	2.27	3.32	0.00	2.80	0.65	0.66	2.71	0.00	2.91	0.22	1.10
5	2.90	2.00	3.65	1.70	2.46	2.56	0.00	1.84	1.36	1.00	5.81	0.00	3.52	0.51	1.40
6	9.43	0.01	17.27	1.47	2.88	3.97	0.05	5.11	0.79	1.15	4.87	0.01	3.45	0.56	1.19
7	3.01	0.00	1.51	0.40	1.64	1.61	0.00	1.96	0.17	0.52	2.76	0.13	4.62	0.29	1.67
8	4.12	0.00	1.53	0.12	1.35	0.83	0.00	0.13	0.25	0.10	1.56	0.81	7.30	0.52	1.28
9	3.53	0.00	1.41	0.39	1.50	2.58	0.00	3.34	0.55	0.65	3.30	0.02	4.73	0.29	1.62
10	3.66	0.00	3.18	0.82	2.10	2.32	0.00	1.69	0.18	0.63	2.77	0.11	4.91	0.94	1.59
11	2.67	0.00	1.61	0.25	1.64	3.72	0.17	1.07	0.76	1.17	3.14	0.00	9.77	0.45	1.61
12	4.70	0.00	1.93	0.45	1.42	3.12	0.00	2.78	0.72	0.66	4.31	0.01	5.62	0.51	1.61
13	5.49	0.00	3.42	0.46	1.67	1.04	0.00	0.30	0.28	0.57	5.03	0.05	3.90	0.69	1.46
14	7.23	0.01	1.54	1.20	2.01	3.14	0.00	1.14	0.66	0.83	6.84	0.16	4.74	0.59	1.41
15	4.10	0.00	3.81	1.55	2.18	2.52	0.00	1.94	0.27	0.50	4.60	0.00	2.36	0.58	0.94
16	3.43	0.00	8.54	0.07	2.02	2.11	0.00	0.57	0.21	0.68	2.90	0.00	0.60	1.70	1.31
17	2.68	0.08	3.08	0.21	1.96	2.45	0.00	1.55	0.30	0.67	1.79	0.00	3.70	0.75	1.50
18	3.38	0.05	7.54	1.15	2.26	5.40	0.00	8.67	0.00	1.17	2.55	0.00	1.95	0.24	1.57

Appendix 3C. Continued.

20 Aug to 18 Sep 1988

Trap No	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	3.25	0.62	1.90	0.44	0.65	2.54	0.00	0.27	1.92	0.21	1.03	0.00	0.20	0.38	0.25
2	4.58	0.62	5.10	0.43	0.83	3.66	0.00	2.53	2.25	0.36	1.07	0.03	0.43	0.12	0.24
3	4.29	0.08	5.04	0.82	0.66	2.89	0.00	1.22	0.16	0.30	2.24	0.00	0.94	0.16	0.17
4	2.86	0.02	0.61	1.99	0.29	2.52	0.04	1.95	0.86	0.31	1.01	0.00	0.08	0.26	0.10
5	3.94	0.16	3.12	2.51	0.44	3.54	0.00	1.15	1.34	0.32	2.10	0.00	3.85	0.20	0.41
6	3.75	0.05	1.22	3.11	0.34	2.74	0.19	3.05	1.92	0.44	1.57	0.01	0.64	0.21	0.24
7	1.90	0.05	5.36	0.22	0.42	2.82	0.00	1.91	1.16	0.25	3.67	0.21	2.81	0.24	0.29
8	6.31	0.00	4.99	0.38	0.45	2.28	0.00	0.58	0.54	0.13	1.21	1.09	0.31	0.10	0.33
9	3.55	0.04	0.43	0.25	0.26	3.18	0.00	2.12	0.70	0.24	2.02	0.00	1.55	1.55	0.29
10	4.10	0.07	0.45	2.67	0.45	2.08	0.00	2.74	0.45	0.12	2.67	0.24	0.78	0.07	0.22
11	3.43	0.14	6.26	0.73	0.33	3.65	0.46	0.29	0.43	0.20	2.14	0.00	0.68	0.63	0.34
12	2.13	0.10	0.88	0.07	0.43	3.04	0.00	1.22	1.08	0.20	3.54	0.03	4.13	0.46	0.32
13	3.98	0.07	6.27	0.62	0.39	1.96	0.00	0.08	0.22	0.08	2.54	0.03	0.08	0.00	0.12
14	4.30	0.04	0.91	0.36	0.25	2.87	0.00	0.13	0.43	0.13	2.37	0.08	2.13	1.03	0.37
15	3.46	0.02	4.92	0.07	0.32	3.74	0.00	2.77	0.20	0.23	2.65	0.05	1.37	0.82	0.13
16	3.87	0.00	4.43	2.35	0.37	7.94	0.00	4.93	0.52	0.23	3.30	0.00	0.30	3.81	0.14
17	2.68	0.16	0.51	0.96	0.40	2.98	0.00	0.86	0.76	0.31	2.98	0.03	2.38	0.22	0.36
18	3.32	0.60	1.99	0.29	0.52	8.63	0.00	9.34	0.04	0.26	2.83	0.00	0.48	1.08	0.15

19 Sep to 20 Oct 1988

Trap No	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	12.22	3.72	9.94	0.18	1.63	6.33	0.07	1.60	0.43	0.49	6.11	0.00	8.12	0.00	1.66
2	11.45	1.90	5.96	0.69	1.62	7.70	0.02	7.46	4.24	0.36	7.55	0.00	9.73	0.00	0.77
3	11.84	0.52	2.50	0.71	1.29	9.73	0.22	3.63	1.03	0.69	5.62	0.03	1.98	0.48	0.62
4	11.06	0.12	2.33	0.03	0.82	7.00	0.00	2.58	0.42	0.63	4.84	0.00	5.49	0.38	0.62
5	10.23	1.21	8.92	1.65	0.94	10.21	0.04	6.01	1.89	0.76	5.70	0.15	2.94	0.18	0.54
6	12.15	0.68	5.04	1.16	1.03	8.58	0.67	2.63	1.31	1.08	4.90	0.16	1.63	1.07	0.50
7	10.33	0.02	6.40	0.51	1.06	6.93	0.00	3.57	0.46	0.53	6.63	0.26	0.95	0.00	0.73
8	16.16	0.02	9.71	1.87	1.08	7.37	0.00	4.01	0.10	0.57	4.19	3.19	1.60	0.15	0.78
9	10.87	0.38	5.15	0.56	1.02	7.61	0.00	6.94	0.45	0.82	5.96	0.03	4.61	0.29	0.54
10	11.00	0.14	3.30	2.71	1.18	8.06	0.00	4.68	0.07	0.68	6.72	0.36	4.54	0.21	0.61
11	9.16	0.88	2.37	0.00	0.49	10.42	2.50	4.12	0.05	0.65	7.64	0.30	4.92	0.00	0.57
12	10.72	1.05	6.07	0.36	0.91	9.53	3.64	3.19	0.75	1.24	9.76	0.14	3.81	0.21	1.02
13	12.20	0.08	3.72	0.46	0.64	6.25	0.04	1.90	0.00	0.72	8.03	0.72	0.54	0.00	0.21
14	11.48	0.37	2.81	1.54	0.69	9.30	0.27	5.84	0.08	1.39	9.55	0.76	3.13	0.20	0.67
15	10.94	1.22	9.63	0.24	1.01	9.11	0.02	1.20	0.10	0.68	9.17	0.00	5.98	1.01	0.82
16	11.23	0.28	5.28	0.00	0.63	12.28	0.00	5.52	0.43	0.83	11.54	0.22	4.82	0.81	0.97
17	10.15	2.32	2.99	0.20	0.63	9.78	0.08	4.53	0.03	1.17	9.74	0.11	13.00	0.00	1.25
18	11.15	2.99	5.52	0.06	0.76	10.68	0.00	7.00	0.24	0.59	8.93	0.09	1.97	0.39	1.05

Appendix 3C. Continued.

21 Oct to 2 Nov 1988

Trap No	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	13.87	1.91	1.12	0.16	0.38	8.92	0.00	0.66	0.85	0.39	8.16	0.00	6.01	0.00	1.00
2	13.62	1.21	0.90	0.00	0.37	10.15	0.00	0.26	1.00	0.11	8.19	0.00	0.63	0.00	0.32
3	16.11	1.25	0.23	0.43	0.34	13.18	0.11	0.82	1.19	0.41	9.26	0.01	1.41	0.00	0.26
4	24.45	0.55	9.81	0.51	0.67	9.72	0.00	0.92	0.61	0.24	7.19	0.04	1.11	0.00	0.22
5	16.74	0.47	0.18	1.50	0.26	12.92	0.14	0.15	0.53	0.25	6.71	0.05	0.67	0.00	0.08
6	18.48	2.04	1.54	0.96	0.47	13.60	0.13	1.87	1.03	0.41	8.77	0.08	0.74	0.00	0.11
7	15.58	0.12	0.42	0.29	0.40	8.21	0.00	0.15	0.50	0.21	7.63	0.36	4.06	0.09	0.38
8	18.61	0.00	0.30	1.66	0.34	7.21	0.00	1.41	0.00	0.39	5.46	0.72	0.98	0.00	0.26
9	17.00	0.17	0.17	0.37	0.50	7.63	0.00	0.24	1.07	0.14	7.28	0.01	3.13	0.00	0.21
10	15.69	0.40	0.71	2.21	0.40	8.17	0.02	1.16	1.44	0.23	10.82	0.09	2.64	0.54	0.24
11	15.37	0.85	0.06	0.88	0.16	11.88	1.70	0.23	0.18	0.16	12.15	0.05	0.67	0.00	0.20
12	14.90	1.05	1.26	0.00	0.23	8.12	2.42	4.63	1.33	0.66	14.92	0.00	0.00	0.00	0.37
13	17.62	0.09	0.45	0.04	0.25	6.62	0.00	0.11	0.00	0.15	10.62	0.46	0.14	0.00	0.10
14	15.60	0.00	0.30	4.07	0.38	7.93	0.00	0.18	0.23	0.41	17.39	0.39	3.30	0.52	0.43
15	12.70	1.48	0.20	0.18	0.22	9.73	0.00	3.30	0.73	0.34	12.73	0.08	1.31	0.63	0.36
16	14.21	0.17	0.36	0.03	0.18	9.83	0.00	0.03	0.04	0.21	15.36	0.00	0.42	0.61	0.27
17	12.71	2.42	0.14	0.09	0.24	11.27	0.03	1.94	0.00	0.30	12.65	0.03	1.05	0.00	0.38
18	16.31	2.28	0.17	0.08	0.20	11.93	0.00	5.47	1.11	0.47	11.67	0.06	0.08	0.78	0.32

