Holocene expansion of the Caledonian pinewoods: Spatial and temporal patterns at regional and landscape scales

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Supplementary Material
Supplementary Text

Palaeovegetation records

Key features of the palaeovegetation record at each site, as illustrated by the pollen diagram (Figures S24 – S48), are outlined below. The estimated date for the main increase in relative abundance of *Pinus* pollen, taken as the mid-point between the ages modelled using Bchron (Parnell et al., 2008) for the pollen samples between which what we have identified as the main increase occurred (see Figures S1 – S23), is given in each case using the median value from the Bchron probability distribution function, with the 2.5% and 97.5% values in parentheses. Ages given in the text without qualification are median ages.

Glen Achall

Ach1  Loch nan Eala  –  Landscape expansion of pinewoods 7684 (7843 – 7570) cal. yr BP

A pollen diagram spanning the interval ca. 10,400 – 700 cal. yr BP (ca. 4.10 – 12.30 m) was prepared, although with sub-sampling focused upon the interval ca. 9800 – 6100 cal. yr BP (Figures S1 and S24). Prior to ca. 8000 cal. yr BP *Betula* pollen dominated, along with moderate abundance of *Corylus*-type pollen. *Juniperus, Salix* and *Populus* were also present, especially in the lowermost sample analysed. Only trace amounts of *Pinus* pollen were recorded before ca. 8500 cal. yr BP, but *Pinus* abundance then began to increase and rose rapidly to a peak ca. 7320 cal. yr BP. The initial increase, here representing expansion of pinewoods across the Glen Achall landscape, was centred on 7684 cal. yr BP. As *Pinus* pollen abundance increased abundances of *Betula* and *Corylus*-type decreased. Pollen of *Quercus* and *Ulmus* was only ever sparsely present, but *Alnus* pollen abundance increased rapidly between ca. 7000 and 6700 cal. yr BP.

Ach2  ‘Terrace Hollow’  –  Local development of pinewoods 7907 (8027 – 7746) cal. yr BP

The pollen diagram spans the interval between ca. 8400 and ca. 6650 cal. yr BP (ca. 2.33 - 2.65 m) (Figures S2 and S25). The two lowermost sub-samples were dominated by *Betula* pollen with only trace amounts of *Pinus* pollen. *Pinus* pollen abundance was much increased in the sub-sample from ca. 7740 cal. yr BP, decreased again somewhat then rose to a peak value at ca. 7280 cal. yr BP; thereafter values were more or less sustained at ca. 18%. *Betula* pollen abundance decreased to 20% during the
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interval of maximum *Pinus* abundance, increasing once again to values >60% after ca. 6800 cal. yr BP. The interval of low *Betula* pollen abundance, and the peak in *Pinus* abundance, saw pollen of dwarf-shrub taxa increase to values of 60 – 70%, and a single sub-sample peak in Gramineae at ca. 7100 cal. yr BP. Pollen of other broad-leaved trees was sparsely present, although with a clear increase in *Alnus* pollen abundance after ca. 6950 cal. yr BP.

Ach3 ‘above Cadubh’ – Local development of pinewoods >5411 (5573 – 5327) cal. yr BP

Pollen samples were analysed only from the lowermost ca. 30 cm of the core, the lowermost sample proving to have > 30% *Pinus* pollen (Figure S26). A single basal age measurement of 5411 (5573 – 5327) cal. yr BP confirmed that sediment accumulation began more than two millennia after the general expansion of pinewoods in Glen Achall, dated to ca. 7680 cal. yr BP at site Ach1.

Ach4 ‘Sheepfold’ – Local development of pinewoods 7204 (7352 – 7048) cal. yr BP

The pollen diagram, spanning the interval ca. 8690 – 6650 cal. yr BP (Figures S3 and S27), shows high abundance of *Betula* pollen until ca. 7000 cal. yr BP, after which it decreases markedly. *Pinus* pollen abundance is very low in the earliest samples, increases slowly after ca. 8200 cal. yr BP, and then increases rapidly after ca. 7000 cal. yr BP, reaching a peak value of 50% in the sample dated to 6857 cal. yr BP. It then decreases in the topmost sample as the abundance of *Alnus* pollen rapidly increases. Identifying the principal increase is difficult at this site; it has been placed where the rate of increase accelerates after the initial slow increase, leading to values exceeding 20% for the first time. *Corylus*-type pollen is present with relatively low abundance throughout, its greatest value being in the lowermost sample. *Ulmus* pollen is also present throughout, albeit at very low values, and *Quercus* is also present at very low values after ca. 8000 cal. yr BP.

Ach5 ‘West Achall Mire’ – Local development of pinewoods 7649 (7748 – 7543) cal. yr BP

The pollen diagram spans the interval between ca. 10,400 and ca. 6600 cal. yr BP (Figures S4 and S28). The earliest sample has high abundance of pollen of Gramineae accompanied principally by pollen of *Juniperus, Betula* and Cyperaceae. By ca. 10,150 cal. yr BP *Betula* pollen abundance reaches high levels and at ca. 9200 cal. yr BP *Corylus*-type pollen increases to moderate levels; pollen of *Ulmus* and *Quercus* is also consistently recorded after this time. *Pinus* pollen is present throughout, but at very low
levels until ca. 8700 cal. yr BP, after which time abundance slowly increases, increasing more rapidly after ca. 7750 cal. yr BP and first exceeding 20% at ca. 7550 cal. yr BP; relatively high values are sustained thereafter until at least 6550 cal. yr BP. Pollen of *Alnus*, which is sparsely present earlier, increases in abundance after ca. 7000 cal. yr BP.

**Ach6 ‘West Achall Gorge’ – Local development of pinewoods 5576 (5950 – 5423) cal. yr BP**

A well-defined and substantial increase in the abundance of *Pinus* pollen was recorded at this site, dating to 5576 cal. yr BP (Figures S5 and S29). Prior to this increase *Betula* was the most abundant pollen taxon, accompanied by moderate abundances of other trees, notably *Corylus*-type, *Alnus* and *Ulmus*, as well as of both herbaceous and dwarf-shrub taxa. Pollen abundances of non-tree taxa, *Betula* and *Corylus*-type decreased most as *Pinus* increased. *Pinus* abundance remained above 30% for approximately a millennium, decreasing to lower values thereafter as abundance of *Alnus* increased.

