Title	A3.6 Holocene vegetation history of SW Connemara, Co. Galway with particular reference to Carna and Roundstone
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Publication Date	2019
Publication Information	O'Connell, Michael, & McDonnell, Karina. (2019). A3.6 Holocene vegetation history of SW Connemara, Co. Galway with particular reference to Carna and Roundstone. In Pete Coxon (Ed.), The Quaternary of Western Ireland. INQUA Field Guide Pre:GL-2. Dublin: Irish Quaternary Association.
Publisher	Irish Quaternary Association
Link to publisher's version	http://iqua.ie/publications/field-guides/
Item record	http://hdl.handle.net/10379/17628

The Quaternary of Western Ireland

INQUA 2019 Field Guide Pre:GL-2

Edited by Pete Coxon
2019

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An Roinn Cumarsáide, Gníomhaithe ar son na hAeráide agus Comhshaoil
Department of Communications, Climate Action & Environment

INQUA 2019
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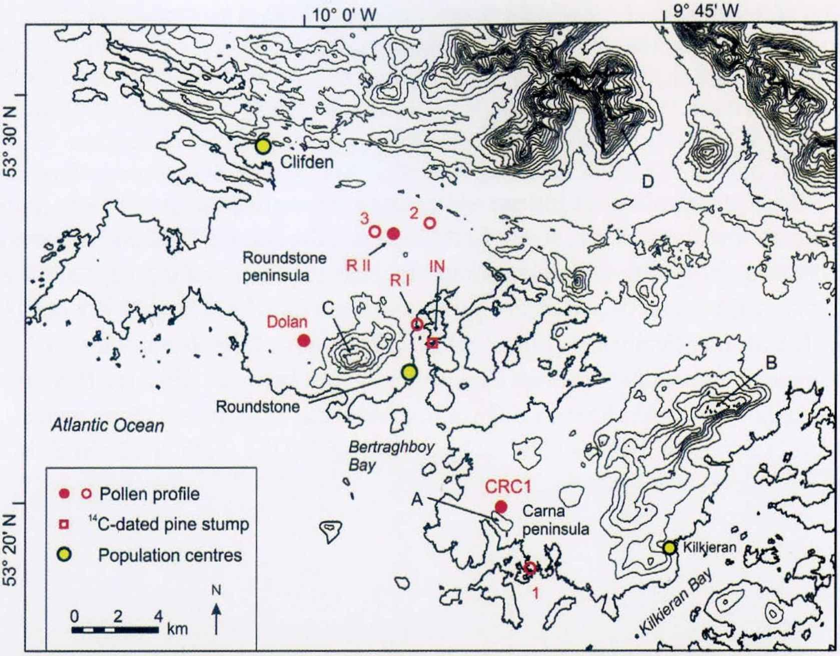
A3.6 Holocene vegetation history of SW Connemara, Co. Galway with particular reference to Carna and Roundstone

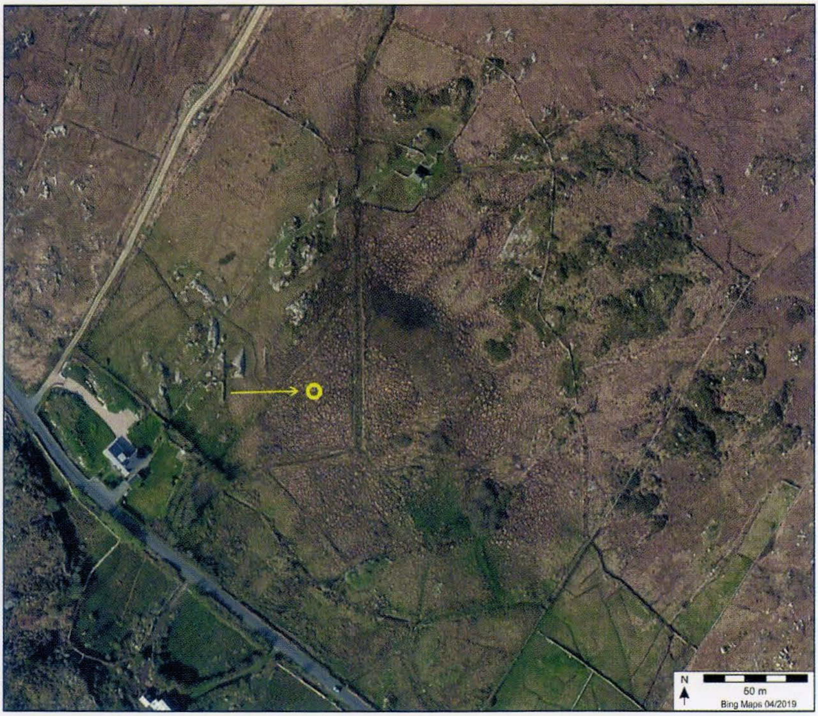
(Michael O'Connell and Karina McDonnell)

