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CAMBRIDGE UNIVERSITY NATURAL RADIOCARBON MEASUREMENTS XV

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The dates presented in this paper are concerned with studies of the vegetational history of Western Scotland and are research projects in collaboration with members of staff and research students of the Subdepartment of Quaternary Research, Cambridge University. The measurements of radioactivity were carried out between 1975 and 1977 at the University Radiocarbon Research Laboratory at Station Road, Cambridge, using highly purified carbon dioxide as filling gas in proportional counters. The dates are conventional radiocarbon dates calculated using the Libby half-life for the ^{14}C isotope of 5568 years and AD 1950 as the reference year. The associated uncertainties represent one standard deviation and are calculated from a combination of the counting statistics of the samples, standards, and backgrounds together with estimates of population variation, variation of the background rate with changes of barometric pressure, and estimates of other laboratory measurement uncertainties. Thus, the stated uncertainty is considered a fairly reliable estimate of the laboratory uncertainty of the dates. The background samples are prepared from Welsh anthracite and the contemporary standard from NBS oxalic acid. A subsidiary standard is also used which is prepared from the AD 1845 to AD 1855 growth rings of an oak tree which grew near Cambridge, and the activity of this is compared frequently with the NBS standard.

The proportional counters in which the radioactivity was measured were so arranged that four might be used simultaneously within one anticoincidence shield. Two counters were of closely similar construction, the body being made from low radioactivity quartz having a tin oxide conducting coating. These were contained inside Faraday shields made from OFHC copper. The axial anode wire was of 0.025mm tungsten held near earth potential, while the EHT was applied to the inner tin oxide conductor. The volume was nominally 1L and the sample gas pressure was normally either 2 or 3 atmospheres. The other two counters were constructed from simple OFHC copper cylinders with volumes about 2L and 0.45L respectively, and here the EHT was applied to the central wire anode. Thus, with these counters it was possible to measure samples within the size range of about 3g to 250mg of carbon, using carbon dioxide as the filling gas. The counting gas was prepared by oxidation of the sample followed by the purification of the combustion gases. Normally oxidation was carried out in a high pressure combustion bomb (Switsur, 1972; Switsur and West, 1973) or when the carbon content of the sample fell below about 2%, as in the case of some lake muds, either a quartz combustion tube was used, or 'wet' oxidation with permanganate. The bomb technique was most convenient. Being highly

automated, it required very little attention, saving the time and salary for one technician, besides producing a more efficient laboratory. The use of either water or potassium permanganate solution inside the pressure vessel container aided absorption of impurities which otherwise would have appeared in the combustion products. Further purification, however, was required before the carbon dioxide was suitable for high sensitivity gas counting. A description of the equipment which may be of value for use with miniature proportional counters, where high purity for the long counting times required is a necessity, is given in a companion paper (Switsur, ms in preparation).

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SAMPLE DESCRIPTIONS

GEOLOGIC SAMPLES

Scotland

Vegetational history of Scotland

There are three large forest regions in Scotland at present: oak forest with birch predominates to the S of The Great Glen and along the W coast as far N as Isle of Skye; pine forest with some oak and birch predominates in the Torridon region of Wester Ross and in the Grampian Highlands; to the N and W birch forest predominates except on the smaller islands which are treeless even at low alt owing to their exposed nature. We are interested in tracing the origin of this pattern and in following its evolution, in studying the factors controlling vegetational differentiation, the relative importance of local environmental factors, plant migration, and the influence of man on the distribution. Members of the Sub-department of Quaternary Research, Cambridge Univ, have long been engaged in such studies and the rate of vegetational changes occurring since the end of the last glaciation. The work has been intensified recently with the aid of a research grant from the NERC.

Sites have been selected in the major forest areas above, particularly in a transect running N-S along the W coast of Scotland from Sutherland to Caithness which passes through all the important vegetational regions. Detailed pollen analyses are made on each site, providing an historical background to interpret the modern pattern of forest distribution. The study relies on many radiocarbon dates which provide the pseudo-absolute chronology for vegetational changes recorded in the pollen stratigraphy, both for the age of observed changes and migration

rates. Small lakes of comparable size were chosen, deliberately avoiding larger lakes because of large catchment areas and uncertain sources of pollen and sediments. Besides smaller catchment, sediment of small lakes is derived substantially from the production of the lake itself. Pollen data is obtained from the number of grains per unit volume of sediment and is converted by sediment accumulation rate (which requires the detailed radiocarbon dates for calculation) into absolute pollen influx rates in terms of the number of pollen grains per unit time. This influx data then eliminates problems of interdependence of relative pollen percentage data and yields an accurate vegetational history. A radiocarbon calibration curve for the entire postglacial is needed for absolute measurements. The results provide firm environmental and chronologic bases for archaeologic investigations in Scotland.