**Ach7 ‘below Doir a’ Ghleannain’ – Local development of pinewoods 7226 (7483 – 6962) cal. yr BP**

Pollen of herbaceous taxa predominates in the earliest sample analysed, that dates from ca. 9600 cal. yr BP (Figures S6 and S30). Thereafter the abundance of pollen of trees, especially *Betula* and *Corylus*-type, increases rapidly, dominating the spectrum by 8500 cal. yr BP. *Pinus* pollen is present at low abundance in the earlier samples, its abundance beginning to increase after ca. 7900 cal. yr BP and subsequently increasing twofold between ca. 7600 cal. yr BP and ca. 6900 cal yr BP. Its abundance is maintained thereafter at least to the latest sample analysed that dates from ca. 4650 cal. yr BP. Pollen of *Salix*, *Quercus* and *Ulmus* is present at low abundance in most samples. A sharp decrease in *Ulmus* abundance between the samples dating from 5427 cal. yr BP and 5181 cal. yr BP probably reflects the local manifestation of the mid-Holocene Elm decline (Parker et al., 2002). Abundance of *Alnus* pollen increased markedly between the samples dating from 5980 cal. yr BP and 5427 cal. yr BP.

**Ach8 Sanctuary Wood – Local development of pinewoods >7595 (9437 – 7470) cal. yr BP**

*Pinus* pollen abundance was almost 40% already in the lowermost sample from this site, dating from 7595 cal. yr BP, and remained >20% in all but two of the subsequent samples that together span the interval...
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until 6405 cal. yr BP (Figures S7 and S31). Abundance of Alnus pollen increased between the samples dating from 6746 cal. yr BP and 6623 cal. yr BP.

Ach9 ‘Eagle calling’ – Local development of pinewoods 6494 (6727 – 6365) cal. yr BP

The earliest sample analysed, dating from 6829 cal. yr BP, was dominated by pollen of dwarf-shrub taxa (Figures S8 and S32). Betula pollen abundance then increased rapidly, dominating the next two samples, before a marked increase in abundance of Pinus pollen between the samples dating from 6553 cal. yr BP and 6434 cal. yr BP. Abundance of Alnus pollen was low in the oldest samples but increased very markedly between the samples dating from 6288 cal. yr BP and 5875 cal. yr BP.

Glen Affric

Aff1 Loch Salach a’ Ghiubhais – Landscape expansion of pinewoods 7945 (8072 – 7835) cal yr BP

Betula pollen dominates the earliest samples dated to >8400 cal. yr BP (Figures S9 and S33). Juniperus, Salix, Corylus-type, Quercus and Ulmus are also all present at low abundances, indicating a landscape occupied principally by a variety of mixed woodlands. Abundance of Pinus pollen is initially low but increasing relatively slowly; it then increases rapidly between 8051 cal yr BP and 7838 cal. yr BP to reach its greatest abundance at this site in the latter sample. Thereafter, Pinus pollen abundance remains relatively high for the remainder of the record, accompanied principally by Betula and Corylus-type, as well as increased abundance of pollen of both dwarf-shrub and herbaceous taxa. Alnus pollen is never abundant at this site, but increases markedly ca. 7600 cal. yr BP from previous trace amounts to values consistently ca. 5%.

Aff2 Loch an Fheadain

The single ¹⁴C age measurement obtained for the base of the sediments recovered from this site gave a calibrated age of 2265 cal. yr BP, the record thus not extending back in time far enough to record the mid-Holocene expansion of pinewoods into the surrounding landscape. Pinus pollen abundances in the samples analysed (Figure S34) were consistently low, only exceeding 10% in a single sample, indicating an absence of any extensive nearby pinewoods during the past two millennia.
Aff3 ‘Adit Track’ – Local development of pinewoods >7375 (8165 – 7274) cal. yr BP

The pollen spectrum from the earliest sample obtained from the sediments at this site, dated to 7375 cal. yr BP, was dominated by Pinus pollen (Figures S10 and S35), thus post-dating the local development of pinewoods. Pinus pollen abundance was consistently >65% until ca. 6550 cal. yr BP, after which values declined steadily over the subsequent millennium. Betula and Corylus-type were present with low abundances in the earliest sample, whereas only very low abundance of Alnus pollen was recorded. The abundance of Alnus did not increase markedly until ca. 5550 cal. yr BP, by which time abundance of Pinus pollen had decreased to ca. 20%.

Aff4 Loch an Amair – Local development of pinewoods 6491 (6560 – 6418) cal. yr BP

Prior to ca. 8500 cal. yr BP Betula was the most abundant pollen taxon, although accompanied by moderate abundance of Corylus-type and consistent presence of Salix, Quercus and Ulmus (Figures S11 and S36). After that date abundance of Pinus pollen very slowly increased until ca. 6700 cal. yr BP, the increase then accelerating and values increasing sharply to >30% at 6491 cal yr BP. A sharp increase in the abundance of Alnus pollen coincided with that in Pinus. The possibility that this represents a core break can be ruled out as the samples below and above the sharp increases came from 8 cm and 12 cm below the top of a core segment. The upper samples analysed recorded a persistence of high abundance of Pinus pollen until at least 5200 cal. yr BP.

Aff5 ‘above Loch an Eang’ – Local development of pinewoods 7462 (7557 – 7362) cal. yr BP

The earliest sample, dated to 9217 cal. yr BP, had >20% Juniperus pollen, with a similar abundance of Betula and >35% pollen of dwarf-shrub taxa (Figures S12 and S37). Thereafter, abundances of Juniperus and dwarf-shrub taxa decreased; Betula dominated the pollen spectra between ca. 8700 and 7600 cal. yr BP, accompanied by moderate abundance of Corylus-type pollen and low values for Salix, Quercus and Ulmus. Pinus pollen abundances were initially very low, began to increase after ca. 7800 cal. yr BP and rapidly increased at 7462 cal yr BP to values >50%. As Pinus increased in abundance, Betula decreased very markedly and Corylus-type also decreased. No marked increase in Alnus was recorded in the samples analysed, although it was consistently present at higher abundances than previously after ca. 7000 cal. yr BP.
Aff6 ‘T-Junction’ – Local development of pinewoods 8112 (8277 – 7998) cal. yr BP

Prior to ca. 8400 cal. yr BP, Betula pollen dominated, accompanied by moderate abundances of Corylus-type and low values of Salix, Populus, Quercus and Ulmus, with moderate abundance of Juniperus in the earliest sample dating from 9794 cal. yr BP (Figures S13 and S38). Pinus pollen was present at very low abundances before ca. 8500 cal yr BP, after which it began to increase, doing so most markedly at between 8279 cal. yr BP and 7945 cal. yr BP and reaching values >30% after ca. 7700 cal. yr BP. The increase in Pinus was paralleled by a decrease in Betula. Alnus pollen values increased after ca. 7500 cal. yr BP, their increase to values >20% being accompanied by a decrease in abundance of Pinus.