Introduction

Stratigraphical investigations and coring were carried out at Loch an Chorcail, Carna peninsula, south-west Connemara in August 1986 with a view to reconstructing long-term environmental change and particularly vegetation change in the southern part of the Carna peninsula (in Irish: *Iorras Aithneach*, i.e. The Stormy Peninsula) (Figure A3.6.1). This rather large peninsula — a prominent feature of south-west Connemara — lies between Kilkieran Bay and Bertraghboy Bay. A mountain ridge (Cnoc Mordáin: 354 m) runs along much of the eastern side. Here, and in the low-lying land to the south, the bedrock is Devonian granite. Otherwise, older Lower Ordovician metagabbro and gneiss dominate (Wright 1963; Pracht *et al.* 2004). The landscape generally is windswept and has few trees apart from recent conifer plantations and shelterbelts associated with settlements. The landscape is largely characterised by extensive blanket bog and heath, and many lakes. Settlement is mainly confined to the coastal strip and especially the southern parts where farming is mainly concentrated (Costello 2016). Farming is based almost entirely on cattle and sheep rearing but in earlier times arable farming that involved cereal growing (mainly oats) and potato cultivation (especially in the nineteenth and early twentieth centuries) was important. Booleying, i.e. movement of livestock from coastal parts into the interior, continued in the region into the early twentieth century (Costello 2016, 2017). Nearby stone-wall field boundaries and local placenames, such as Loch an tSeangharraí (lake of the old garden/cultivated ground) and Loch an Mhuillin (lake of the mill) (Robinson 1990, 2007), as well as remains of two watermills, including a horizontal watermill, attest to considerable farming activity, including arable, especially to the south-west of Loch an Chorcail.

Figure A3.6.1 (over page) Contoured map of the study region, namely Carna and Roundstone peninsulas, south-west Connemara. Contours at 50 m intervals are shown (© Ordnance Survey Ireland; all rights reserved; Licence No. NUIG220212). Pollen profiles (profiles presented here indicated by closed circles): CRC1 = Loch an Chorcail; Dolan; R I = Roundstone I, R II = Roundstone II; 1 = Mweenish; 2 = Oak Island; 3 = Birch Island. IN = Inis Ní (14C-dated pine stump). Elevated terrain: A = Coilleen Hill (An Coillín); B = Cnoc Mordáin; C = Errisbeg; D = The Twelve Bens. The aerial photograph (from Bing Maps, accessed 01/04/2019) shows Loch an Chorcail and environs. The location of core CRC1, which is off-centre with respect to the basin as a whole, is indicated by an open circle and arrow.


10° 0' W
9° 45' W
53° 30' N
53° 20' N
Clifden
D
3
2
R II
Roundstone
peninsula
R I
IN
Dolan
C
B
Roundstone
Atlantic Ocean
Bertraghboy
Bay
CRC1
A
Carna
peninsula
Kilkieran
1
Kilkieran Bay
Pollen profile
14C-dated pine stump
Population centres
0 2 4 km
N


N
50 m
Bing Maps 04/2019

The basin, referred to as Loch an Chorcail, lies at the southern edge of extensive lowland blanket bog and heath (Figures A3.6.1 and A3.6.2). It is sheltered from direct influence of the Atlantic Ocean by Coilleen Hill (*An Coillín,* i.e. the little wood) which rises to 97 m immediately to the south. Other pertinent geographical details and botanical information are given in Table 1.