Many workers in the Sub-department of Quaternary Research were involved in this large program, in obtaining the lake sediment cores, pollen analysis, in radiocarbon determinations, and in interpretation of results. These included P Adams, H J B Birks, H H Birks, A R Hall, B Huntley, B Madsen, R W Mathewes, S M Peglar, I C Prentice, L Rymer, V R Switsur, A P Ward, W Williams, and J E Young. H J B Birks acted as coordinator of the program. Interpretation of the results of this work is in progress and a combined publication by all participants is projected shortly. In the following series, definitive descriptions of radiocarbon samples are presented together with the dates obtained. Samples are identified by depths. The sample size was chosen to be commensurate with growth rate and carbon content to obtain the best temporal resolution. In the lower regions where carbon content was low, loss on ignition tended to overestimate carbon content, the loss probably including both volatile sulphur compounds and bound water from the mineral constituents. Pretreatment was mainly physical, followed by heating with dilute hydrochloric acid.

Loch Assynt series

Vertical sequence through limnic deposits near Loch Assynt, Sutherland (58° 10′ N, 5° 04′ W, Natl Grid Ref 19/210254), ca 16km W Lochinver, one of NERC project sites from predominantly birch forest region, has been subjected to pollen analysis and radiocarbon dating. Core, 6.72m long and 5cm diam, taken with Livingstone piston corer (Wright, 1967) from deposits extending from beginning of Flandrian to recent times. Core was stored wet at 5°C until examined in lab. Following pollen counting, samples were taken for radiocarbon dating as thin slices of mud at levels corresponding to significant changes in pollen spectra. Organic content of deposits, determined by ignition loss, increased upwards in column from ca 20% to ca 50%; samples were thus suitable for oxidation in high pressure combustion unit.

Core coll Aug 1973 by P Adam, H J B Birks, I C Prentice, and J E Young; pollen analyses by H J B Birks and H H Birks and radiocarbon measurements by V R Switsur.

Q-1280. Loch Assynt, 673-668cm **9430 ± 150**

4cm moss-rich silts and sands, Troels-Smith (1955) classification: Tb2, Gal, Ag1, Dh+. Pollen indicates expansion of *Juniperus*. *Comment*: provides basal date for organic deposition at site.

Q-1279. Loch Assynt, 649-641cm **9200 ± 120**

8cm silty fine detrital mud, Troels-Smith classification: Ld2, Ag2, Ga+, Dh+, Dg+. Organic content 22%. Pollen diagram indicates decrease of *Juniperus* with increase of *Betula* pollen.

Q-1278. Loch Assynt, 624-616cm **8950 ± 140**

8cm fine detrital mud, Troels-Smith classification: Ld4, Dg+, Dh+, Ag+. Organic content 25%. Pollen diagram indicates expansion of *Corylus* pollen.

Q-1277. Loch Assynt, 584-576cm **8310 ± 130**

8cm fine detrital mud, Troels-Smith classification: Ld4, Dg+, Dh+, Ag+. Organic content 30%. Pollen diagram indicates fall of *Corylus* pollen.

Q-1276. Loch Assynt, 514-506cm **6500 ± 130**

8cm fine detrital mud, Troels-Smith classification: Ld4, Dg+, Dh+, Ag+. Organic content 35%. Pollen diagram shows expansion of *Alnus* frequencies.

Q-1275. Loch Assynt, 454-444cm **5240 ± 110**

10cm fine detrital mud, Troels-Smith classification: Ld2, Dh1, Dg1, Sh+. Organic content 40%. Pollen diagram shows local expansion of *Pinus* frequencies.