Aff7 ‘Cattle grid’ – Local development of pinewoods 8303 (8412 – 8208) cal. yr BP

The earliest sample analysed, dating from the Younger Dryas interval (12,617 cal. yr BP), was dominated by a combination of herbaceous and dwarf-shrub taxa (Figures S14 and S39). Subsequently, Betula and Juniperus pollen rapidly increased in abundance, followed by Corylus-type, with consistent low values of Salix and Populus. Low values of Quercus and Ulmus accompanied the increase in Corylus-type. Pinus pollen was very sparsely present prior to ca. 9000 cal. yr BP, after which time low values preceded a very rapid increase to values >50% dated to 8303 cal. yr BP. After about two millennia, Pinus pollen abundance decreased once again to values of <15% by ca. 5000 cal. yr BP.

Aff8 ‘Road below Beinn a’ Mheadhoin’ – Local development of pinewoods 7839 (8003 – 7480) cal. yr BP

Betula and Cyperaceae are the most abundant pollen taxa in the lowermost sample shown on the pollen diagram, which dates from before 11,000 cal. yr BP and is interpreted as representing the earliest Holocene (Figures S15 and S40). Corylus-type pollen subsequently increases in abundance. Pinus pollen is sparsely present prior to ca. 9000 cal. yr BP, increases somewhat thereafter before rapidly increasing to almost 75%, the latter increase dating to 7839 cal. yr BP. The rapid increase in Pinus pollen abundance is accompanied by a rapid decrease in Betula. Subsequently values of Pinus steadily decrease once again, to <20% by ca. 3000 cal. yr BP, whilst Betula increases. Alnus is present after Pinus begins to decrease, but remains at low abundance even in the uppermost sample dating from ca. 2500 cal. yr BP.
Glen Rannoch

Ran1 ‘Finnart mire’ – Landscape expansion of pinewoods 8070 (8110 – 8023) cal yr BP

Pollen of tree and shrub taxa, principally *Betula* accompanied by *Corylus*-type, *Ulmus* and *Quercus*, dominates the earlier part of the record (Figures S16 and S41) prior to ca. 8150 cal. yr BP. *Pinus* pollen abundance increases sharply at 8070 cal. yr BP with values during the following four centuries consistently >30%. The increase in *Pinus* abundance is complemented principally by decreases in abundance of *Betula* and of herbaceous taxa.

Ran2 ‘Gunnar’s Tree’ – Local development of pinewoods 8170 (8252 – 8084) cal. yr BP

Notwithstanding their median ages according to the age–depth model, the earliest pollen samples, dominated by dwarf-shrub taxa with low abundances of *Juniperus*, *Betula* and *Salix* (Figures S17 and S42), probably date from the end of the Younger Dryas, an age that falls within the 95% uncertainty range for the earliest pollen sample analysed (18,829 – 12,100 cal. yr BP). Abundance of pollen of trees and shrubs then rapidly increases, with *Betula* and *Corylus*-type the most abundant taxa. *Pinus* pollen is initially present in small amounts, but then increases very rapidly at 8170 cal. yr BP, dominating pollen spectra for the next two millennia before decreasing somewhat, although nonetheless maintaining values that indicate local pinewood presence.

Ran3 ‘No Aerial’ – Local development of pinewoods 6535 (6616 – 6443) cal. yr BP

Pollen of dwarf-shrub taxa, *Betula* and *Corylus*-type together make up the majority of the spectra from the two earliest samples analysed that date from before ca. 6550 cal. yr BP (Figures S18 and S43). *Pinus* pollen abundance then increases rapidly at 6535 cal. yr BP, reaching values close to or exceeding 30% thereafter until ca. 2700 cal. yr BP, after which values decrease to <20% before increasing once again to 50% in the topmost sample that dates from 987 cal. yr BP. *Alnus* pollen is present from the time of the initial *Pinus* increase, although values are <5% before ca. 5000 cal yr BP and even after that time only rarely exceed 10%.
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Ran4 ‘Craiganour’ – No local presence of pinewoods

Pollen of trees and shrubs, principally *Betula*, along with *Salix* and *Corylus*-type, dominates the earliest sample analysed, which dates from 7939 cal. yr BP (Figures S19 and S44). *Pinus* pollen is also present in this sample at low abundance, and continues to be present, generally with values of <10%, throughout the record. *Betula* pollen remains the most abundant taxon until after ca. 3500 cal. yr BP, although other tree and shrub taxa decrease earlier as dwarf-shrub taxa and subsequently herbaceous taxa increase in abundance.

Ran5 ‘Rannoch Forest’ – Local development of pinewoods 7912 (8051 – 7786) cal. yr BP

The earliest sample, dated to 9237 cal. yr BP, is dominated by *Betula*, accompanied by *Juniperus*, *Salix*, herbaceous taxa and dwarf-shrub taxa (Figures S20 and S45). *Juniperus* abundance then rapidly decreases whereas *Corylus*-type markedly increases; dwarf-shrub and herbaceous taxa also decrease, albeit more gradually. *Pinus* pollen is present from the earliest sample, albeit at very low values, but increases in abundance rapidly at 7912 cal. yr BP, thereafter sustaining values >20% for almost two millennia. After ca. 6200 cal. yr BP *Pinus* values fluctuate considerably, with three peaks in abundance centred on 5407, 3010 and 1565 cal. yr BP. The values reached at these peaks indicate a high likelihood of local pinewood presence, perhaps reflecting temporary expansions of pinewoods onto surrounding peatland surfaces during intervals when these were drier. This inference is supported by woody remains of *Pinus* seen in peat exposures at various localities on the north side of Glen Rannoch (authors’ personal observations).