In this paper, the results of the investigations at Loch an Chorcail (pollen profile CRC1) are presented and evaluated. In the Discussion, the findings from Loch an Chorcail are considered in the context of the vegetation history of the wider region, and especially that of the Roundstone peninsula and the investigations carried out there by others including Jessen (1949), Joyce (1976), Teunissen and Teunissen-van Oorschot (1980), and Hannon and Bradshaw (1989).

Figure A3.6.2 (previous page) View of site from lower slopes of Coilleen Hill (An Coillín) to the north-west. In the foreground is Loch an Chorcail basin (perimeter suggested by a broken red line). Location of core CRC1 is indicated by a circle. Features of note include (a) the largely overgrown drainage channel that runs from the basin centre towards the north-west, (b) extensive heath, shallow bog and lakes, (c) Bertraghboy Bay, and (d) The Twelve Bens in the background. *Salix* bushes are present in and near the basin; *Ulex gallii* (in flower) is common to the east of the basin. Photo: 22/09/2013, M. O'Connell.

Table 1. Geographical details relating to Loch an Chorcail and features of core CRC1.

Name of lake: Loch an Chorcail (Robinson 1990; he suggests it indicates a marsh) and Lough Corker (Ordnance Survey of Ireland (OSI) 1839 map). The former is used here.

Lake features: Shallow basin (maximum recorded depth 630 cm; dimensions: 150 x 100 m, 1.2 ha) surrounded by bog/heathy vegetation; peat at the southern edge of the basin removed for fuel several decades ago; no obvious inflow; outflow from NW end to Owenhid River; drainage furthered by a substantial channel that runs diagonally across the basin and connects to an outflow that which has been artificially deepened. The OSI 1839 map indicates open water. Before the end of 1800s, the lake had infilled (Robinson 1990), the infilling process probably furthered, at that time and subsequently, by drainage and disturbance in the catchment. The basin is now a *Schwingmoor*, i.e. a quaking mat of wetland plant communities (fen) covering soft lake sediment.

Vegetation*: The scraw communities are species-rich and include rarities such as *Carex curta, C. lasiocarpa,* and *Juncus planifolius*, the last mentioned a neophyte introduced from South America probably in the late 1960s (Webb and Scannell 1983; Lockhart *et al*. 1989). Fen mosses include *Calliergon cordifolium* and *Sphagnum contortum*. Other species common in nearby lakes/basins and of biogeographical interest include *Cladium mariscus* and *Eriocaulon aquaticum*. Heaths include *Ulex gallii* and *Daboecia cantabrica*, common *Erica* spp. (*E. tetralix* and *E. cinerea*) and the rare heather, *E. mackayana* (BSBI 2019; Sheehy Skeffington and Van Doorslaer 2015). North of Loch an Chorcail (2 km distant) is the site of a failed conifer plantation from the late nineteenth century (Robinson 1990).

Core CRC1: Core taken in the south-western part of basin where the deepest sediments were detected (WGS84 co-ordinates: 53.33701, -9.85402; ca. 17 m asl). Sediment consists predominantly of organic-rich, dark-brown gyttja. Fine sand layers present from 310 cm to near the top; frequent between 146 and 93 cm. Between 588 cm and 610 cm, clay-rich sediment followed by gyttja to 630 cm which most likely pertain to the Younger Dryas and Bølling/Allerød, respectively. Bedrock reached.

* Plant nomenclature is as follows: vascular plants, Parnell and Curtis (2012); bryophytes, Atherton *et al*. (2010); pollen taxa, mainly Moore *et al*. (1991).
Classical pollen zones (Boreal, Atlantic, etc.) are as defined by Mitchell (1951).

Methods

Stratigraphical investigations and lake coring were carried out in August 1986. Pollen analytical and related investigations were completed by early 1988 (McDonnell 1988) and ^{14}C dates were obtained later. Details of the methods used for investigations at Loch an Chorcail and for replotting pollen data from Roundstone are given in Table 2.