Q-1274. Loch Assynt, 383-377cm **4340 ± 100**

6cm fine detrital mud with some wood fragments, Troels-Smith classification: Dh2, Dg1, Ld1, Sh+, D1+. Organic content 50%. Pollen diagram indicates first major decline of *Pinus* pollen frequencies.

Q-1273. Loch Assynt, 272-267cm **3300 ± 90**

6cm fine detrital mud, Troels-Smith classification: Ld2, Dh2, Dg+, Sh+, D1+. Organic content 40%. Pollen diagram shows final decline of *Pinus* pollen frequencies.

Q-1265. Loch Assynt, 172.5-167.5cm **1570 ± 80**

5cm organic fine detrital mud, Troels-Smith classification: Dh2, Ld2, Dg+, Sh+, D1+. Organic content 50%. Pollen diagram shows major decrease of tree pollen, particularly *Betula* and *Alnus*.

General Comment: results are internally consistent and indicate deposition rate of ca 1cm in 7.6 yr for first 750 yr. Deposition rate for ca next 7000 yr is ca 1cm in 16.8 yr. Figures help determination of pollen influx rate. Compare with data for other sites in Britain: Scaleby Moss (R, 1972, v 14, p 239-246); Red Moss (R, 1970, v 12, p 590-598); Tregaron

(R, 1972, v 14, p 239-246); Nant Ffrancon (R, 1973, v 15, p 156-159); Loch Maree (R, 1973, v 15, p 159-160); Din Moss (R, 1973, v 15, p 536-538); Drimnagall (R, 1975, v 17, p 304-305); and Crose Mere (R, 1975, v 17, p 302-303).

Loch Meodal series

Pollen analyses by W Williams and radiocarbon measurements by V R Switsur were made on samples from core of limnic mud from Loch Meodal in the S of Isle of Skye (57° 8′ N, 5° 5′ W, Natl Grid ref 18/656114) as part of NERC sponsored project vegetational history of W Scotland. Today region is predominantly oak with some birch. The core, 7.6m long and 7.5cm diam, containing deposits representative of entire Flandrian, was obtained Aug 1972 with a Livingstone piston sample corer by P Adams, H J B Birks, W Williams, and J E Young. The still waterlogged core was stored in the lab at 5°C before examination. Its lithology was very uniform as was organic content, apart from lowest levels. Deposits contained much sulphur which was probably included in the loss on ignition 'organic' content. Pretreatment was by dilute hydrochloric acid only, which did not remove sulphur compounds totally. 'Wet' oxidation was used for these samples. A previous measurement on basal layers of this site gave date of Q-960: 9480 ± 150 (R, 1972, v 14, p 243). For more information on past and present vegetation of Isle of Skye, see Birks (1973, p 170-206, 244-272).

Q-1301. Loch Meodal, 735-730cm **9610 ± 150**

5cm fine detritus mud, Troels-Smith classification: Ld2, Dg1, Lso+, As+, Ag+. Organic content 10%. Pollen diagram shows expansion of *Corylus* pollen.

Q-1302. Loch Meodal, 677.5-672.5cm **8240 ± 150**

5cm fine detrital mud, Troels-Smith classification: $Ld^{2}2$, Dg1, Lso+, As+, Ag+. Organic content 18%. Pollen diagram shows rise of *Pinus* pollen frequencies.

Q-1303. Loch Meodal, 630-625cm **6590 ± 110**

5cm fine detrital mud, Troels-Smith classification: $Ld^{2}2$, Dg1, Lso+, As+, Ag+. Organic content 17%. *Alnus* pollen shows initial increase at this level.

Q-1304. Loch Meodal, 615-610cm **6140 ± 110**

5cm fine detrital mud, Troels-Smith classification: $Ld^{2}3$, Dg1, Lso+, As+, Ag+. Organic content 17%. The pollen diagram shows rapid increase in frequencies of *Alnus* pollen at this level.

Q-1305. Loch Meodal, 577.5-572.5cm **5160 ± 100**

5cm fine detrital mud, Troels-Smith classification: $Ld^{2}3$, Dg1, Lso+, As+, Ag+. Organic content 18%. At this level in pollen diagram *Ulmus* pollen frequencies fall rapidly.

Q-1306. Loch Meodal, 512.5-507.5cm 4630 ± 80

5cm fine detritus mud, Troels-Smith classification: $Ld^{2}3$, Dg1, Lso+, As+, Ag+. Organic content 18%. *Pinus* pollen frequencies, never very high, fall to very low levels at this part of pollen diagram.