Ran6 ‘Camusericht’ – Local development of pinewoods 7227 (7489 – 6456) cal. yr BP

*Betula* and Cyperaceae are the two most abundant taxa in the two earliest samples analysed that date, respectively, from 10,933 and 10,517 cal. yr BP (Figures S21 and S46). Thereafter *Corylus*-type increases in abundance, *Betula* decreases somewhat and Cyperaceae decreases substantially. With the exception of a single anomalous sample dated to 9053 cal. yr BP, in which *Pinus* reaches almost 40%, *Betula* decreases very markedly, *Quercus*, *Ulmus* and *Alnus* show small peaks, pollen of herbaceous taxa decreases markedly in abundance, and *Sphagnum* shows a peak, *Betula* and *Corylus*-type together dominate the pollen spectra in samples dated to between ca. 10,000 and ca. 8000 cal. yr BP. The
sediment column shows no obvious evidence of disturbance or contamination at the level of the anomalous sample, and its pollen spectrum is not matched by that of any of the other samples analysed, none having a comparable abundance of *Pinus* pollen. Although it seems unlikely that this sample represents a transient local early-Holocene development of pinewoods at the site, this possibility cannot be excluded. The interval between the median ages of the preceding and succeeding samples of 164 yr (127 yr for the 2.5% and 92 yr for the 97.5% ages) is comparable in duration to brief mid-Holocene local colonisations of peatlands in far northern Scotland by a single generation of *Pinus sylvestris*, as determined by dendrochronological data (Daniell, 1997, Fig. 3.61). After ca. 8000 cal. yr BP a persistent increase in *Pinus* pollen abundance, rising to a peak of >20%, is taken to indicate the local development of pinewoods around the site, which we date to 7227 cal. yr BP. *Pinus* pollen abundance is not maintained thereafter but decreases as the abundance of *Alnus* increases rapidly to >25% at ca. 6400 cal. yr BP.

**Ran7 ‘Black 4A’ – Local development of pinewoods 8462 (8775 – 8344) cal. yr BP**

*Betula*, *Corylus*-type and dwarf-shrub taxa together dominate the two earliest samples analysed, dated to 11,154 and 10,379 cal. yr BP (Figures S22 and S47). Subsequently, dwarf-shrub taxa decrease in abundance, as does *Corylus*-type, whereas *Betula* increases in abundance, accompanied by *Salix*. *Pinus* pollen is present in all but the earliest sample, but at very low values prior to its rapid increase at 8462 cal. yr BP, values ≥30% being sustained thereafter until ca. 7100 cal. yr BP. Even after that time values remain >25%, only falling to just below 20% in the most recent sample analysed that dates from 4918 cal. yr BP. Although increasing in abundance initially at ca. 7000 cal. yr BP, and again a millennium later, *Alnus* pollen values never exceed 10%. Pollen of *Quercus* and *Ulmus* is sparsely present more or less throughout.

**Ran8 ‘Log Canyon’ – Local development of pinewoods 8114 (8182 – 8058) cal. yr BP**

*Betula*, *Corylus*-type and Cyperaceae dominate the earliest sample, dating from 9298 cal. yr BP, dwarf-shrub taxa then replacing Cyperaceae as the most abundant taxon in subsequent samples (Figures S23 and S48). *Pinus* pollen is absent from the two oldest samples, thereafter being present at low abundance until its rapid increase to >30% at 8114 cal. yr BP. Apart from decreasing to 20% in a single sample dating from 7812 cal. yr BP, in which *Betula* pollen shows a short-lived peak abundance of ca. 50%,
perhaps indicating a local disturbance of the pinewoods, *Pinus* abundance remains >30% up to the most recent sample analysed, dating from 7001 cal. yr BP.
### Table S1: $^{14}$C age measurements

| Site | Lab. No.* | Depth† (m) | Rationale | Material dated | $^{14}$C age (±1σ) | Calibrated age (yr BP) |
|------|-----------|------------|-----------|----------------|---------------------|------------------------|
|      |           |            |           |                |                     | 2.5%  | 50%  | 97.5% |
| Ach1 | 62972     | 9.90       | Just post main *Pinus* increase | *Pinus* (bud scales; bark flakes); *Betula* fruits (3); leaf fragments | 6234 ±36 | 7019 | 7167 | 7249 |
|      | 62973     | 10.10      | Late in the main *Pinus* increase | *Pinus* (bud scales; bark flakes; needles); *Betula* fruit; leaf fragments | 6462 ±38 | 7290 | 7371 | 7433 |
|      | 62974     | 10.25      | Early in the main *Pinus* increase | *Pinus* (bud scales; bark flakes; needles); leaf fragments | 6794 ±38 | 7584 | 7635 | 7683 |
|      | 62975     | 10.45      | Just prior to main *Pinus* increase | *Betula* (catkin scale; bud scale); cf. *Calluna* flower; leaf fragments | 7398 ±42 | 8066 | 8233 | 8325 |
| Ach2 | 62982     | 2.47       | Just post main *Pinus* increase | Woody fragments | 6215 ±37 | 7006 | 7104 | 7241 |
|      | 62981     | 2.50       | Late in the main *Pinus* increase | Bark fragments; cf. Cyperaceae epidermis | 6426 ±37 | 7277 | 7359 | 7420 |
|      | 62980     | 2.54       | Early in the main *Pinus* increase | Wood | 7040 ±38 | 7790 | 7880 | 7946 |
|      | 62976     | 2.58       | Just prior to main *Pinus* increase | Wood and bark fragments; cf. Cyperaceae epidermis | 7339 ±42 | 8035 | 8133 | 8291 |
| Ach3 | 63005     | 2.39       | Basal sediment age | cf. Cyperaceae epidermis; wood and bark fragments | 4701 ±37 | 5327 | 5411 | 5573 |
| Ach4 | 62991     | 1.92       | Just post main *Pinus* increase | Woody fragments | 5948 ±37 | 6680 | 6773 | 6880 |
|      | 62990     | 1.98       | Main *Pinus* increase | Woody fragments | 6047 ±37 | 6795 | 6898 | 6995 |
|      | 62986     | 2.08       | End of early *Pinus* increase | Woody fragments | 6239 ±39 | 7020 | 7173 | 7252 |
|      | 62985     | 2.25       | Middle of early *Pinus* increase | Woody fragments | 6760 ±37 | 7572 | 7615 | 7669 |
|      | 62984     | 2.35       | Early in early *Pinus* increase | Woody fragments | 6981 ±38 | 7707 | 7815 | 7922 |
|      | 62983     | 2.48       | Just prior to early *Pinus* increase | Woody fragments | 7807 ±39 | 8479 | 8583 | 8690 |
| Ach5 | 62490     | 5.10       | Just post *Pinus* peak | *Pinus* needles | 5966 ±38 | 6693 | 6797 | 6902 |
|      | 62489     | 5.40       | Plateau in *Pinus* increase | *Pinus* (needle fragments; bark flakes); cf. *Betula* bud scales; leaf fragments | 6412 ±36 | 7272 | 7352 | 7418 |
|      | 62488     | 5.50       | Main *Pinus* increase | *Pinus* (needle fragments; bark flakes); *Betula* fruit; leaf fragments | 6811 ±39 | 7590 | 7644 | 7713 |
|      | 62484     | 5.59       | Start of main *Pinus* increase | *Pinus* (needle fragments; bud scales); *Betula* (catkin scales; fruits (3)); leaf fragments | 7105 ±39 | 7852 | 7939 | 7999 |
|      | 62483     | 5.78       | After first *Pinus* increase | *Betula* fruit; Cyperaceae fragments; leaf fragments | 7389 ±38 | 8067 | 8232 | 8320 |
|      | 62482     | 5.90       | Main increase of first *Pinus* increase | Leaf fragments; wood and bark fragments; *Betula* fruits (2) | 7750 ±38 | 8436 | 8525 | 8592 |
### Table S1: \(^{14}\)C age measurements (continued)