3 Nov to 23 Nov 1988

1	20.34	0.59	0.13	0.00	0.26	14.23	0.00	0.47	0.67	0.13	20.13	0.00	0.52	0.02	0.21
2	22.03	0.02	2.10	0.00	0.32	12.93	0.00	0.24	1.45	0.06	24.56	0.00	0.52	0.00	0.12
3	21.54	0.00	0.04	0.28	0.16	17.87	0.00	0.52	0.32	0.30	25.05	0.00	0.17	0.00	0.14
4	20.49	0.00	0.63	0.00	0.16	14.88	0.00	0.14	0.12	0.21	22.87	0.00	0.24	0.15	0.20
5	15.63	0.38	0.50	1.43	0.15	23.08	0.00	0.25	1.43	0.10	25.22	0.00	0.47	0.00	0.20
6	29.30	0.00	6.99	0.89	0.18	17.90	0.08	1.65	1.22	0.08	21.76	0.00	1.04	0.22	0.25
7	21.35	0.00	0.37	0.21	0.10	12.52	0.00	0.31	0.41	0.13	23.65	0.00	0.81	0.11	0.29
8	22.85	0.00	1.16	0.63	0.15	14.56	0.00	0.13	0.00	0.12	16.88	0.00	0.07	0.37	0.07
9	21.53	0.00	0.20	0.10	0.20	12.58	0.00	0.08	0.78	0.09	21.42	0.00	0.45	0.00	0.11
10	20.10	0.11	0.56	0.75	0.17	16.70	0.00	0.12	0.46	0.09	19.72	0.00	1.46	0.00	0.09
11	20.16	0.09	0.17	0.00	0.08	15.85	0.08	0.00	0.00	0.10	23.28	0.00	0.74	0.00	0.30
12	21.04	0.52	1.01	0.00	0.25	12.98	0.00	0.61	1.84	0.21	18.72	0.00	0.37	0.00	0.12
13	16.13	0.05	0.93	0.00	0.20	13.89	0.00	0.23	0.27	0.04	3.13	0.00	0.08	0.00	0.02
14	20.44	0.00	0.22	1.22	0.15	18.38	0.00	0.50	0.00	0.28	13.35	0.74	1.38	0.10	0.35
15	12.34	0.52	0.15	0.19	0.08	15.17	0.00	0.41	0.03	0.14	16.38	0.00	0.11	0.50	0.15
16	18.69	0.00	0.00	0.09	0.07	14.42	0.00	2.29	0.13	0.09	12.30	0.00	0.14	0.63	0.07
17	15.27	1.86	0.22	0.00	0.11	16.27	0.00	2.30	0.90	0.20	19.69	0.00	0.22	0.00	0.21
18	13.12	0.89	0.13	0.12	0.10	15.15	0.00	0.07	0.00	0.12	23.58	0.00	0.70	0.00	0.12

Appendix 3C. Continued.

24 Nov to 20 Dec 1988

Trap No	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	2.60	0.04	2.44	0.00	0.62	0.26	0.00	0.19	0.00	0.27	1.36	0.00	0.47	0.00	0.24
2	2.60	0.00	1.69	0.18	0.36	1.82	0.00	0.16	0.00	0.15	2.53	0.00	0.33	0.22	0.17
3	0.77	0.02	0.23	0.00	0.19	1.74	0.00	0.37	0.00	0.18	2.97	0.00	0.88	0.00	0.33
4	0.71	0.09	0.33	0.00	0.21	1.85	0.00	0.71	0.29	0.20	3.51	0.00	0.25	0.00	0.20
5	1.01	0.12	0.18	0.14	0.38	3.89	0.23	0.77	0.00	0.34	2.16	0.00	0.70	0.00	0.20
6	0.31	0.01	1.17	0.00	0.23	1.98	0.00	0.47	0.25	0.21	3.57	0.00	2.03	0.00	0.31
7	2.46	0.00	0.43	0.00	0.22	1.28	0.00	0.17	0.00	0.06	1.47	0.00	0.27	0.00	0.10
8	0.77	0.02	0.98	0.08	0.16	0.89	0.00	0.05	0.00	0.12	2.95	0.00	0.38	0.00	0.13
9	0.52	0.00	0.17	0.00	0.22	0.94	0.00	0.09	0.00	0.13	4.92	0.00	1.58	0.00	0.12
10	0.24	0.00	0.04	0.00	0.20	0.87	0.00	0.28	0.00	0.17	1.97	0.00	0.68	0.00	0.14
11	0.96	0.00	0.12	0.10	0.24	0.61	0.00	0.30	0.11	0.21	1.57	0.00	1.60	0.00	0.44
12	0.27	0.01	1.13	0.00	0.25	0.91	0.00	0.86	0.00	0.14	1.30	0.00	1.88	0.00	0.15
13	2.15	0.00	0.48	0.00	0.22	0.18	0.00	0.00	0.12	0.04	1.25	0.00	0.06	0.00	0.13
14	4.11	0.00	0.08	0.08	0.25	1.35	0.00	0.29	0.00	0.26	0.86	0.10	0.76	0.00	0.46
15	0.83	0.07	0.41	0.00	0.15	0.46	0.00	0.18	0.00	0.14	1.88	0.00	0.21	0.00	0.17
16	2.48	0.00	0.21	0.00	0.19	1.45	0.00	0.15	0.00	0.14	0.47	0.01	0.68	0.00	0.42
17	0.54	0.00	0.08	0.00	0.11	2.01	0.24	2.49	0.20	0.34	0.99	0.00	0.44	0.00	0.17
18	0.00	0.01	1.66	0.00	0.17	1.38	0.00	0.34	0.00	0.11	0.87	0.00	0.30	0.12	0.15

21 Dec 1988 to 30 Jan 1989

Trap No	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	0.03	0.00	3.55	0.00	0.59	*	*	*	*	*	0.00	0.00	0.36	0.00	0.28
2	0.06	0.00	1.15	0.00	0.61	0.04	0.00	0.22	0.00	0.13	0.04	0.00	0.65	0.00	0.36
3	0.01	0.00	0.61	0.23	0.45	0.21	0.00	0.08	0.27	0.31	0.00	0.00	1.11	0.00	0.42
4	0.03	0.00	0.69	0.00	0.53	0.00	0.00	0.17	0.00	0.25	0.00	0.00	0.57	0.00	0.41
5	0.12	0.00	0.58	0.40	0.38	0.22	0.00	0.30	0.00	0.45	0.13	0.00	1.05	0.10	0.49
6	0.03	0.00	0.65	0.00	0.52	0.07	0.00	0.30	0.00	0.40	0.26	0.00	1.53	0.00	0.75
7	0.21	0.00	1.66	0.00	0.47	0.00	0.00	0.55	0.00	0.14	0.27	0.00	0.79	0.00	0.69
8	0.03	0.00	0.47	0.00	0.44	*	*	*	*	*	0.20	0.00	0.69	0.00	0.48
9	0.13	0.00	1.95	0.00	0.49	0.04	0.00	0.12	0.00	0.24	0.10	0.00	1.03	0.00	0.74
10	0.00	0.00	2.60	0.00	0.52	0.05	0.00	1.35	0.00	0.12	0.07	0.00	1.94	0.00	0.69
11	0.08	0.00	0.85	0.00	0.60	0.00	0.00	0.53	0.00	0.32	0.01	0.00	1.00	0.00	0.60
12	0.12	0.00	3.40	0.00	0.56	0.14	0.00	2.31	0.00	0.27	0.05	0.00	1.17	0.00	0.91
13	0.47	0.00	0.52	0.00	0.43	0.00	0.00	0.51	0.00	0.09	0.27	0.00	1.03	0.00	0.46
14	0.10	0.00	0.23	0.00	0.46	0.06	0.00	1.00	0.00	0.31	0.24	0.00	0.30	0.00	0.27
15	0.09	0.00	0.56	0.00	0.37	0.00	0.00	0.00	0.00	0.05	0.61	0.00	0.20	0.00	1.31
16	0.10	0.00	0.94	0.00	0.36	0.00	0.00	0.16	0.00	0.25	0.60	0.00	2.00	0.00	0.52
17	0.20	0.00	0.39	0.00	0.42	0.00	0.00	0.22	0.00	0.38	0.68	0.00	0.51	0.00	1.03
18	4.44	0.00	8.79	0.00	0.87	0.00	0.00	0.33	0.00	0.31	0.15	0.00	2.49	0.00	0.95

Appendix 3C. Continued.