Q-1307. Loch Meodal, 437.5-432.5cm 4030 ± 60

5cm fine detrital mud, Troels-Smith classification: $Ld^{2}3$, Dg1, Dh+, Lso+, As+, Ag+. Organic content 18%. At this point in pollen diagram *Quercus* frequencies fall to low values.

Q-1308. Loch Meodal, 352-5-347.5cm 3170 ± 50

5cm fine detrital mud, Troels-Smith classification: $Ld^{2}3$, Dg1, Dh+, Lso+, Ag+, As+. Organic content 16%. Pollen curves stable at this level, but date increases precision in pollen influx computations.

Q-1309. Loch Meodal, 252.5-247.5cm 2760 ± 50

5cm fine detrital mud, Troels-Smith classification: $Ld^{2}3$, Dg+, Lso+, Dh+, Ag+, As+. Organic content 17%. As with Q-1308, date is for greater precision in pollen influx computations.

Q-1310. Loch Meodal, 152.5-147.5cm 1930 ± 50

5cm fine detrital mud, Troels-Smith classification: $Ld^{2}3$, Dg1, Dh+, Lso+, Ga+, As+, Ag+. Organic content 22%. *Betula, Alnus, Corylus, Calluna, Graminae,* and *Cyperaceae* pollen curves continue at high levels. Age allows greater precision in sedimentation rate determinations and, hence, pollen influx computations.

General Comment: results are internally consistent and indicate a deposition rate of ca 3.5cm per radiocarbon century between ca 9500 BP and 5000 BP after which time, rate increased to ca 13.3cm per radiocarbon century until ca 2000 BP. Figures in detail enable calculations of pollen influx rates for entire period. Calibration curve for entire Flandrian is required for absolute values. Results may be compared with those at Loch Assynt (above) and sites mentioned in General Comment to that series.

Loch of Winless series

A square-rod Livingstone corer was used to obtain a complete core, 6m long and 5cm diam, from undisturbed sediments through a post-glacial lake and fen at Loch of Winless, Caithness (58° 28′ N, 3° 13′ W, Natl Grid ref 39/293547) 8km WNW of Wick, 22.5km SE Thurso, alt 10m OD. Core was taken June 1972 by H J B Birks and J E Young. Pollen analyses were made by S Peglar and radiocarbon measurements by V R Switsur. Site is in region of predominantly birch forest. Previous dates from lower levels of deposits are reported in Switsur and West (1973).

Q-1325. Loch of Winless, LW 405-395cm 9430 ± 110

10cm silty detrital mud at level where pollen diagram shows *Betula* max. Organic content very low.

Q-1326. Loch of Winless, LW 360-350cm **8650 ± 100**

Silty detrital mud from 250 to 360cm depth in core, of very low organic content.

Q-1327. Loch of Winless, LW 295-290cm **7570 ± 80**

5cm slice of coarse silty detrital mud of moderate organic content.

Q-1328. Loch of Winless, LW 225-220cm **6920 ± 70**

5cm slice of coarse detrital mud of moderate organic content at level in pollen diagram indicating max in *Pinus* frequencies.

Q-1443. Loch of Winless, LW 162.5-157.5cm **4840 ± 90**

5cm slice of peat, Troels-Smith classification: Ag+, As+, Ldl, Dgl, Dh2, Dl+. High organic content. Pollen diagram shows decrease in *Ulmus* frequences.

Q-1444. Loch of Winless, LW 120-115cm **3420 ± 80**

5cm slice of peat, Troels-Smith classification: Ag+, As+, Ldl, Dgl, Dhl, Dl+ taken where pollen diagram shows decrease in frequencies of *Pinus* pollen.

Q-1445. Loch of Winless, LW 105-100cm **3070 ± 80**

5cm slice of peat, Troels-Smith classification: Ag+, As+, Ldl, Dgl, Dh2, Dl+ taken at level in pollen diagram showing decline in forest tree pollen.

Q-1329. Loch of Winless, LW 80-70cm **2210 ± 50**

10cm slice of herbaceous peat where pollen diagram shows decline in tree pollen frequencies.