| Site | Lab. No.* | Depth\(^{†}\) (m) | Rationale | Material dated | \(^{14}\)C age (±1σ) | Calibrated age (yr BP) |
|------|-----------|------------------|-----------|----------------|---------------------|------------------------|
|      |           |                  |           |                | 2.5% 50% 97.5%      |                        |
| Ach5 | 62481     | 6.02             | Just prior to first *Pinus* increase | Leaf fragments; wood; bud scale fragments | 7966 ±39 | 8655 8841 8985 |
| Ach6 | 62494     | 3.19             | Just post *Pinus* peak | *Pinus* (needle fragments; bark flakes); *Betula* fruits (2) and catkin scale; leaf fragments | 4662 ±35 | 5318 5401 5560 |
|      | 62493     | 3.35             | Mid-point of *Pinus* increase | *Betula* fruits and catkin scales; *cf. Betula* bud scales; woody fragments | 4694 ±38 | 5325 5406 5571 |
|      | 62492     | 3.53             | Just prior to *Pinus* increase | *Betula* fruits (2); woody fragments; leaf fragments; *Cyperaceae* fragments | 2208 ±37 | 2130 2233 2326 |
|      | 62491     | 3.97             | Basal sediment age | *cf. Betula* woody detritus | 2835 ±37 | 2856 2940 3061 |
| Ach7 | 63000     | 2.55             | Just post main *Pinus* increase | *Cyperaceae* leaf/stem fragments; lenticular *Carex* nutlet; bark fragments; twig fragments | 4947 ±37 | 5606 5672 5831 |
|      | 62996     | 2.65             | End of first main *Pinus* increase | *Cyperaceae* leaf/stem fragments; bark fragments; twig fragments | 5868 ±38 | 6574 6690 6774 |
|      | 62995     | 2.70             | Main *Pinus* increase | charcoal fragments | 7568 ±42 | 8291 8383 8432 |
|      | 62994     | 2.76             | End of plateau in *Pinus* increase | *Cyperaceae* leaf/stem fragments; woody fragments | 7144 ±36 | 7881 7968 8017 |
|      | 62993     | 2.85             | Beginning of plateau in *Pinus* increase | wood and twig fragments | 7575 ±36 | 8341 8388 8423 |
|      | 62992     | 2.96             | Just prior to first *Pinus* increase | lenticular *Carex* nutlets; *Cyperaceae* leaf/stem fragments; wood and bark fragments | 8594 ±39 | 9506 9547 9658 |
| Ach8 | 63010     | 2.57             | *Alnus* increase | *Cyperaceae* epidermis; *Pinus* bark flakes | 5873 ±38 | 6580 6696 6779 |
|      | 63006     | 2.88             | Basal sediment age | Bark – including *Pinus*; woody fragments; lenticular *Carex* nutlets (2) | 6603 ±38 | 7437 7497 7565 |
| Ach9 | 63004     | 2.80             | *Alnus* rise | *cf. Cyperaceae* epidermis; woody fragments | 5213 ±38 | 5914 5965 6161 |
|      | 63003     | 2.85             | Just post main *Pinus* increase | leaf fragments; wood and bark fragments | 5633 ±38 | 6319 6412 6489 |
|      | 63002     | 2.90             | Main *Pinus* increase | *cf. Cyperaceae* rootlets | 4793 ±38 | 5357 5517 5593 |
|      | 63001     | 2.95             | Just prior to main *Pinus* increase | *cf. Cyperaceae* rootlets | 5066 ±38 | 5711 5816 5903 |
| Aff1 | OxA-32018 | 8.90             | End of main *Pinus* increase | *Pinus* bark and bud scales; *Calluna* leaves; Gramineae/Cyperaceae epidermis | 6945 ±40 | 7690 7770 7909 |
|      | OxA-33285 | 8.95             | Main *Pinus* increase | *Betula* fruits (>4); *Pinus* bark and bud scales; leaf fragments | 7249 ±36 | 7985 8074 8161 |
### Table S1: $^{14}$C age measurements (continued)