31 Jan to 28 Feb 1989

Trap No	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
1	0.08	0.00	2.02	0.00	1.30	0.15	0.00	2.14	0.00	0.27	0.00	0.00	0.36	0.00	0.28
2	0.41	0.00	3.90	0.00	0.35	0.10	0.00	0.80	0.11	0.31	0.04	0.00	0.65	0.00	0.36
3	0.09	0.00	1.54	0.00	0.80	0.16	0.00	0.32	0.27	0.70	0.00	0.00	1.11	0.00	0.42
4	0.16	0.00	1.02	0.00	0.55	0.26	0.00	6.11	0.00	0.36	0.00	0.00	0.57	0.00	0.41
5	0.15	0.00	1.28	0.00	0.32	0.25	0.00	1.09	0.00	0.37	0.13	0.00	1.05	0.00	0.49
6	0.09	0.00	0.82	0.00	0.41	0.21	0.00	1.25	0.00	0.48	0.26	0.00	1.53	0.00	0.75
7	0.12	0.00	1.19	0.00	0.79	0.08	0.00	0.60	0.05	0.42	0.27	0.00	0.79	0.00	0.69
8	1.00	0.00	9.02	0.00	0.62	0.18	0.00	7.93	0.00	0.39	0.20	0.00	0.69	0.00	0.48
9	0.09	0.00	1.59	0.00	0.93	0.50	0.00	0.36	0.00	0.47	0.10	0.00	1.03	0.00	0.74
10	0.05	0.00	3.38	0.00	0.98	0.07	0.00	0.73	0.00	0.21	0.07	0.00	1.94	0.00	0.69
11	0.16	0.00	2.28	0.00	0.42	0.04	0.00	0.82	0.14	0.18	0.01	0.00	1.00	0.00	0.60
12	0.08	0.00	1.17	0.00	0.53	0.08	0.00	0.57	0.00	0.41	0.05	0.00	1.17	0.00	0.91
13	0.07	0.00	1.40	0.00	0.81	0.36	0.00	0.73	0.00	0.22	0.27	0.00	1.03	0.00	0.46
14	0.04	0.00	3.80	0.00	0.33	0.17	0.00	0.84	0.00	0.32	0.24	0.00	0.30	0.00	0.27
15	0.03	0.00	1.20	0.00	0.45	0.11	0.00	0.37	0.03	0.29	0.61	0.00	0.20	0.00	1.31
16	0.20	0.00	1.15	0.00	0.38	0.09	0.00	0.66	0.00	0.30	0.60	0.00	2.00	0.00	0.52
17	0.12	0.00	1.32	0.00	0.51	0.25	0.00	0.43	0.00	0.45	0.68	0.00	0.51	0.00	1.03
18	0.05	0.00	0.27	0.00	0.50	0.12	0.00	0.38	0.00	0.42	0.15	0.00	2.49	0.00	0.95

1 Mar to 29 Mar 1989

1	0.05	0.00	1.01	0.00	0.12	0.00	0.00	0.30	0.00	0.07	*	*	*	*	*
2	0.00	0.00	0.64	0.00	0.18	0.04	0.00	0.32	0.00	0.51	0.04	0.00	0.38	0.00	0.18
3	0.10	0.00	2.46	0.00	0.16	*	*	*	*	*	0.06	0.00	0.44	0.00	0.12
4	0.11	0.00	0.55	0.00	0.23	0.00	0.00	0.98	0.00	0.11	0.08	0.00	0.51	0.00	0.10
5	0.03	0.00	0.32	0.00	0.10	0.13	0.00	1.05	0.00	0.08	0.10	0.00	0.32	0.00	0.13
6	0.00	0.00	0.99	0.00	0.14	0.08	0.00	2.41	0.00	0.05	0.00	0.00	0.08	0.00	0.16
7	0.00	0.00	1.62	0.00	0.20	0.00	0.00	0.73	0.00	0.04	0.00	0.00	0.19	0.00	0.12
8	0.12	0.00	1.30	0.00	0.19	*	*	*	*	*	0.08	0.00	0.27	0.00	0.09
9	0.08	0.00	0.39	0.00	0.15	0.06	0.00	2.49	0.00	0.09	0.05	0.00	0.20	0.00	0.14
10	0.00	0.00	0.25	0.00	0.13	0.18	0.00	1.48	0.00	0.04	0.03	0.00	0.11	0.00	0.08
11	0.05	0.00	0.80	0.00	0.06	*	*	*	*	*	0.09	0.00	1.05	0.00	0.17
12	0.00	0.00	1.18	0.00	0.04	0.00	0.00	2.36	0.00	0.11	0.08	0.00	0.38	0.00	0.07
13	0.00	0.00	0.82	0.00	0.07	0.00	0.00	0.43	0.00	0.08	0.12	0.00	0.40	0.00	0.29
14	0.00	0.00	0.27	0.00	0.16	0.00	0.00	0.37	0.00	0.07	0.20	0.00	0.22	0.00	0.23
15	0.00	0.00	0.20	0.00	0.11	*	*	*	*	*	0.00	0.00	0.04	0.00	0.15
16	0.08	0.00	0.10	0.00	0.08	*	*	*	*	*	0.10	0.00	0.89	0.00	0.14
17	0.10	0.00	0.19	0.00	0.12	0.11	0.00	0.05	0.00	0.12	0.00	0.00	1.82	0.00	0.21
18	0.00	0.00	0.97	0.00	0.14	0.08	0.00	0.87	0.00	0.10	0.15	0.00	2.91	0.00	0.19

30 Mar to 29 Apr 1989. Sum for 18 traps in plot 7 and 17 traps in each of the plots 8 and 9.

0.45	0.00	1.16	0.00	1.30	0.02	0.00	1.85	0.00	0.85	0.00	0.00	0.20	0.80	0.80

Appendix 3D

a) Nitrogen, phosphorus, potassium, sodium, calcium and magnesium concentrations (mg g^{-1}) of; (OL) oak leaves, (BL) birch leaves, (SW) small wood, (F) fruit, and (Mis) miscellaneous litterfall for different sampling dates in the three plots in Ross. Asterisk indicates that the dry mass of the sample per plot was less than 0.5 g, required for chemical analysis (see the text)

NITROGEN

Sample date	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 Oct 1987	9.6	12.5	6.9	6.9	19.1	14.4	15.2	9.0	*	20.8	11.0	6.7	8.5	9.3	15.8
4 Nov "	7.0	11.2	7.8	7.8	*	8.7	*	12.2	*	*	8.6	8.2	9.7	12.0	*
21 Nov "	7.3	*	9.5	9.5	26.8	9.8	*	9.0	*	20.7	7.1	*	4.9	14.2	18.7
12 Dec "	7.1	*	7.4	7.4	*	8.3	*	*	*	*	8.0	*	*	*	*
13 Jan 1988	9.4	*	12.9	12.9	13.3	10.6	*	*	*	20.0	9.9	*	9.8	*	16.9
13 Feb "	*	*	9.8	9.8	13.5	*	*	6.8	*	15.4	*	*	10.2	*	14.4
13 Mar "	*	*	*	*	7.1	*	*	*	*	*	8.7	*	8.7	*	*
13 Apr "	*	*	*	*	16.0	*	*	8.6	*	16.6	*	*	7.2	*	13.3
12 May "	4.7	*	13.8	13.8	15.8	*	*	10.6	*	19.1	*	*	*	*	16.7
12 Jun "	3.6	*	12.0	12.0	15.8	30.7	*	12.3	*	20.4	28.5	*	12.3	*	15.6
14 Jul "	2.3	*	10.8	10.8	15.3	23.8	*	11.5	*	16.1	19.7	*	9.5	*	12.2
9 Aug "	0.9	22.0	8.8	8.8	14.2	21.5	*	8.0	12.4	17.1	20.5	*	9.4	12.8	13.4
10 Sep "	9.9	19.7	8.5	8.5	16.0	15.3	*	9.1	12.3	15.3	10.4	17.7	7.2	13.2	13.6
12 Oct "	8.4	13.2	7.2	7.2	16.3	9.4	13.3	7.6	11.6	16.6	9.8	9.3	7.1	*	13.1
31 Oct "	7.5	*	*	*	*	8.7	*	*	*	*	9.4	*	*	*	*

PHOSPHORUS

Sample date	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 Oct 1987	1.3	1.1	0.8	1.1	1.6	1.1	1.5	0.9	*	1.3	0.7	0.5	0.7	0.9	1.0
4 Nov "	1.2	1.0	0.6	1.3	*	0.5	*	1.0	*	*	0.5	0.5	1.1	1.8	*
21 Nov "	1.5	*	0.9	1.0	2.3	0.5	*	0.5	*	1.6	0.4	*	0.2	1.6	1.5
12 Dec "	2.1	*	0.6	1.1	*	0.7	*	*	*	*	0.6	*	*	*	*
13 Jan 1988	0.7	*	1.1	*	1.0	0.3	*	*	*	1.4	0.4	*	0.7	*	0.8
13 Feb "	*	*	0.3	*	0.6	*	*	0.3	*	0.8	*	*	0.7	*	1.1
13 Mar "	*	*	*	*	0.3	*	*	*	*	*	*	*	0.4	*	*
13 Apr "	*	*	*	*	0.8	*	*	0.2	*	0.9	*	*	0.5	*	0.4
12 May "	0.9	*	0.8	*	1.0	*	*	0.7	*	1.3	*	*	*	*	1.7
12 Jun "	2.7	*	0.8	*	0.7	2.6	*	0.8	*	1.0	2.0	*	0.6	*	0.7
14 Jul "	1.2	*	0.5	*	0.6	1.1	*	0.6	*	0.8	0.7	*	0.3	*	0.6
9 Aug "	1.3	1.0	0.4	0.7	0.7	1.0	*	0.5	0.8	0.8	0.8	*	0.5	0.6	0.6
10 Sep "	0.5	0.9	0.5	0.8	1.3	0.8	*	0.6	0.6	0.8	0.4	0.7	0.5	0.7	0.4
12 Oct "	1.1	1.1	1.0	1.2	1.5	0.6	*	0.5	0.6	0.9	0.4	0.4	0.3	*	0.6
31 Oct "	1.3	*	*	*	*	0.5	*	*	*	*	0.5	*	*	*	*

Appendix 3D. a) Continued.