General Comment: results are internally consistent and indicate deposition rate of ca 5.9cm per radiocarbon century between ca 13,000 and 7000 BP, falling after that time to ca 3.7cm per century until ca 2000 BP, the break corresponding with change of sediment type. Results may be contrasted with sites in this project on W side of country, such as Loch Assynt and Loch Meodal, and with those further S, such as Coire Fee and Loch Cill an Aonghais.

Loch Cill an Aonghais series

Samples from core through limnic sediments at Loch Cill an Aonghais Argyll (55° 47′ N, 5° 32′ W, Natl Grid Ref 16/776617). Pollen analysis made by S Peglar and radiocarbon analysis by V R Switsur as part of NERC supported project on vegetational history of W Scotland. Site lies within region of predominantly oak forests with some birch.

P Adams, H J B Birks, L Rymer, and J E Young obtained a core Aug 1973 using a Livingstone square rod piston corer. Core, 8.5m long and 7.5cm diam, covered all postglacial sedimentation in loch. In its natural wet condition the core was stored at 5°C prior to its lab examination in Cambridge. Organic content was generally low and basal layers were reddish-brown clays or muds with little pollen, interspersed with black sulphur-rich bands.

Q-1417. Loch Cill an Aonghais, 708-702cm 9690 ± 140

6cm fine detrital mud. Pollen diagram of layer shows sudden increase in *Betula* pollen.

Q-1416. Loch Cill an Aonghais, 698-692cm 9230 ± 130

6cm fine detrital mud. Pollen diagram of layer shows sudden increase in frequencies of *Corylus* pollen.

Q-1415. Loch Cill an Aonghais, 615-609cm 7490 ± 110

6cm fine detrital mud. Pollen diagram of layer shows expansion of *Alnus* pollen.

Q-1414. Loch Cill an Aonghais, 543-537cm 5210 ± 80

6cm fine detrital mud. Pollen diagram for layer indicates first decline of *Ulmus* pollen.

Q-1413. Loch Cill an Aonghais, 498-492cm 4650 ± 70

6cm fine detrital mud. Pollen diagram for this layer indicates last decline of *Ulmus* pollen.

Q-1412. Loch Cill an Aonghais, 453-447cm 3810 ± 100

6cm fine detrital mud. Pollen diagram shows small peak in *Betula* pollen spectrum.

Q-1411. Loch Cill an Aonghais, 353-347cm 2930 ± 80

6cm fine detrital mud. Pollen curves are stable at this level, but date increases precision in pollen influx calculations.

Q-1410. Loch Cill an Aonghais, 253-247cm 2420 ± 80

6cm fine detrital mud. Pollen curves are stable at this level, but date increases precision in sedimentation curves and pollen influx calculations.

General Comment: results are internally very consistent and comparable with other sites studied in the project. From ca 9500 to ca 5000 BP, sedimentation rate is quite constant at ca 3cm per radiocarbon century while subsequent rate is more than doubled, at ca 7cm per radiocarbon century.

Coire Fee series

Samples are from core through sediments of freshwater lake at Coire Fee, Glen Clova, August (56° 52′ N, 3° 14′ W, Natl Grid Ref 37/251751). Pollen analysis was by B Huntley and radiocarbon analysis by V R Switsur. Area is predominantly oak forest with some birch. P Adam, H J B Birks, B Huntley, I C Prentice, and J E Young obtained core Sept 1973 with a Livingstone piston corer. Core, 16m long and 5cm diam, was stored wet at 5°C and samples subm for dating Oct 1975. Sediment samples include entire Flandrian. Samples varied throughout column in relative importance of detritus, silt, and sand particles. Coarse plant remains were also present.

Q-1424. Coire Fee, CF #7 **9640 ± 110**

Lake detritus mud with silts and micaceous fragments from 15.75m to date basal sediments of site.

Q-1423. Coire Fee, CF #6 **6930 ± 80**

Lake mud from 13.75m depth. Pollen diagram shows main expansion of *Alnus* pollen frequencies at this level.

Q-1422. Coire Fee, CF #5 **6060 ± 100**

Lake mud from 12.6m depth. Layer shows consistent decreases in both *Pinus* and *Ulmus* pollen frequencies.