| Site  | Lab. No.* | Depth† (m) | Rationale | Material dated | $^{14}$C age (±1σ) | Calibrated age (yr BP)  |
|-------|-----------|------------|-----------|----------------|---------------------|------------------------|
|       |           |            |           |                | 2.5% 50% 97.5%     | 2.5% 50% 97.5%         |
| Aff1  | OxA-32019 | 9.02       | Start of main *Pinus* increase | *Alnus* seeds and *catkin* scales; *leaf* fragments; *twigs* | 7865 ±45 | 8560 8668 8942 |
|       |           |            |           |                | 2.5% 50% 97.5%     | 2.5% 50% 97.5%         |
| Aff2  | OxA-31777 | 7.90       | Basal sediment age | *Betula* fruits (2) and bud scale; *Pinus* bark fragments; *leaf* fragments; *woody* fragments | 2269 ±27 | 2167 2265 2341 |
|       |           |            |           |                | 2.5% 50% 97.5%     | 2.5% 50% 97.5%         |
| Aff3  | 62479     | 2.80       | *Alnus* increase | fibrous *Cyperaceae* material; *woody* flakes | 4844 ±38 | 5484 5590 5648 |
|       | 62478     | 2.88       | Basal sediment age | fibrous *Cyperaceae* material; *woody* flakes | 6396 ±38 | 7261 7333 7416 |
| Aff4  | 64778     | 4.40       | Mid-point of minor decline at *Pinus* peak | *Betula* fruits (8) and *catkin* scales (5); *Pinus* needle; *Alnus* fruit; *leaf* fragments | 5572 ±38 | 6300 6355 6431 |
|       | OxA-31608 | 4.60       | End of main *Pinus* increase | *Betula* fruits (6); *Pinus* bud and bark; *leaf* fragments; *woody* fragments | 5730 ±34 | 6435 6524 6629 |
|       |           |            |           |                | 2.5% 50% 97.5%     | 2.5% 50% 97.5%         |
|       | 64779     | 4.65       | Just prior to first *Pinus* peak | *Pinus* needle fragments and bud scales; *Betula* fruits (4); *leaf* fragments | 5663 ±36 | 6388 6443 6538 |
| OxA-31609 | 4.70     |            | Main *Pinus* increase | *needle* bundle bases and bark; *Betula* fruit; *leaf* fragments | 6308 ±36 | 7170 7232 7310 |
| OxA-31773 | 4.80     |            | Start of main *Pinus* increase | *Ranunculus* achene; *woody* fragments; *twig*; *leaf* fragments | 7817 ±36 | 8501 8593 8695 |
| Aff5  | OxA-31778 | 3.55       | Main *Pinus* increase | *Pinus* needles | 6247 ±32 | 7034 7197 7251 |
|       | 64781     | 3.65       | Middle of main *Pinus* increase | *Pinus* needles and bark; *Betula* fruit; *woody* fragments | 6690 ±38 | 7488 7560 7627 |
|       | 64785     | 3.75       | Start of main *Pinus* increase | *Pinus* needles; *Calluna* shoots | 6772 ±39 | 7576 7623 7673 |
|       | 64786     | 3.95       | Just prior to main *Pinus* increase | *Betula* fruit; *leaf* fragments; partial bud scale; *Pinus* needle fragment; *woody* fragments | 7090 ±38 | 7843 7922 7986 |
| Aff6  | OxA-31776 | 9.50       | End of main *Pinus* increase | *Pinus* bud scale and bark; *Betula* fruit; *Calluna* shoot tips; *leaf* fragments | 6967 ±34 | 7578 7621 7670 |
|       | OxA-32020 | 9.70       | Main *Pinus* increase | *Betula* fruits and *catkin* scales; *leaf* fragments; *woody* fragments; *Calluna* leaves | 7350 ±50 | 8033 8161 8308 |
|       | 64780     | 9.88       | Start of *Pinus* increase | *Calluna* shoot; partial bud scale; *leaf* fragments | 7845 ±39 | 8553 8624 8828 |
| Aff7  | 62474     | 3.73       | End of *Pinus* increase | fibrous *Cyperaceae* material | 6716 ±35 | 7515 7584 7652 |
|       | 62473     | 3.88       | Second phase of main *Pinus* increase | *Pinus* seeds (2) and needle bundle base; *Betula* fruits (3); *leaf* fragments | 7030 ±39 | 7768 7872 7943 |
|       |           |            |           |                | 2.5% 50% 97.5%     | 2.5% 50% 97.5%         |
Table S1: $^{14}$C age measurements (continued)

| Site | Lab. No.* | Depth† (m) | Rationale | Material dated | $^{14}$C age (±1σ) | Calibrated age (yr BP) |
|------|-----------|------------|-----------|----------------|---------------------|------------------------|
|      |           |            |           |                |                     | 2·5%  50%  97·5%        |
| Aff7 | 62472     | 4·25       | Short decrease during main Pinus increase | Pinus needle and needle base; Betula fruits (2); leaf fragments; Cyperaceae leaf fragments | 7278 ±38 | 8011 8097 8169 |
|      |           |            |           |                |                     |                        |
|      | 62471     | 4·41       | Main Pinus increase | leaf fragments; cf. Cyperaceae epidermis; cf. Vaccinium oxyccocus twigs | 7421 ±38 | 8178 8258 8339 |
|      | 62470     | 4·65       | First peak in Pinus | fibrous Cyperaceae material | 7791 ±39 | 8462 8568 8637 |
|      | 62469     | 4·82       | Just prior to first Pinus increase | Cyperaceae leaf fragments | 7884 ±39 | 8597 8688 8944 |
| Aff8 | OxA-31774 | 140        | End of main Pinus increase | woody fragments; bark flakes | 5459±32 | 6202 6260 6302 |
|      | OxA-32017 | 145        | Main Pinus increase | woody fragments | 6964±38 | 7697 7793 7917 |
|      | OxA-31775 | 157        | Start of main Pinus increase | twigs | 7601±36 | 8360 8400 8468 |
| Ran1 | 52334     | 4·95       | Post Pinus increase | Cyperaceae stem/leaf fragments | 6969 ±35 | 7703 7801 7917 |
|      | 52347     | 5·05       | End of main Pinus increase | wood | 7129 ±36 | 7874 7958 8009 |
|      | 52333     | 5·15       | Main Pinus increase | wood | 7401 ±39 | 8083 8246 8328 |
|      | 62461     | 5·20       | Early in main Pinus increase | Cyperaceae stem/leaf fragments | 7195 ±37 | 7954 8000 8142 |
|      | 52332     | 5·30       | Start of Pinus increase | Cyperaceae stem/leaf fragments | 7363 ±38 | 8048 8180 8307 |
|      | 62460     | 5·40       | Pre Pinus increase | Cyperaceae stem/leaf fragments | 7630 ±39 | 8381 8420 8526 |
| Ran2 | 52336     | 2·25       | Post Pinus increase | Pinus needles and cone fragment | 7080 ±38 | 7837 7903 7976 |
|      | 52351     | 2·32       | Short decrease in Pinus | wood | 7131 ±39 | 7871 7959 8012 |
|      | 52348     | 2·41       | Main Pinus increase | wood | 7322 ±38 | 8029 8112 8217 |
|      | 52335     | 2·50       | Start of Pinus increase | wood fragments | 7487 ±38 | 8202 8314 8378 |
| Ran3 | 52341     | 2·835      | Post Pinus increase | Calluna shoot; cf. Pinus bark; woody fragments | 5141 ±36 | 5761 5904 5981 |
|      | 62468     | 2·87       | Late in Pinus rise | Cyperaceae leaf fragments; bark fragments | 6442 ±40 | 7280 7364 7425 |
|      | 52338     | 2·905      | Pinus increase | Cyperaceae stem/leaf fragments | 5791 ±38 | 6498 6590 6689 |
|      | 52337     | 3·025      | Basal organic sediment age | Cyperaceae stem/leaf fragments | 5782 ±38 | 6489 6582 6667 |
### Table S1: $^{14}$C age measurements (continued)