Table 2. Summary of laboratory methods

Core CRC1 from Loch an Chorcail

Sampling lake sediment: 1 cm-thick slices taken for pollen analysis (82 samples; interval between samples averages 6 cm) and ashing (98 samples; sampling generally as same depths as for pollen analysis).

Lake sediment analysis: samples were processed following standard procedures for pollen analysis (includes treatment with hydroflouric acid and acetolysis, and pollen mounting in glycerol) and ashing as implemented in the Palaeoenvironmental Research Unit, NUI Galway. The age of five bulk-sediment samples was determined by the conventional ^{14}C-dating method at the Centre for Isotope Research, University of Groningen. Macrofossil investigations were carried out by Waldner (2013), the results from which will be presented elsewhere.

Pollen diagram construction: pollen percentage values are based on a total terrestrial pollen (TTP) sum. *Sphagnum,* aquatics, non-pollen palynomorphs (NPPs) and micro-charcoal (charcoal particles ≥37 μm) values are based on TTP plus the sum of the particular category. The pollen diagrams are plotted to a depth scale. Ages, derived from the age-depth curve, and ^{14}C dates, ash values, etc. are also indicated. PAZ boundaries, which are fitted by eye, are placed where there are major changes in the pollen curves.

Age/depth model: an age/depth curve was constructed using CLAM ver. 2.2 (Blaauw 2010) and the ^{14}C calibration curve IntCal13 (Reimer *et al.* 2013). A smooth spline curve (smoothing factor: 0.3) was fitted to the five available ^{14}C dates and the top (assigned to AD 1980±5) and bottom (Late-glacial/Holocene transition, i.e. 11650±99 cal. BP; Walker *et al.* 2009) of the profile.

Pollen profiles from Roundstone (Dolan and Roundstone II)

Pollen diagram construction, profiles Dolan and Roundstone II: percentage curves are based on TTP, i.e. bog/heath taxa are included in the pollen sum (PS). This PS was used so as to give pollen curves that are constructed in the same way, as far as that it possible, as the curves in profile CRC1. Using such a PS is reasonable given that the greater part of the deposits consisted of gyttja (lake mud) or reedswamp peat. Peat derived from bog vegetation was confined to the upper parts of the cores and so any undue influence on the course of the pollen curves by locally present (at sampling site) bog/heath taxa is confined to the upper intervals.

The pollen profiles have been re-zoned so as to facilitate comparison with profile CRG1. Tentative ages are indicated based on key pollen indicators and the age/depth model constructed for CRG1.

Table 3. Overview of pollen profile CRC1 (Loch an Chorcail) and interpretation of the data.