POTASSIUM

Sample date	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 Oct 1987	5.1	5.0	4.7	12.1	6.2	5.4	3.7	3.7	*	2.3	4.7	5.1	4.5	5.7	*
4 Nov "	5.5	4.1	4.4	12.8	*	4.5	*	4.7	*	*	4.7	2.9	4.0	9.6	*
21 Nov "	5.8	*	4.4	10.8	*	3.4	*	1.9	*	3.7	3.6	*	1.2	9.9	3.8
12 Dec "	6.6	*	3.3	*	*	4.4	*	*	*	*	5.0	*	*	*	*
13 Jan 1988	0.9	*	4.7	*	1.0	0.8	*	*	*	0.9	0.8	*	4.4	*	*
13 Feb "	*	*	0.8	*	0.8	*	*	0.9	*	*	*	*	*	*	1.6
13 Mar "	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13 Apr "	*	*	2.1	*	0.9	*	*	0.9	*	1.1	*	*	0.6	*	*
12 May "	*	*	*	*	3.6	*	*	3.1	*	3.2	*	*	*	*	*
12 Jun "	2.8	*	3.1	*	1.2	2.3	*	2.6	*	1.7	2.1	*	3.4	*	1.5
14 Jul "	2.7	2.9	2.6	*	0.8	2.3	*	2.6	*	0.8	2.7	*	2.3	*	0.6
9 Aug "	5.8	*	1.8	3.8	1.5	3.6	*	1.8	3.2	1.2	3.5	*	2.3	*	1.1
10 Sep "	2.7	*	2.9	1.1	1.4	2.9	*	3.3	0.9	1.3	1.7	*	2.6	*	0.8
12 Oct "	3.3	3.5	3.5	6.0	2.7	2.4	2.9	2.5	2.3	2.1	2.4	2.6	2.7	*	1.7
31 Oct "	3.8	*	*	*	*	3.3	*	*	*	*	2.6	*	*	*	*

SODIUM

Sample date	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 Oct 1987	0.4	0.3	0.6	0.2	0.2	0.4	0.2	0.2	*	0.2	0.5	0.2	0.6	0.2	*
4 Nov "	0.4	0.3	0.5	0.2	*	0.4	*	0.4	*	*	0.7	0.3	0.5	0.2	*
21 Nov "	0.6	0.4	*	0.2	*	0.4	*	0.2	*	0.4	0.7	*	0.2	0.3	0.6
12 Dec "	0.7	*	0.4	*	*	0.8	*	*	*	*	0.8	*	*	*	*
13 Jan 1988	0.3	*	0.5	*	0.2	0.2	*	*	*	0.1	0.2	*	0.4	*	*
13 Feb "	*	*	0.3	*	0.3	*	*	0.2	*	0.2	*	*	*	*	0.4
13 Mar "	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13 Apr "	*	*	0.4	*	0.3	*	*	0.2	*	0.2	*	*	0.3	*	*
12 May "	*	*	*	*	0.3	*	*	0.3	*	0.2	*	*	*	*	*
12 Jun "	0.1	*	0.4	*	0.1	0.1	*	0.2	*	0.1	0.1	*	0.5	*	0.1
14 Jul "	0.2	*	0.3	*	0.2	0.1	*	0.2	*	0.1	0.1	*	0.3	*	0.1
9 Aug "	0.1	0.1	0.2	0.1	0.1	0.1	*	0.2	0.1	0.1	0.1	*	0.3	*	0.1
10 Sep "	0.3	*	0.3	0.1	0.2	0.2	*	0.2	0.1	0.2	0.3	*	0.3	*	0.2
12 Oct "	0.5	0.6	0.4	0.3	0.4	0.4	0.5	0.2	0.2	0.3	0.5	0.4	0.4	*	0.4
31 Oct "	0.4	*	*	*	*	0.4	*	*	*	*	0.4	*	*	*	*

Appendix 3D. a) Continued.

CALCIUM

Sample date	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 Oct 1987	0.7	8.6	6.1	4.6	4.7	10.0	12.7	4.9	*	5.5	9.1	9.6	6.2	5.9	*
4 Nov "	0.2	9.0	6.9	3.1	*	11.2	*	5.3	*	*	9.6	9.4	6.0	3.9	*
21 Nov "	3.4	*	6.0	3.3	*	11.8	*	4.9	*	5.8	12.3	*	5.1	4.8	6.7
12 Dec "	2.7	*	5.5	*	*	13.3	*	*	*	*	12.1	*	*	*	*
13 Jan 1988	2.5	*	5.8	*	4.4	10.2	*	*	*	5.3	11.6	*	5.5	*	*
13 Feb "	*	*	5.7	*	4.5	*	*	5.1	*	4.8	*	*	*	*	6.6
13 Mar "	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13 Apr "	*	*	9.0	*	5.4	*	*	7.5	*	5.1	*	*	3.6	*	*
12 May "	*	*	*	*	6.0	*	*	5.0	*	5.4	*	*	*	*	*
12 Jun "	5.4	*	6.0	*	6.0	4.8	*	4.8	*	5.9	4.2	*	5.4	*	5.4
14 Jul "	6.3	*	6.9	*	6.0	6.3	*	4.8	*	5.4	5.1	*	5.4	*	6.3
9 Aug "	6.5	5.1	5.7	8.4	5.6	6.6	*	5.4	8.4	5.7	5.7	*	5.7	*	5.6
10 Sep "	8.1	*	4.8	8.7	5.1	8.1	*	4.2	7.9	5.0	7.5	*	5.6	*	5.1
12 Oct "	9.6	7.5	5.6	6.5	6.9	4.5	7.2	4.8	8.0	5.4	9.2	9.3	5.6	*	6.3
31 Oct "	9.6	*	*	*	*	9.2	*	*	*	*	9.3	*	*	*	*

MAGNESIUM

Sample date	Plot 1					Plot 2					Plot 3				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 Oct 1987	2.4	4.6	0.8	1.4	1.2	2.0	3.6	0.9	*	1.0	2.1	5.4	1.1	1.5	*
4 Nov "	2.6	4.7	0.9	1.1	*	2.1	*	0.8	*	*	2.3	4.3	1.1	1.4	*
21 Nov "	2.4	*	0.9	1.0	*	2.0	*	0.8	*	1.5	2.5	*	0.6	1.4	1.5
12 Dec "	2.4	*	0.9	*	*	2.1	*	*	*	*	2.4	*	*	*	*
13 Jan 1988	1.8	*	0.9	*	0.9	1.6	*	*	*	0.7	1.7	*	0.8	*	*
13 Feb "	*	*	0.7	*	0.6	*	*	0.5	*	0.7	*	*	*	*	0.9
13 Mar "	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13 Apr "	*	*	0.6	*	0.5	*	*	1.1	*	0.8	*	*	0.5	*	*
12 May "	*	*	*	*	1.2	*	*	0.6	*	0.9	*	*	*	*	*
12 Jun "	1.2	*	0.7	*	0.7	1.0	*	0.8	*	0.9	1.0	*	1.0	*	0.8
14 Jul "	0.9	*	0.7	*	0.6	0.9	*	0.7	*	0.6	1.0	*	0.6	*	0.5
9 Aug "	1.4	3.0	0.7	1.3	0.6	1.3	*	0.7	1.2	0.6	1.4	*	0.8	*	0.6
10 Sep "	1.4	*	0.6	1.0	0.7	1.4	*	0.6	0.8	0.6	1.3	*	0.5	*	0.5
12 Oct "	1.6	3.8	0.5	1.2	0.9	1.5	2.0	0.5	1.0	0.8	1.6	4.1	0.7	*	0.8
31 Oct "	1.4	*	*	*	*	1.6	*	*	*	*	1.6	*	*	*	*

Appendix 3D continued

b) Nitrogen, phosphorus, potassium, sodium, calcium and magnesium concentrations (mg g^{-1}) of; (OL) oak leaves, (BL) birch leaves, (SW) small wood, (F) fruit, and (Mis) miscellaneous litterfall for different sampling dates in the three plots in **Gartfairn**. Asterisk indicates that the dry mass of the sample per plot was less than 0.5 g, required for chemical analysis (see the text)

NITROGEN

Sample date	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
6 Nov 1987	12.0	16.8	11.0	13.8	21.0	11.3	10.5	17.3	12.3	24.4	13.4	14.1	7.8	14.8	22.0
22 Nov "	11.4	14.4	13.6	15.5	27.5	11.9	11.5	12.4	14.1	24.6	11.8	13.9	13.9	13.7	22.6
13 Dec "	12.0	*	*	*	*	11.2	*	*	*	*	15.0	*	*	8.6	*
12 Jan 1988	15.4	*	9.7	*	*	15.0	*	16.8	*	20.5	16.5	*	14.2	*	18.8
12 Feb "	11.4	*	11.2	*	17.7	*	*	11.6	*	21.2	13.8	*	13.3	*	17.3
14 Mar "	16.0	*	16.4	*	20.0	*	*	8.3	*	19.0	13.3	*	14.5	*	17.4
13 Apr "	12.6	*	15.5	*	20.4	*	*	15.5	*	20.4	*	*	17.2	*	18.1
12 May "	*	*	12.5	*	19.0	*	*	9.8	*	17.7	41.2	*	10.2	*	22.7
12 Jun "	31.1	*	16.3	*	22.8	30.6	*	13.1	*	19.4	36.0	*	15.4	*	21.3
13 Jul "	28.0	*	14.9	*	22.9	25.3	*	14.3	*	20.7	25.8	*	14.7	*	22.4
9 Aug "	26.9	20.8	14.0	13.8	22.4	25.3	21.2	11.1	12.9	18.8	24.6	21.7	12.7	14.8	20.4
10 Sep "	20.2	17.4	10.7	10.8	20.8	24.2	14.8	12.2	11.7	14.9	22.0	16.6	10.5	12.2	17.3
13 Oct "	16.4	15.3	10.7	10.8	20.5	12.4	12.9	10.5	10.7	18.8	18.3	16.5	11.3	10.6	20.4
1 Nov "	13.1	*	*	*	*	10.0	*	*	*	*	13.9	*	*	*	*