Q-1421. Coire Fee, CF #4 **4560 ± 80**

Lake mud from 10.3m depth. Pollen diagram shows consistent fall in *Alnus* pollen frequencies.

Q-1420. Coire Fee, CF #3 **3480 ± 80**

Lake mud from 8.75m depth. Pollen diagram shows secondary fall in *Pinus* pollen frequencies at this level.

Q-1419. Coire Fee, CF #2 **2610 ± 80**

Lake mud from 6.95m depth. At this level pollen diagram shows consistent increase in frequencies of *Calluna* pollen.

Q-1418. Coire Fee, CF #1 **790 ± 60**

Lake mud from 3.25m depth. Pollen diagram shows little change at this level, but date increases precision in sediment rate calculations and, hence, in pollen influx calculations.

General Comment: dates from this site fall on a very smooth curve indicating a steadily increasing sedimentation rate. Rate for first 2000 yr is ca 7.4cm per radiocarbon century and for last 2000 yr ca 20.4cm per radiocarbon century.

Caenlochan Glen series

Samples from core through sediments of freshwater pond at Caenlochan Glen, Angus (56° 52′ 25″ N, 3° 21′ 50″ W, Natl Grid Ref 37/185766) 28km SW Ballater. Pollen analysis was by B Huntley and radiocarbon analysis by V R Switsur. Area is predominantly oak forest with some birch. P Adam, K Edwards, R Gunson, B Huntley, and W Williams obtained core July 1974 with a Livingstone corer. Core was 4.6m long and 5cm diam and contained sediments from entire Flandrian. It was stored wet at 5°C and sampled for dating in March 1976.

Q-1450. Caenlochan Glen, #5 **9100 ± 150**

Coarse detrital mud coll from depth 4.57 to 4.52m to date basal layers of site.

Q-1449. Caenlochan Glen, #4 **8150 ± 150**

Coarse detrital mud from depth 4m to 3.95m. Pollen diagram shows first expansion of *Pinus* pollen.

Q-1448. Caenlochan Glen, #3 **6740 ± 100**

Coarse detrital mud coll from depth 3m to 2.95m. Pollen diagram shows secondary rise in *Pinus* pollen values.

Q-1447. Caenlochan Glen, #2 **4760 ± 80**

Coarse detrital mud from depth 2.05m to 2m. Pollen diagram shows decrease in frequencies of both *Ulmus* and *Cyperaceae*.

Q-1446. Caenlochan Glen, #1 **1110 ± 60**

Coarse detrital mud coll from depth 1.15m to 1.1m. Pollen diagram shows fall in *Cyperaceae* pollen and increase in *Calluna* pollen frequencies.

General Comment: Q-1450 to Q-1447 dates indicate linear deposition rate of 5.8cm per radiocarbon century during the first 5000 yr.

Loch Coultrie series

Samples from core through waterlogged blanket bog overlying limnic sediments in small hollow at site *near* Loch Coultrie, Wester Ross (57° 26′ N, 5° 36′ W, Natl Grid Ref 18/857435). Pollen analysis was by H H Birks and radiocarbon analysis was by V R Switsur. Core, 4.25m long and 7.5cm diam taken April 1975 by H J B Birks, A R Hall, B Huntley and W Williams using a Livingstone piston corer. Core was stored in natural condition at 5°C prior to sampling. Organic content was generally high, allowing high pressure bomb combustion. Stable isotope measurements were made by M A Hall using a V G Micromass 602 mass spectrometer.

9250 ± 120

Q-1518. Loch Coultrie, #1 $\delta^{13}C = -27.8‰$

Silty fine detrital mud from depth 425 to 420cm, Troels-Smith classification: $Ld^{2}3$, Ag1, Dh+, Fg+. Organic content 25%. *Comment*: dates basal organic deposits at site in hollow originally containing a pool.

8630 ± 100

Q-1517. Loch Coultrie, #2 $\delta^{13}C = -26.5‰$

Coarse detrital mud from depth 410 to 405cm, Troels-Smith classification: $Ld^{2}1$, Dh2, Dg1, D1+. Organic content 45%. Pollen diagram shows expansion of *Corylus* pollen frequencies.

7280 ± 80

Q-1516. Loch Coultrie, #3 $\delta^{13}C = -27.2‰$

Highly humified peat from depth 347.5 to 342.5cm, Troels-Smith classification: Sh4, Th+, T1+. Organic content 45%. Pollen diagram shows first increase of *Pinus* pollen frequencies.