| Site | Lab. No.* | Depth† (m) | Rationale | Material dated | $^{14}$C age (±1σ) | Calibrated age (yr BP) | 2-5% | 50% | 97-5% |
|------|------------|------------|-----------|---------------|-------------------|------------------------|------|-----|-------|
| Ran4 | 62464      | 4.85       | Onset of *Alnus* increase | *Betula* fruits (~36), bud scales (~8) and catkin scales (~4); *Calluna* leaf; leaf fragments | 6339 ±37 | 7178 7270 7402 |
|      | 52345      | 5.23       | Basal sediment age | wood | 7036 ±38 | 7777 7878 7943 |
| Ran5 | 52344      | 6.70       | End of main *Pinus* increase | woody fragments; bark fragments | 6173 ±35 | 6967 7076 7167 |
|      | 52343      | 6.85       | *Pinus* increase | *Pinus* needles, bark and bud scales | 7034 ±38 | 7778 7877 7942 |
|      | 52342      | 7.00       | Start of *Pinus* increase | *Betula* fruits (4); woody fragments; *Vaccinium oxycoccos* leaf | 7736 ±38 | 8430 8510 8586 |
| Ran6 | 52353      | 2.49       | Main *Pinus* increase | cf. *Betula* wood | 6601 ±38 | 7436 7495 7564 |
|      | 62463      | 2.60       | Increase in rate of *Pinus* increase | cf. *Betula* wood; Cyperaceae leaf fragments | 6661 ±38 | 7466 7534 7590 |
|      | 62464      | 2.70       | Onset of main *Pinus* increase | woody fragments; bark fragments | 7849 ±38 | 8557 8628 8841 |
|      | 52352      | 3.20       | Early *Pinus* peak | wood | 8265 ±36 | 9128 9258 9398 |
| Ran7 | OxA-31606  | 1.70       | End of main *Pinus* increase | *Pinus* bud scale and bark; *Ranunculus* achenes (2-5); Cyperaceae stem/leaf fragments; woody fragments | 7284 ±38 | 8015 8098 8173 |
|      | OxA-31607  | 1.76       | Main *Pinus* increase | Cyperaceae stem/leaf fragments | 7410 ±45 | 8089 8252 8339 |
|      | OxA-33247  | 1.815      | Main *Pinus* increase | Cyperaceae stem/leaf fragments | 7551 ±39 | 8240 8373 8411 |
|      | OxA-31772  | 1.89       | Start of *Pinus* increase | twig | 7867 ±38 | 8577 8655 8927 |
| Ran8 | 64787      | 3.18       | Just post *Pinus* increase | Cyperaceae stem/leaf fragments; charcoal fragments; *Pinus* bark; woody fragments | 7179 ±38 | 7942 7990 8112 |
|      | OxA-31746  | 3.225      | End of main *Pinus* increase | cf. *Pinus* bark fragments | 7296 ±36 | 8022 8102 8174 |
|      | OxA-31747  | 3.25       | Main *Pinus* increase | bark fragments; small twig | 7310 ±40 | 8024 8107 8188 |
|      | OxA-31748  | 3.275      | Start of main *Pinus* increase | Cyperaceae stem/leaf fragments | 7368 ±37 | 8053 8189 8310 |

* Unless otherwise indicated, Laboratory Numbers are prefixed SUERC-.
† Depths are given below coring datum; whereas this datum is the sediment surface in the case of terrestrial sites, in the case of lacustrine cores it is the top of the casing, the depths in these cases thus including the water depth as well as the length of the casing protruding above the water surface.
Supplementary Figures S1 – S48

Figures S1 – S23 show age–depth models for those sites for which several $^{14}$C age measurements were made and where such models could be fitted. Age–depth models were fitted using Bchron (Parnell et al., 2008). Given the project aims, age measurements at each site generally were focused around any increase in abundance of Pinus recorded, with the result that age uncertainties are generally much greater away from this part of the record. The figures presented thus in general focus upon that part of each record where any Pinus increase was recorded, and hence where the age uncertainty is least. Age–depth models were not fitted for two sites, Ach3 and Aff2, for each of which only a single ‘basal’ $^{14}$C age measurement was made.

Pollen diagrams for the 25 sites examined are presented in Figures S24 – S48. Curves showing the percentage values of eleven more important and/or diagnostic pollen taxa are plotted, along with a summary plot for three principal growth forms of pollen producing plant taxa: Tree and shrub taxa; Dwarf-shrub taxa; and Herbaceous taxa. Values are calculated as percentages of the total number of pollen grains of terrestrial plant taxa counted. The abundance of Sphagnum spores is also plotted, as percentage of the total number of pollen grains of terrestrial plant taxa plus the number of Sphagnum spores counted. The total concentration of pollen of terrestrial plant taxa is also plotted. The principal vertical axis for the majority of pollen diagrams is the calibrated age, derived from the age–depth model. For the two sites for which an age–depth model was not fitted, the pollen diagram is plotted using a depth scale, the locations and ages of samples for which $^{14}$C age measurements were made being plotted alongside this scale. Note that, for consistency and ease of comparison of the pollen diagrams, the same pollen taxa are plotted in the same order on all of the diagrams, thus some pollen taxa are included on diagrams for sites where they were not recorded.
Figure S1: Ach1 Loch nan Eala – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the four $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the Pinus pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in Pinus pollen abundance that we have identified as indicating expansion of pinewoods in Glen Achall.
Figure S2: Ach2 ‘Terrace Hollow’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the four $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the Pinus pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in Pinus pollen abundance that we have identified as indicating local development of pinewoods.
Figure S3: Ach4 ‘Sheepfold’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the six $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in *Pinus* pollen abundance that we have identified as indicating local development of pinewoods.
Holocene expansion of the Caledonian pinewoods