PHOSPHORUS

Sample date	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
6 Nov 1987	1.5	2.1	1.1	1.2	2.2	1.6	1.9	1.2	1.5	1.8	1.5	1.7	0.6	1.3	2.1
22 Nov "	1.4	1.5	1.2	1.5	2.3	1.8	1.5	1.0	1.4	1.4	1.2	1.6	0.9	1.1	1.7
13 Dec "	2.1	*	*	*	*	1.9	*	*	*	*	1.9	*	*	0.5	*
12 Jan 1988	1.1	*	0.9	*	1.5	1.2	*	1.3	*	1.5	1.4	*	1.0	*	1.4
12 Feb "	0.9	*	0.8	*	1.1	*	*	0.6	*	1.2	1.2	*	1.1	*	1.4
14 Mar "	0.8	*	0.7	*	0.9	*	*	0.5	*	1.1	1.7	*	1.4	*	1.3
13 Apr "	0.7	*	1.0	*	1.0	*	*	0.8	*	1.2	1.7	*	1.4	*	1.2
12 May "	*	*	0.8	*	1.6	*	*	0.4	*	1.5	2.0	*	0.9	*	2.1
12 Jun "	2.4	*	0.8	*	1.5	2.8	*	0.9	*	1.1	2.0	*	0.8	*	1.1
13 Jul "	1.7	*	0.7	*	1.0	1.3	*	0.8	*	1.2	1.5	*	1.2	*	1.5
9 Aug "	1.4	1.2	0.7	0.9	1.6	1.6	1.3	0.5	0.8	1.0	1.4	1.6	1.6	1.6	1.8
10 Sep "	1.2	1.1	0.9	0.7	1.4	1.0	1.3	0.8	0.8	1.1	1.3	1.7	1.0	1.2	1.6
13 Oct "	1.4	1.5	0.9	1.0	1.4	1.1	1.3	0.8	1.1	1.4	1.4	1.9	1.3	1.5	2.0
1 Nov "	1.2	*	*	*	*	1.2	*	*	*	*	1.2	*	*	*	*

Appendix 3D. b) Continued.

POTASSIUM

Sample date	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
6 Nov 1987	3.8	4.8	4.3	4.2	4.3	4.5	3.5	2.7	9.6	5.3	4.6	3.5	4.5	9.7	*
22 Nov "	4.9	3.5	3.0	9.5	4.8	4.2	1.9	3.9	9.3	3.9	3.8	2.7	6.6	9.3	4.2
13 Dec "	6.0	*	*	*	*	5.0	*	*	*	*	5.1	*	*	5.6	*
12 Jan 1988	1.4	*	1.0	*	1.2	1.3	*	1.1	*	1.6	1.4	*	2.2	*	1.3
12 Feb "	*	*	1.7	*	1.2	*	*	0.9	*	1.3	*	*	1.7	*	1.4
14 Mar "	*	*	1.0	*	*	*	*	1.0	*	*	*	*	*	*	*
13 Apr "	0.6	*	0.9	*	0.9	*	*	0.7	*	1.0	*	*	1.2	*	1.1
12 May "	*	*	1.9	*	2.5	*	*	1.4	*	2.7	7.7	*	1.6	*	4.6
12 Jun "	5.3	*	2.7	*	1.8	6.4	*	2.4	*	1.7	4.5	*	3.2	*	1.7
13 Jul "	2.5	*	2.4	*	1.3	3.2	*	2.1	*	1.3	3.4	*	2.8	*	1.6
9 Aug "	4.3	2.4	2.1	5.1	2.0	4.0	2.7	1.2	4.7	1.8	6.3	3.2	4.0	6.1	2.2
10 Sep "	2.6	2.1	2.6	3.3	1.4	4.5	3.1	2.3	2.5	1.6	2.3	2.3	3.1	3.4	1.5
13 Oct "	5.2	3.8	3.1	6.8	3.6	3.3	3.1	2.7	7.2	2.6	4.4	3.9	2.0	4.1	2.9
1 Nov "	4.7	*	*	*	*	3.0	*	*	*	*	3.8	*	*	*	*

SODIUM

Sample date	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
6 Nov 1987	0.8	0.5	0.4	0.1	0.2	0.5	0.4	0.3	0.2	0.3	0.7	0.6	0.7	0.2	*
22 Nov "	0.8	0.8	0.5	0.2	0.9	0.5	0.4	0.5	0.2	0.5	0.8	1.2	0.4	0.4	1.3
13 Dec "	0.9	*	*	*	*	1.1	*	*	*	*	1.0	*	*	0.6	*
12 Jan 1988	0.5	*	0.3	*	0.4	0.4	*	0.3	*	0.4	0.6	*	0.6	*	0.5
12 Feb "	*	*	0.6	*	0.7	*	*	0.5	*	0.4	*	*	0.9	*	0.9
14 Mar "	*	*	0.8	*	*	*	*	0.4	*	*	*	*	*	*	*
13 Apr "	0.3	*	0.4	*	0.3	*	*	0.3	*	0.3	*	*	0.5	*	0.3
12 May "	*	*	0.5	*	0.3	*	*	0.5	*	0.4	0.1	*	0.6	*	0.3
12 Jun "	0.1	*	0.4	*	0.1	0.1	*	0.4	*	0.4	0.1	*	0.6	*	0.1
13 Jul "	0.2	*	0.3	*	0.2	0.2	*	0.4	*	0.2	0.3	*	0.5	*	0.2
9 Aug "	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.2	0.2
10 Sep "	0.3	0.3	0.4	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.4	0.5	0.6	0.2
13 Oct "	0.6	0.7	0.4	0.2	0.5	0.5	0.6	0.4	0.3	0.4	0.8	1.1	0.2	0.5	0.8
1 Nov "	0.6	*	*	*	*	0.5	*	*	*	*	0.6	*	*	*	*

Appendix 3D. b) Continued.

CALCIUM

Sample date	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
6 Nov 1987	6.8	15.8	6.9	5.2	6.1	9.8	10.1	7.9	3.2	6.7	12.5	12.2	5.8	2.9	*
22 Nov "	14.7	17.4	6.6	3.7	6.9	13.4	11.7	7.1	4.6	6.8	12.9	14.1	*	4.4	6.4
13 Dec "	17.1	*	*	*	*	14.0	*	*	*	*	13.5	*	*	3.6	*
12 Jan 1988	16.1	*	6.4	*	5.4	14.1	*	5.9	*	5.6	17.0	*	6.5	*	4.3
12 Feb "	*	*	7.5	*	5.0	*	*	5.9	*	5.1	*	*	7.0	*	9.7
14 Mar "	*	*	6.5	*	*	*	*	7.6	*	*	*	*	*	*	*
13 Apr "	12.8	*	4.2	*	5.7	*	*	5.0	*	6.4	*	*	5.9	*	5.5
12 May "	*	*	6.0	*	5.1	*	*	6.4	*	4.8	3.3	*	6.3	*	5.0
12 Jun "	7.2	*	6.5	*	6.3	5.3	*	6.6	*	7.2	5.0	*	7.0	*	6.7
13 Jul "	6.5	*	7.4	*	7.1	6.5	*	6.7	*	7.1	7.2	*	3.4	*	4.4
9 Aug "	7.1	7.2	6.8	8.0	7.4	6.4	6.4	6.2	7.9	6.5	6.7	8.4	5.7	7.9	6.6
10 Sep "	8.0	8.3	7.4	6.6	5.3	7.4	8.1	5.3	7.5	3.8	8.5	8.6	5.7	6.4	4.8
13 Oct "	9.5	10.8	6.6	6.2	6.8	8.4	9.1	4.0	5.4	6.8	9.6	10.2	7.5	7.2	7.0
1 Nov "	4.8	*	*	*	*	9.2	*	*	*	*	9.2	*	*	*	*

MAGNESIUM

Sample date	Plot 4					Plot 5					Plot 6				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
6 Nov 1987	2.5	3.5	1.4	1.4	1.5	3.5	4.1	2.0	1.3	1.7	3.2	4.4	1.6	1.2	*
22 Nov "	3.4	3.5	1.3	1.2	2.2	3.4	3.8	1.3	2.1	2.1	3.0	4.3	1.7	1.6	2.5
13 Dec "	3.5	*	*	*	*	3.5	*	*	*	*	3.0	*	*	1.1	*
12 Jan 1988	2.4	*	1.1	*	1.1	1.8	*	*	1.3	1.4	2.5	*	1.7	*	1.3
12 Feb "	*	*	1.0	*	0.9	*	*	1.3	*	1.3	*	*	1.7	*	2.3
14 Mar "	*	*	0.8	*	*	*	*	1.4	*	*	*	*	*	*	*
13 Apr "	0.9	*	0.6	*	0.8	*	*	1.0	*	1.1	*	*	1.2	*	1.0
12 May "	*	*	1.1	*	1.0	*	*	1.2	*	1.6	2.7	*	1.3	*	1.8
12 Jun "	1.7	*	1.2	*	1.1	2.1	*	1.2	*	1.4	2.3	*	1.6	*	1.5
13 Jul "	1.6	*	1.2	*	1.1	2.0	*	1.5	*	1.4	2.2	*	1.5	*	1.5
9 Aug "	2.2	2.0	1.2	2.0	1.5	2.2	2.6	1.1	2.3	1.4	2.5	3.0	1.5	2.4	1.5
10 Sep "	1.8	1.6	1.1	1.5	0.8	2.1	2.6	1.3	1.8	1.1	2.3	2.5	1.5	1.5	1.1
13 Oct "	2.3	2.4	1.0	1.3	1.5	2.6	3.0	1.4	1.6	1.7	2.8	3.5	2.1	1.9	1.7
1 Nov "	2.5	*	*	*	*	2.1	*	*	*	*	2.3	*	*	*	*