5920 ± 80

Q-1515. Loch Coultrie, #4 $\delta^{13}C = -23.5‰$

Highly humified peat from depth 287.5 to 282.5cm, Troels-Smith classification: Sh4, Th+, T1+. Organic content 50%. Pollen diagram shows sharp increase in *Alnus* pollen frequencies.

Q-1514. Loch Coultrie, #5 **5250 ± 80**
$\delta^{13}C = -26.7‰$

Highly humified peat from depth 247.5 to 242.5cm, Troels-Smith classification: Sh4, Th+, Tl+. Organic content 50%. Pollen diagram shows sudden decline of *Ulmus* pollen frequencies.

Q-1513. Loch Coultrie, #6 **4090 ± 70**
$\delta^{13}C = -27.5‰$

Highly humified peat from depth 167.5 to 162.5cm, Troels-Smith classification: Sh3, Th1, Tb+. Organic content 50%. Pollen diagram shows major decline in *Pinus* pollen frequencies at this level.

Q-1512. Loch Coultrie, #7 **3290 ± 70**
$\delta^{13}C = -26.4‰$

Highly humified peat from depth 142.5 to 137.5cm, Troels-Smith classification: Sh3, Th1, Tb+. Organic content 50%. Pollen diagram shows final decline of *Pinus* pollen frequencies.

Q-1511. Loch Coultrie, #8 **1680 ± 50**
$\delta^{13}C = -26.6‰$

Highly humified peat from depth 67.5 to 62.5cm, Troels-Smith classification: Sh3, Th1, Tb+. Organic content 60%. Pollen diagram shows major decline in tree pollen frequencies at this level.

General Comment: sedimentation rate throughout this core is quite uniform with average rate of ca 4.9cm per radiocarbon century.

Little Loch Roag series

Little Loch Roag, Isle of Lewis, Outer Hebrides (58° 7′ N, 6° 58′ W, Natl Grid Ref 19/141248) site is small valley mire within a rock basin in Lweisian gneiss, alt 30m, 28km N Tarbert (Isle of Harris) to N of B8011 rd, and ca 20km from Standing Stones of Callanish and Dun Carloway. A core through the mire, at its deepest part, was taken Aug 1972 by P Adam, H J B Birks, and J E Young with a 5cm diam Livingstone piston corer. It was stored in natural condition at 5°C in a cold room until examined in lab in 1976-1977.

Pollen counts were made by B Madsen and radiocarbon measurements by V R Switsur. Pollen diagram shows virtually no change throughout its length of 3m, so that pollen assemblage zones could not be distinguished as in other sites studied in our work. Hence, radiocarbon dates were basis for chronologic presentation of data. These allowed for sedimentation and, hence, pollen influx rates to be calculated. This work is the first published on vegetational history of the Isle of Lewis. It provides important comparison with work in the Inner Hebrides, Orkneys, Shetland, and Caithness, reconstructing past vegetation, particularly forestation, of the Isle of Lewis.

Q-1531. Little Loch Roag I **9140 ± 140**

Silty peat with transition above to peat, coll from depth 300 to 295cm. *Comment*: dates earliest postglacial peat at base of site.

Q-1530. Little Loch Roag II **5670 ± 120**
Humified peat coll from depth 262.5 to 257.5cm.

Q-1529. Little Loch Roag III **4570 ± 90**
Humified peat coll from depth 212.5 to 207.5cm.

Q-1528. Little Loch Roag IV **3520 ± 70**
Humified peat coll from depth 162.5 to 157.5cm.

Q-1527. Little Loch Roag V **2350 ± 50**
Humified peat coll from depth 112.5 to 107.5cm.

Q-1526. Little Loch Roag VI **1340 ± 40**
Humified peat coll from depth 62.5 to 57.5cm.

General Comment: Q-1530 to Q-1526 dates fall on smooth curve against sample depth with sedimentation rate of ca 4.6cm per radiocarbon century. Extrapolation to basal sediments yields age of ca 6500 yr whereas measurements of Q-1530 yield 9140 ± 140. Low apparent sedimentation rate for early deposits is not discernible in the pollen diagram nor in the core. Dates of appearance of *Corylus, Ulmus, Quercus,* and *Alnus* agree with dates from mainland. First signs of pollen types that might reflect human interference on vegetation of area begin ca 5500 BP, ca 2000 yr earlier than estimated age of Standing Stones of Callanish.