Figure S4: Ach5 ‘West Achall Mire’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the seven $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the Pinus pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in Pinus pollen abundance that we have identified as indicating local development of pinewoods.
Figure S5: Ach6 ‘West Achall Gorge’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of two of the four $^{14}$C age measurements made at this site, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts included in the pollen diagram (Figure S29) were obtained. The other two $^{14}$C age measurements made are excluded because, although they come from the deepest sediment recovered, they are much younger than the two measurements used and were obtained using material from a different core that penetrated to greater depth than that in which the Pinus increase is recorded. Also shown is the Pinus pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in Pinus pollen abundance that we have identified as indicating local development of pinewoods.
Figure S6: Ach7 ‘below Doir’ a’ Ghleannain’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the six $^{14}$C age measurements made, including one outlying date, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in *Pinus* pollen abundance that we have identified as indicating local development of pinewoods.
Figure S7: Ach8 Sanctuary Wood – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the two $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen); at this site the local increase in *Pinus* pollen abundance preceded the onset of sediment accumulation.
Hocone expansion of the Caledonian pinewoods

Figure S8: Ach9 ‘Eagle calling’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the four $^{14}$C age measurements made, including two outlying dates (shaded in grey), and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the Pinus pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in Pinus pollen abundance that we have identified as indicating local development of pinewoods.
Figure S9: Aff1 Loch Salach a’ Ghiubhais – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the three $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in *Pinus* pollen abundance that we have identified as indicating expansion of pinewoods in Glen Affric.
Figure S10: Aff3 ‘Adit Track’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the two $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen); at this site the local increase in *Pinus* pollen abundance preceded the onset of sediment accumulation.
Figure S11: Aff4 Loch an Amair – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the five $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the $Pinus$ pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in $Pinus$ pollen abundance that we have identified as indicating local development of pinewoods.
Figure S12: Aff5 ‘above Loch an Eang’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the four $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in *Pinus* pollen abundance that we have identified as indicating local development of pinewoods.
**Figure S13:** Aff6 ‘T-Junction’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the three $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in *Pinus* pollen abundance that we have identified as indicating local development of pinewoods.
Figure S14: Aff7 ‘Cattle grid’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the six $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in *Pinus* pollen abundance that we have identified as indicating local development of pinewoods.
Figure S15: Aff8 ‘Road below Beinn a’ Mheadhoin’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the three $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the Pinus pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in Pinus pollen abundance that we have identified as indicating local development of pinewoods.
Holocene expansion of the Caledonian pinewoods

Figure S16: Ran1 ‘Finnart mire’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the six $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the Pinus pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in Pinus pollen abundance that we have identified as indicating expansion of pinewoods in Glen Rannoch.
Figure S17: Ran2 ‘Gunnar’s Tree’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the four $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in *Pinus* pollen abundance that we have identified as indicating local development of pinewoods.
Holocene expansion of the Caledonian pinewoods

Figure S18: Ran3 ‘No Aerial’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the four \(^{14}\text{C}\) age measurements made, including one outlying date (shaded in grey), and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the \textit{Pinus} pollen curve (\% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in \textit{Pinus} pollen abundance that we have identified as indicating local development of pinewoods.
**Figure S19: Ran4 ‘Craiganour’ – Age–depth model**

Bchron age-depth model, showing probability density functions for the calibrated ages of the two $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen). No increase in *Pinus* pollen abundance can be identified, whilst the consistently relatively low values indicate local absence of pinewoods throughout the period when such woodlands were expanding in other parts of the Glen Rannoch landscape.
Holocene expansion of the Caledonian pinewoods

Figure S20: Ran5 ‘Rannoch Forest’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the three $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the Pinus pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in Pinus pollen abundance that we have identified as indicating local development of pinewoods.
Figure S21: Ran6 ‘Camusericht’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the four $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the Pinus pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in Pinus pollen abundance that we have identified as indicating local development of pinewoods.
Figure S22: Ran7 ‘Black 4A’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the four $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in *Pinus* pollen abundance that we have identified as indicating local development of pinewoods.
Figure S23: Ran8 ‘Log Canyon’ – Age–depth model

Bchron age-depth model, showing probability density functions for the calibrated ages of the four $^{14}$C age measurements made, and the 50% and 95% age ranges for the sediment sub-samples from which pollen counts were obtained. Also shown is the *Pinus* pollen curve (% Total terrestrial pollen), with the semi-transparent vertical red band indicating the increase in *Pinus* pollen abundance that we have identified as indicating local development of pinewoods.
Figure S24: Ach1 Loch nan Eala – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S25: Ach2 ‘Terrace Hollow’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Holocene expansion of the Caledonian pinewoods

Figure S26: Ach3 ‘above Cadubh’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S27: Ach4 ‘Sheepfold’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S29: Ach6 ‘West Achall Gorge’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Holocene expansion of the Caledonian pinewoods

Note: As a result of poor core recovery and general coring difficulties at this site, resulting largely from the extremely loose and wet nature of much of the sediment, obtaining a sequence of pollen sub-samples spanning the overall depth of sediment recovered required the use of sub-samples from both the duplicate sediment cores. A well-defined increase in abundance of Pinus pollen was located among sub-samples from the fourth segment of the first core. Samples from greater depths were taken from the fifth segment of the second core and had consistently low Pinus abundance. Subsequently, however, 14C age measurements on material from the fifth segment of the second core proved to be substantially younger than those made on material from the segment of the first core in which the Pinus increase was recorded (Table 2). Accordingly, the pollen diagram and chronology presented here exclude pollen data and 14C age measurements made on the fifth segment of the second core.
Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S31: Ach8 Sanctuary Wood – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S34: Aff2 Loch an Fheadain – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Holocene expansion of the Caledonian pinewoods

Figure S35: Aff3 ‘Adit Track’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S37: Aff5 ‘above Loch an Eang’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.

Figure S38: Aff6 ‘T-Junction’ – Pollen diagram
Holocene expansion of the Caledonian pinewoods

Figure S39: Aff7 ‘Cattle grid’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S41: Ran1 ‘Finnart mire’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S42: Ran2 ‘Gunnar’s Tree’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S43: Ran3 ‘No Aerial’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Holocene expansion of the Caledonian pinewoods

Figure S45: Ran5 ‘Rannoch Forest’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Holocene expansion of the Caledonian pinewoods

Figure S47: Ran7 ‘Black 4A’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus Sphagnum, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
Figure S48: Ran8 ‘Log Canyon’ – Pollen diagram

Pollen percentage diagram for the principal pollen taxa, plus *Sphagnum*, recorded; also shown is the total pollen concentration. In addition to the actual percentage values (solid ‘curves’), 10x exaggerated values (unfilled outlines) are also shown so as to reveal changes in abundance of less abundant taxa.
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