Appendix 3D continued

c) Nitrogen, phosphorus, potassium, sodium, calcium and magnesium concentrations (mg g^{-1}) of; (OL) oak leaves, (BL) birch leaves, (SW) small wood, (F) fruit, and (Mis) miscellaneous litterfall for different sampling dates in the three plots in Methven. Asterisk indicates that the dry mass of the sample per plot was less than 0.5 g, required for chemical analysis (see the text)

NITROGEN

Sample date	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 May 1988	*	*	13.5	*	23.1	*	*	11.6	*	22.5	*	*	17.6	*	19.1
17 Jun "	33.7	*	15.9	*	26.2	33.2	*	15.6	*	29.2	33.6	*	15.1	*	24.8
19 Jul "	27.6	*	15.6	*	22.2	24.9	*	26.6	12.0	20.1	25.1	*	13.6	*	20.4
19 Aug "	27.3	24.7	11.4	14.6	22.2	25.9	*	12.2	*	21.3	27.6	25.8	10.3	13.2	22.7
18 Sep "	17.4	20.4	10.5	12.2	23.5	16.7	17.0	9.1	9.8	28.8	17.5	13.5	9.8	10.2	19.9
20 Oct "	14.8	15.3	9.6	13.9	22.6	14.8	17.6	9.7	9.4	20.6	14.8	15.4	9.4	10.7	21.0
2 Nov "	13.6	13.5	13.2	11.2	24.2	11.2	14.9	9.2	14.3	22.1	12.1	11.8	9.6	12.6	21.8
23 Nov "	14.5	*	14.3	8.0	23.2	13.1	*	13.0	13.2	23.4	11.7	13.7	11.1	8.4	22.5
20 Dec "	14.5	14.2	13.5	13.5	25.6	13.4	25.4	16.0	10.2	21.7	11.1	*	13.7	*	22.3
30 Jan 1989	22.1	*	15.7	6.9	23.3	17.3	*	14.6	*	22.2	23.6	*	15.4	*	25.7
28 Feb "	21.0	*	13.7	*	21.9	28.9	*	13.2	*	20.3	17.5	*	13.8	*	*

PHOSPHORUS

Sample date	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 May 1988	*	*	1.0	*	1.3	*	*	1.2	*	1.9	*	*	1.7	*	1.7
17 Jun "	3.2	*	1.4	*	1.8	3.1	*	1.0	*	1.8	3.2	*	1.5	*	1.9
19 Jul "	1.4	*	1.1	*	2.1	1.2	*	0.6	0.6	1.3	1.4	*	1.2	*	1.6
19 Aug "	1.7	1.9	1.2	1.4	2.0	1.6	*	0.6	*	1.0	1.8	*	1.2	1.2	1.3
18 Sep "	1.6	*	1.2	1.5	2.4	1.0	1.1	2.3	0.9	2.7	1.4	1.7	1.1	1.3	1.4
20 Oct "	1.4	1.7	1.1	1.5	1.8	0.8	1.1	0.7	0.9	1.9	0.9	1.6	0.9	1.1	1.2
2 Nov "	1.3	1.4	1.3	1.4	1.8	0.7	1.0	0.7	1.3	1.6	0.9	1.4	1.1	1.3	1.6
23 Nov "	1.2	*	1.5	0.6	1.3	0.6	*	0.9	1.3	2.0	0.8	1.0	0.9	0.5	1.6
20 Dec "	1.6	1.7	1.4	1.4	1.5	0.7	1.3	1.1	*	1.7	0.7	*	1.3	*	1.8
30 Jan 1989	1.3	*	1.1	0.6	1.2	1.1	*	1.1	*	1.7	1.3	*	1.5	*	2.2
28 Feb "	1.0	*	0.9	*	1.1	1.4	*	0.9	*	1.2	1.0	*	1.1	*	*

Appendix 3D. c) Continued.

POTASSIUM

Sample date	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 May 1988	*	*	1.9	*	6.9	*	*	1.7	*	7.2	*	*	5.2	*	4.4
17 Jun "	10.8	*	3.7	*	7.8	11.4	*	4.8	*	6.9	12.3	*	5.1	*	8.1
19 Jul "	3.9	*	3.2	*	1.7	3.0	*	4.3	4.9	2.2	3.7	*	3.2	*	1.3
19 Aug "	3.6	*	3.0	3.5	2.2	3.5	*	2.5	*	1.2	3.2	2.1	2.9	4.7	2.4
18 Sep "	7.3	6.5	4.0	7.4	3.1	6.2	*	4.6	6.0	3.3	5.3	6.8	4.5	6.7	2.9
20 Oct "	5.4	5.3	4.4	7.2	5.8	5.2	6.5	4.4	6.1	5.3	4.9	3.9	4.4	4.9	5.4
2 Nov "	5.9	9.0	6.5	8.7	5.7	5.7	8.5	3.4	10.8	6.4	6.5	8.4	4.7	9.2	6.7
23 Nov "	4.2	4.1	5.4	6.6	4.5	4.2	*	4.4	8.5	4.7	5.0	*	5.2	5.9	5.0
20 Dec "	2.8	*	3.2	*	2.0	2.7	*	3.4	*	2.2	3.0	4.6	4.5	*	3.0
30 Jan 1989	1.7	*	2.2	6.0	2.1	1.5	*	3.1	*	2.3	1.9	*	3.4	*	2.6
28 Feb "	1.3	*	2.7	*	1.4	1.3	*	3.1	*	1.7	1.2	*	3.1	*	*

SODIUM

Sample date	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 May 1988	*	*	0.2	*	0.2	*	*	0.2	*	0.3	*	*	0.4	*	0.2
17 Jun "	0.2	*	0.3	*	0.2	0.2	*	0.4	*	0.2	0.1	*	0.5	*	0.2
19 Jul "	0.1	*	0.2	*	0.1	0.2	*	0.3	0.1	0.1	0.1	*	0.2	*	0.0
19 Aug "	0.1	*	0.1	0.1	0.1	0.1	*	0.2	*	0.1	0.1	0.1	0.2	0.1	0.1
18 Sep "	0.2	0.1	0.2	0.1	0.1	0.3	*	0.3	0.2	0.6	0.2	0.2	0.2	0.1	0.2
20 Oct "	0.3	0.3	0.3	0.1	0.2	0.3	0.5	0.3	0.2	0.3	0.3	0.2	0.3	0.2	0.2
2 Nov "	0.5	0.5	0.2	0.1	0.2	0.4	0.7	0.2	0.1	0.2	0.4	0.4	0.2	0.1	0.2
23 Nov "	0.3	0.4	0.3	0.1	0.2	0.4	*	0.2	0.2	0.2	0.4	0.3	0.2	0.2	0.4
20 Dec "	0.3	*	0.3	*	0.2	0.4	*	0.3	*	0.3	0.4	*	0.4	*	0.5
30 Jan 1989	0.3	*	0.4	0.2	0.4	0.5	*	0.6	*	0.6	0.5	*	0.4	*	0.7
28 Feb "	0.5	*	0.5	*	0.4	0.5	*	0.5	*	0.5	0.5	*	0.5	*	*

Appendix 3D. c) Continued.

CALCIUM

Sample date	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 May 1988	*	*	9.0	*	6.4	*	*	6.6	*	6.3	*	*	7.2	*	7.1
17 Jun "	5.6	*	7.4	*	6.5	6.6	*	7.4	*	6.3	5.1	*	7.1	*	7.2
19 Jul "	7.4	*	8.3	*	7.1	7.5	*	6.6	8.3	7.2	7.5	*	6.9	*	7.5
19 Aug "	7.5	*	7.2	8.9	7.7	7.2	*	6.9	*	6.9	8.0	7.8	5.7	7.2	6.9
18 Sep "	9.7	9.1	6.5	7.8	7.1	9.3	*	6.6	8.7	7.5	8.4	9.3	6.3	5.7	7.1
20 Oct "	10.4	11.7	6.9	6.8	6.3	11.0	15.6	7.8	8.1	6.9	10.4	9.6	6.5	6.3	6.9
2 Nov "	10.7	11.7	6.8	4.5	5.4	11.4	16.8	7.2	5.3	5.6	10.5	11.7	6.1	4.7	6.2
23 Nov "	12.6	13.4	7.8	5.7	6.9	12.2	*	8.7	6.0	6.6	12.0	12.0	6.6	5.7	8.4
20 Dec "	13.2	*	3.5	*	3.3	13.5	*	8.0	*	6.6	14.4	*	8.4	*	8.8
30 Jan 1989	12.0	*	6.6	4.8	5.9	12.0	*	8.3	*	6.6	12.6	*	7.2	*	9.9
28 Feb "	11.7	*	6.6	*	6.3	12.3	*	6.6	*	7.2	12.0	*	6.9	*	*

MAGNESIUM

Sample date	Plot 7					Plot 8					Plot 9				
	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis	OL	BL	SW	F	Mis
18 May 1988	*	*	0.9	*	1.5	*	*	0.8	*	1.7	*	*	1.1	*	1.5
17 Jun "	2.2	*	1.4	*	1.9	2.4	*	1.1	*	1.7	2.5	*	1.2	*	1.8
19 Jul "	1.7	*	1.2	*	1.1	1.6	*	0.8	1.7	1.1	1.8	*	1.3	*	1.2
19 Aug "	1.9	*	0.9	1.9	1.2	1.6	*	0.8	*	1.0	1.9	1.9	0.9	1.8	1.3
18 Sep "	2.1	2.4	0.8	1.7	1.4	1.8	*	0.7	1.7	1.3	2.1	2.2	1.0	1.6	1.4
20 Oct "	1.8	2.8	0.9	1.3	1.2	1.7	3.2	0.8	1.3	1.1	2.0	2.3	1.0	1.4	1.4
2 Nov "	1.8	3.2	0.9	0.8	1.2	1.7	3.5	0.7	0.9	1.0	2.0	3.2	0.9	0.9	1.4
23 Nov "	1.8	3.1	1.1	0.9	1.4	1.5	*	0.9	0.8	1.2	2.0	4.3	1.3	1.0	1.7
20 Dec "	1.6	1.0	*	*	1.1	1.4	*	1.0	*	1.2	2.1	*	1.3	*	1.5
30 Jan 1989	1.7	*	1.1	0.9	1.1	1.8	*	1.1	*	1.1	2.2	*	1.2	*	1.7
28 Feb "	1.6	*	1.1	*	1.1	1.4	*	0.9	*	1.1	1.5	*	1.2	*	*

APPENDIX 4

Mean ± SE (*n*=6) oven dried (85 °C) weights (kg ha^{-1}) of leaf, small wood (<2 cm diameter) and fruit in the litter layer and their total for each of the three plots in each of Ross (1), Gartfairn (2) and Methven (3) in each of four sampling dates. The mean ± SE for each site (*n*=18) is shown. The significance of variations between sample dates (V.B.Sa) are given in (Table 23) chapter 5.