Abernethy Forest series

Abernethy Forest, Inverness-Shire (56° 14′ N, 3° 43′ W, Natl Grid Ref 28/967175) was earlier studied by H H Birks (1970) using pollen-analytic techniques. Results were indeterminate and extent and nature of Late Devensian deposits at site were uncertain owing to possible contamination of sediments coll by narrow Hiller peat sampler. New core with larger diam, 7.5cm, hand operated piston corer (Wright, 1967) was taken June 1972 by H H Birks, H J B Birks, and J E Young. Core 5.5m long, was stored in cold room at 5°C prior to lab examination. Study includes pollen analysis by H H Birks, macrofossil analysis by R W Mathewes, Simon Fraser Univ, Burnaby, British Columbia, Canada, and radiocarbon analysis by V R Switsur, to confirm sequence of Late Devensian and Early Flandrian deposits between ca 3m to 5.5m.

Site is at alt 221m OD in boggy infill of glacial channel between Loch Mallachie and Loch Garten, 44km S E Inverness, on NW side of Cairngorm range. Region is predominantly forested with pine with some birch and oak.

Q-1266. Abernethy Forest No. 1 **11,760 ± 250**
Core sample from 540 to 530cm with transition from above to silt and sand, Troels-Smith classification: Ga2, Ag2, Dh+, Dg+ (Troels-Smith, 1955). *Comment*: dates start of Alleröd climatic amelioration at this site, and confirms Late Devensian age of sediments.

Q-1267. Abernethy Forest No. 2 **11,120 ± 220**
Fine detrital mud coll from 514 to 506cm with transition to less silty mud, Troels-Smith classification: Ld^{1}3, Ag1, Ga+, Dh+, Dg+.

Comment: date confirms Late Devensian age of sediments and dates upper boundary of Alleröd climatic amelioration.

Q-1268. Abernethy Forest No. 3 **9740 ± 170**

Fine detrital silty mud coll from depth 469 to 461cm, Troels-Smith classification: $Ld^{1}2$, Ag2, Ga+, Dh+, Dg+. *Comment*: dates opening of *Betula-Juniperus* pollen assemblage zone.

Q-1269. Abernethy Forest No. 4 **8670 ± 150**

Fine detrital mud from depth 432.5 to 427.5cm, Troels-Smith classifition: $Ld^{1}4$, Ag^{1}, Dh+, Dg+. *Comment*: dates opening of *Betula-Corylus* pollen assemblage zone.

Q-1270. Abernethy Forest No. 5 **7650 ± 120**

Fine detrital lake mud with herbaceous fragments coll from depth 375 to 370cm, Troels-Smith classification: $Ld^{1}3$, Dh1, Dg+. *Comment*: dates expansion of *Pinus* pollen in diagram.

Q-1271. Abernethy Forest No. 6 **6810 ± 110**

Fine detrital lake mud with herbaceous fragments from depth 357.5 to 352.5cm, Troels-Smith classification: $Ld^{1}3$, Dh+, Dg+. *Comment*: dates max frequencies of *Pinus* pollen in diagram.

Q-1272. Abernethy Forest No. 7 **6160 ± 100**

Fine detrital lake mud with herbaceous fragments coll from depth 330 to 325cm in core, Troels-Smith classification: $Ld^{1}2$, Dh1, Dg1. *Comment*: dates time of silting-in of lake and beginning of *Eriophorum* peat formation.

General Comment: sediment growth rate was fairly uniform at ca 3.7cm per radiocarbon century. Main change of slope was at ca 370cm. Site showed grass sedge colonization of bare moraine that developed into shrub tundra, dominated by *Empetrum* and *Betula nana* scrub, resulting from climatic warming during Alleröd time. Younger Dryas climatic deterioration led to formation of open vegetation rich in *Artemisia*. Opening of Flandrian at ca 9700 BP developed *Juniperus* and *Betula nana* scrub, later colonized by tree *Betula* and then *Corylus*. From ca 7225 BP *Pinus* dominated forest.

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