Wood	Plot	Leaf		Small wood		Fruit		Total	
Sampling 1 (late July to early August 1988)									
1	1	2672±	162	835±	162	24±	7	3530±	288
	2	1839	219	1401	190	1	1	3241	379
	3	1359	108	619	151	29	10	2008	185
Mean		1957	160	952	121	18	5	2926	226
2	4	1142	89	507	131	14	8	1664	88
	5	985	119	536	143	10	5	1532	240
	6	1049	109	1322	272	47	15	2418	372
Mean		1059	60	788	139	24	7	1871	170
3	7	1388	220	1406	285	85	22	2878	448
	8	1989	152	1922	245	158	40	4069	372
	9	1867	393	1099	161	101	52	3066	475
Mean		1748	162	1476	152	115	23	3338	267
Sampling 2 (late November 1988)									
1	1	2925±	79	1314±	165	24±	13	4263±	224
	2	2887	145	1310	378	1	1	4198	447
	3	2949	100	1092	147	8	7	4049	113
Mean		2920	61	1239	139	11	5	4170	162
2	4	2803	132	692	171	32	11	3527	228
	5	2515	255	443	130	21	16	2979	323
	6	2986	45	678	105	9	4	3673	127
Mean		2768	102	605	80	20	7	3393	149
3	7	2904	82	825	150	59	29	3788	170
	8	2559	202	1294	206	107	16	3959	333
	9	3227	88	1287	140	110	30	4625	177
Mean		2897	99	1136	106	92	15	4124	156
Sampling 3 (early April 1989)									
1	1	1827±	98	1194±	130	18±	7	3040±	206
	2	1637	107	1216	312	5	4	2858	415
	3	1829	101	1034	140	0	0	2863	180
Mean		1764	60	1148	116	8	3	2920	157
2	4	1631	152	1061	115	12	7	2704	223
	5	1385	100	500	128	11	5	1896	189
	6	1608	129	1055	173	7	3	2670	226
Mean		1541	75	872	99	10	3	2423	147
3	7	1995	213	1154	167	21	5	3170	250
	8	1355	215	1823	256	64	21	3242	83
	9	1580	324	1148	161	66	57	2794	413
Mean		1643	153	1375	133	50	20	3069	161
Sampling 4 (mid-June 1989)									
1	1	1454±	63	945±	109	0±	0	2399±	146
	2	1136	47	755	133	0	0	1891	131
	3	1553	92	744	179	1	1	2297	204
Mean		1381	57	815	81	0	0	2196	103
2	4	1243	87	950	109	0	0	2194	167
	5	1230	160	794	183	9	5	2033	325
	6	1609	262	1250	156	4	2	2863	322
Mean		1361	109	998	94	4	2	2363	176
3	7	1679	140	1044	237	38	9	2760	343
	8	1189	259	1626	282	52	16	2867	417
	9	1016	211	1157	240	13	6	2187	274
Mean		1295	132	1276	151	34	7	2605	203

APPENDIX 5

a) Nutrient concentrations (mg g^{-1}) and ash (%) of remaining litter, on an oven dried basis (85 °C), in coarse meshes, fine meshes and frames during the four samplings in the each of the plots in the three sites.

ROSS

Sampling	N	P	K	Na	Ca	Mg	Ash
Plot 1							
Coarse mesh							
1	9.57	0.39	1.23	0.57	10.2	1.89	4.0
2	14.2	0.72	1.38	0.12	11.2	1.32	4.3
3	11.8	0.85	1.46	0.18	11.8	1.37	4.1
4	15.3	1.52	1.89	0.18	16.5	1.80	4.8
Fine mesh							
1	9.20	0.69	1.26	0.51	11.7	1.86	4.2
2	11.3	0.75	1.32	0.21	11.3	1.35	5.0
3	10.6	0.90	1.58	0.21	14.5	1.43	4.4
4	14.0	1.59	2.31	0.15	17.7	1.80	5.2
Plot 2							
Coarse mesh							
1	11.7	0.44	1.05	0.38	11.1	1.73	3.8
2	10.5	0.87	1.38	0.12	11.8	1.59	4.3
3	14.9	0.68	1.56	0.21	11.2	1.20	4.2
4	18.0	1.35	1.83	0.15	15.0	1.59	4.8
Fine mesh							
1	11.5	0.40	0.90	0.45	10.5	1.89	4.2
2	10.3	0.72	1.43	0.30	11.8	1.65	4.7
3	12.8	0.60	1.47	0.21	12.2	1.29	4.5
4	17.8	1.37	2.37	0.18	15.9	1.50	4.9
Ross plot 3							
Coarse mesh							
1	11.7	0.34	0.90	0.48	8.55	1.89	3.8
2	11.4	0.49	0.99	0.15	10.2	1.47	4.2
3	14.8	0.56	1.41	0.24	10.9	1.47	4.0
4	14.8	0.90	1.70	0.15	14.0	1.82	4.5
Fine mesh							
1	11.3	0.25	0.87	0.39	10.5	1.98	4.0
2	11.7	0.45	0.93	0.20	8.06	1.58	4.4
3	12.0	0.49	1.17	0.15	11.3	1.47	4.4
4	15.6	0.81	1.83	0.15	15.3	1.65	4.6
Gartfairn (plot 4) leaves in Ross (plot 1)							
1	15.1	0.68	1.35	0.54	11.7	2.64	4.4
2	15.8	1.02	1.52	0.17	12.5	2.12	4.9
3	17.1	0.96	1.44	0.27	13.3	1.77	4.7
4	19.3	1.57	1.77	0.12	17.7	2.07	5.0
Methven (plot 7) leaves in Ross (plot 1)							
1	16.7	0.63	1.23	0.54	11.0	2.07	4.7
2	18.1	0.98	1.35	0.15	10.4	1.62	4.8
3	18.4	0.90	1.29	0.18	11.6	1.44	4.5
4	19.9	1.43	1.71	0.18	16.0	1.86	5.4

Appendix 5 a. Continued.

GARTFAIRN

Sampling	N	P	K	Na	Ca	Mg	Ash
Plot 4							
Coarse mesh							
1	15.4	0.75	1.44	0.69	12.9	2.76	4.8
2	17.7	1.22	2.49	0.18	5.70	2.46	5.1
3	18.5	1.28	2.01	0.18	14.0	2.31	5.4
4	20.1	1.79	2.88	0.18	18.6	3.27	5.9
Fine meash							
1	17.1	1.07	2.04	0.78	15.3	2.88	5.3
2	16.2	1.22	2.10	0.45	8.43	2.64	5.3
3	19.2	1.24	2.52	0.42	14.9	2.73	6.0
4	19.5	1.64	2.85	0.30	18.3	3.36	6.2
Plot 5							
Coarse mesh							
1	13.6	0.80	1.20	0.63	10.5	2.34	3.9
2	15.2	1.04	1.71	0.09	6.72	1.74	3.9
3	14.5	1.33	1.44	0.24	9.81	1.92	4.0
4	16.2	1.55	2.31	0.18	16.2	3.27	4.9
Fine mesh							
1	14.7	1.07	1.62	0.60	11.0	2.46	4.3
2	13.9	1.04	1.47	0.27	6.48	2.07	4.4
3	15.6	1.07	1.56	0.30	10.1	2.46	4.8
4	16.8	1.73	2.73	0.15	16.8	3.27	4.8
Plot 6							
Coarse mesh							
1	18.0	1.16	1.65	0.74	12.8	2.31	5.4
2	16.7	1.11	1.91	0.21	6.71	1.98	5.4
3	18.8	0.90	1.98	0.36	11.1	2.22	5.8
4	21.1	1.78	2.43	0.27	16.2	3.03	6.7
Fine meash							
1	18.3	0.96	1.50	0.75	12.9	2.91	4.7
2	15.4	1.07	1.56	0.42	9.57	2.16	5.0
3	20.4	1.37	1.97	0.39	14.3	2.43	5.9
4	21.7	1.95	2.76	0.20	19.1	2.96	6.3
Ross (plot 1) leaves in Gartfairn (plot 4)							
1	10.4	0.58	1.35	0.74	12.0	2.07	4.5
2	11.8	1.07	2.31	0.15	5.94	1.71	4.6
3	13.0	0.98	1.95	0.21	12.2	1.95	4.7
4	16.8	1.88	2.91	0.21	17.1	2.73	5.6
Methven (plot 7) leaves in Gartfairn (plot 4)							
1	17.0	0.86	1.68	0.66	12.9	2.22	5.9
2	17.9	1.11	2.37	0.15	6.06	1.86	4.9
3	19.0	1.08	1.88	0.18	12.6	2.16	5.6
4	20.7	1.70	2.96	0.26	17.6	2.90	6.1

Appendix 5 a. Continued.

METHVEN

Sampling	N	P	K	Na	Ca	Mg	Ash
Plot 7			Coarse mesh				
1	15.6	0.58	1.56	0.42	12.6	1.95	5.2
2	16.5	0.88	1.92	0.27	8.37	1.59	5.6
3	17.8	0.90	2.22	0.27	10.1	1.62	5.8
4	19.0	1.39	3.75	0.18	18.0	2.07	6.0
			Fine meash				
1	16.1	0.79	2.37	0.45	12.9	2.07	5.3
2	15.2	0.85	2.91	0.48	9.59	1.71	5.6
3	17.4	0.87	2.73	0.36	12.5	1.92	5.7
4	19.7	1.51	4.80	0.24	19.8	2.28	9.0
Plot 8			Coarse mesh				
1	15.9	0.53	1.50	0.48	13.2	1.80	5.8
2	15.9	0.79	1.80	0.27	6.57	1.56	5.9
3	16.2	0.79	1.98	0.24	13.7	1.50	5.8
4	18.4	1.26	2.70	0.27	16.8	1.92	7.8
			Fine mesh				
1	15.9	0.63	2.82	0.54	13.2	2.07	5.1
2	16.9	0.87	2.54	0.50	12.0	1.76	5.9
3	16.5	0.79	2.91	0.36	12.4	1.62	5.8
4	19.0	1.37	3.36	0.30	19.5	2.16	7.1
Plot 9			Coarse mesh				
1	15.0	0.72	1.74	0.54	12.6	2.16	5.7
2	16.5	1.04	2.52	0.24	8.97	1.80	5.9
3	17.4	1.03	2.31	0.24	12.5	1.77	5.8
4	17.4	1.33	2.93	0.18	17.4	2.12	6.4
			Fine mesh				
1	16.1	0.96	3.18	0.63	13.5	2.55	6.2
2	18.7	1.34	3.30	0.45	14.3	2.01	6.3
3	16.3	1.02	2.88	0.33	13.0	2.13	6.2
4	18.0	1.46	3.36	0.24	18.0	2.46	7.3
			Coarse mesh				
Ross (plot 1) leaves in Methven (plot 7)							
1	8.81	0.51	1.26	0.39	12.0	1.86	4.3
2	10.2	0.80	1.94	0.29	9.39	1.58	5.0
3	11.2	0.83	2.16	0.24	10.1	1.59	5.2
4	12.5	1.14	3.21	0.33	16.8	1.95	6.0
			Coarse mesh				
Gartfairn (plot 4) leaves in Methven (plot 4)							
1	14.8	0.72	1.50	0.48	14.1	2.82	5.4
2	14.8	0.88	2.07	0.33	10.7	2.25	5.8
3	16.0	0.94	2.10	0.21	14.6	2.10	6.3
4	18.8	1.55	4.71	0.27	20.1	3.00	7.7
Frames in Methven (plot 7)							
1	15.1	0.62	2.18	0.80	12.3	2.40	10.9
2	15.2	0.81	2.31	0.39	12.2	1.74	8.1
3	18.4	1.02	2.49	0.36	13.1	1.83	10.0
4	19.2	1.46	3.90	0.30	17.7	2.22	9.5

Appendix 5 Continued.

b) Remaing oven dried (85 °C) mass (g) of litters in coarse meshes (n=4), fine meshes (n=4) and frames (n=5) during four sampling in different plots in the three sites.

ROSS

	Coarse				Fine			
Samplings	1	2	3	4	1	2	3	4
Plot 1								
	3.14	2.91	2.61	2.11	3.32	2.88	2.76	2.17
	3.19	2.77	2.43	2.33	3.52	2.75	2.78	1.89
	3.13	2.82	2.40	2.26	3.31	2.79	2.36	2.47
	3.38	2.86	2.50	2.04				
	3.25	2.67	2.55	2.27				
	3.19	2.75	2.68	2.26				
	3.12	2.69	2.23	1.87				
Plot 2								
	3.13	2.75	2.25	2.19	2.95	3.28	2.67	1.77
	3.07	2.71	2.76	2.25	3.15	3.06	2.20	2.09
	3.12	2.99	2.64	2.08	3.20	2.75	2.55	1.97
	3.30	2.92	2.41	1.43				
	3.06	2.91	2.37	1.64				
	3.01	3.02	2.45	1.80				
	3.15	3.12	2.46	2.00				
Plot 3								
	3.42	2.95	2.76	2.57	3.24	2.87	2.86	2.83
	3.31	3.32	2.73	2.31	3.20	3.24	3.19	2.71
	3.43	3.27	2.45	2.72	3.39	3.34	3.02	1.94
	3.42	3.16	3.14	2.66				
	3.17	3.39	2.76	2.33				
	4.00	3.09	2.54	2.35				
	3.43	3.33	2.48	2.34				

Coarse mesh
Endogeneous leaves in Ross Plot 1

Gartfairn leaves (plot 4)				Methven leaves (plot 7)			
3.26	2.88	2.43	1.72	3.39	3.05	2.28	1.47
3.07	2.91	2.19	1.85	2.98	3.09	2.58	2.13
3.04	3.03	2.26	1.93	3.18	3.01	2.47	1.93
3.14	2.93	2.64	2.12	3.29	2.89	2.57	2.16
2.93	3.03	2.47	1.72	3.10	2.86	2.10	2.07
3.28	3.00	2.29	1.87	3.46	2.89	2.15	1.72
3.32	2.90	2.33	1.48	3.17	2.82	2.64	2.13

Appendix 5 b. Continued

GARTFAIRN

Samplings

	Coarse 1	2	3	4	Fine 1	2	3	4
Plot 4								
	3.34	2.91	1.74	2.26	3.41	3.17	3.24	2.56
	3.54	2.88	1.82	2.56	3.31	3.05	2.77	2.74
	2.99	2.74	1.85	0.86	2.84	3.22	2.56	2.60
	3.27	2.94	2.58	1.59				
	3.34	2.34	1.65	1.26				
	3.26	2.49	1.98	1.15				
	3.13	2.33	2.63	1.29				
Plot 5								
	3.23	3.06	2.83	1.36	3.47	3.36	2.89	2.86
	3.12	3.01	2.46	1.26	3.29	3.15	2.96	2.42
	3.28	2.96	2.79	1.02	3.31	3.37	3.05	2.51
	3.22	2.81	2.50	1.23				
	3.27	3.18	2.27	1.22				
	3.31	2.92	2.48	1.25				
	3.31	3.07	2.72	1.22				
Plot 6								
	3.25	3.15	1.66	1.20	3.27	3.39	3.27	2.49
	3.45	3.10	2.85	2.00	3.23	3.29	3.03	1.56
	3.28	2.92	2.55	2.69	3.19	3.35	3.12	2.02
	3.36	3.10	2.68	0.49				
	3.03	3.27	1.64	1.82				
	3.48	3.37	1.93	1.63				
	3.67	2.70	2.54	1.65				

Coarse mesh

Endogenous leaves in Gartfairn (plot 4)

Ross leaves (plot 1)				Methven leaves (plot 7)			
3.27	2.91	1.87	1.06	3.42	2.53	2.03	0.60
3.27	2.64	2.13	0.60	3.42	2.38	2.17	1.02
3.15	3.00	2.44	0.62	3.18	2.67	2.65	1.77
3.38	2.79	1.53	1.11	3.33	2.79	2.41	1.79
3.36	2.91	1.64	1.23	3.09	2.32	2.15	0.56
3.34	2.98	2.25	2.28	3.33	2.32	1.47	1.06
3.69	2.77	2.20	0.86	3.45	2.85	2.44	0.41

Appendix 5 b. Continued.

METHVEN

Samplings	Coarse				Fine		
1	2	3	4	1	2	3	4
Plot 7							
3.83	2.99	3.06	1.23	3.65	3.37	3.37	2.72
3.26	3.45	2.68	1.37	3.63	3.56	3.26	2.31
3.91	3.08	2.20	1.86	3.67	3.61	3.40	2.14
3.22	3.20	2.81	2.01				
3.50	3.00	2.93	1.67				
3.42	3.26	2.67	0.79				
3.74	3.04	2.61	1.50				
Plot 8							
3.95	3.08	3.15	2.89	3.76	3.51	3.53	3.19
3.40	3.38	3.35	2.59	3.62	3.49	3.31	2.72
3.61	3.18	2.91	1.15	3.73	3.40	3.30	2.95
3.70	3.33	2.86	1.18				
3.77	3.15	2.62	2.40				
3.66	3.24	3.13	2.55				
3.75	3.31	2.95	2.05				
Plot 9							
3.32	2.52	2.51	2.03	3.88	3.35	3.52	3.09
3.89	2.58	2.62	2.29	3.72	3.66	3.35	3.25
3.64	3.41	2.75	2.31	3.99	2.53	3.22	3.16
3.79	3.26	2.55	1.55				
3.69	2.87	2.96	2.23				
3.85	3.38	2.86	2.68				
3.18	3.37	3.17	0.54				

Coarse mesh

Endogenous leaves in Methven (plot 7)

Ross leaves (plot 1)				Gartfairn leaves (plot 4)			
3.67	3.59	3.45	1.93	3.11	3.11	2.76	0.94
3.74	3.39	2.99	1.96	3.41	3.10	2.89	0.55
3.75	3.53	2.91	2.16	3.70	3.57	2.67	1.92
3.57	3.61	2.79	2.15	3.43	3.67	2.70	1.00
3.56	3.29	2.90	0.99	3.45	2.96	2.45	1.65
3.47	3.67	2.62	2.27	3.79	2.71	2.53	2.06
3.69	3.58	2.57	1.58	4.05	3.29	2.94	1.37

Frames In Methven (plot 7)

6.26	4.26	4.34	2.46
5.56	4.40	3.98	2.50
5.66	4.46	2.85	2.54
5.67	4.33	4.28	2.67
5.23	4.31	3.18	2.09