PAZ	Age (ka cal. BP)	Pollen features: spectra and main pollen features indicated	Interpretation of pollen data; vegetation and land-use history
9	3.83–0.95 Subzone boundaries 9a/b: 2.86 9b/c: 1.78	AP and especially *Pinus* low values. Poaceae and bog taxa have increased representation. Subzones are 9a: *Pinus* falls to ca. 2% and does not recover, a *Fagus* curve, *Myrica* and *Nymphaea* achieve ca. 10% and 15%, respectively; 9b: *Quercus* declines to ca. <9%; 9c: low *Quercus* values, minor increase in *Pinus*	Main lake infilling occurs. Shallow lake conditions favoured *Nymphaea alba* and *E. aquaticum*. Pine probably extinct from near base of 9a (ca. 3.6 ka) and final demise of oak at ca. 2.8 ka (9a/b boundary). Fagus may be indicative of local presence of beech but long-distance transport cannot be excluded (O'Connell and Molloy 2019). Late Bronze Age and Iron Age (subzone 9b) a time of most intensive local land-use (cf. elevated NAP values; sandy layers and substantial variation in ash content indicate of severe erosion in catchment). The short period with increased *Corylus* and also *Fraxinus* at 9b/9c boundary dates to the early centuries AD. It may represent a Late Iron Age Lull, a feature common in pollen diagrams from western Ireland (Molloy and O'Connell 2014)
8	4.58–3.83	238–210 cm. *Quercus* declines and *Alnus* increases	Increased NAP, incl. *Plantago lanceolata*, and the decrease in *Quercus* suggest that oak (also yew) woodland has declined probably due to farming
7	5.01–4.58	258–242 cm. Substantial AP changes including rise and decrease in *Pinus*, decrease in *Ulmus* and minor peaks in *Fraxinus* and subsequently *Taxus*	A 'pine flush', i.e. pine growing on bog surfaces, is recorded at the base of the zone. As a result, pollen and spores of bog taxa decline. The 'pine flush' spans the interval ca. 5000–4750 cal. BP. This is in good agreement recently published ^{14}C dates from nearby coastal sites, including Inis Ní between Carna and Roundstone (O'Connell and Molloy 2017). Ash expands briefly. Yew spreads into the area and assumes some importance
6	5.86–5.01	289–262 cm. *Pinus* declines and decline in *Ulmus* continues. NAP and bog/heath taxa expand	The mid-Holocene Elm Decline is reflected at the base of the zone. As expected, *P. lanceolata* expands but values are modest (max. 1.4%; average 0.4%). Opening of the landscape (facilitating expansion of bog/heath) has its origins in natural causes rather than Neolithic farming. Aquatics increase suggesting lower lake level
5	8.14–5.87 Subzone boundaries 5b/c: 6.7 5a/b: 7.5	436–306 cm. Gradual, subdued expansion of *Alnus* to achieve ca. 4%. Subzones are 5a: curves for *Nymphaea* and *Potamogeton*; 5b: *Pinus* values generally lower; 5c: *Pinus* and *Quercus* higher and *Corylus* lower	Alder is probably established locally but does not contribute substantially. Hazel declines sharply at ca. 6.7 ka (5b/5c). Elm declines towards the top of the zone. *E. aquaticum* locally present from top of subzone 5b (ca. 6.73 ka). Heath/bog vegetation and grasses important throughout (cf. *Calluna*, *Sphagnum*; minor curves for *Empetrum* and *E. tetralix* in 5a). Firing persists

PAZ	Age (ka cal. BP)	Pollen features: spectra and main pollen features indicated	Interpretation of pollen data; vegetation and land-use history
4	10.1–8.14	530–442 cm. *Corylus* 26%, *Betula* 13%, *Pinus* 12%, *Quercus* 9.4%, *Ulmus* 6.6%, *Alnus* 0.25%, Poaceae 10%, *Calluna* 14% (averages). First *Cladium* records in the basal spectra. An 8.2 ka event is not obvious	Tall canopy woodland consisting mainly of hazel, oak, pine, elm and birch. High *Calluna* and Poaceae values and high NAP diversity (also *Pteridium aquilinum* and *Osmunda regalis*) suggest considerable open habitat with light-demanding plant communities including ling-dominated heath with *Sphagnum*. Steady increase in micro-charcoal suggests increasing fire frequency. Closer sampling may reveal an 8.2 ka event (the interval in this part is ca. 140 yr)
3	10.7–10.1	554, 546, 538 cm. *Corylus* expands and peaks (47%). *Pinus* expands slowly, *Ulmus* and *Quercus* expand at the top	Hazel expands rapidly, largely at expense of birch. Pine begins a slow expansion. Oak and elm are present as the zone closes; prior to that, low pollen values may reflect long-distance transport. *Osmunda* remains important and *Hymenophyllum wilsonii* is present throughout. Aquatics decline which suggests increase in lake watertable level
2	10.8	562 cm. *Betula* at 54% dominates AP; Poaceae 19%, *Calluna* 11%	Birch has expanded considerably. This presumably has contributed to decline of juniper and crowberry. Grasses and ling (*Calluna*) are important (open habitat). *Osmunda* and *Nymphaea* assume important, near and in the lake, respectively
1	11	570 cm. *Juniperus* 36%, *Empetrum* 20%, *Betula* 13%, ferns 10%	Juniper dominant; tall woody vegetation limited to birch. Early Holocene vegetation development

Results

An age/depth curve for core CRC1 is presented in Figure A3.6.3. The main terrestrial percentage pollen curves, including arboreal pollen (AP) and non-arboreal pollen (NAP), are presented in Figure A3.6.4. Composite percentage curves, as well as curves for ferns and related taxa (these are included within the PS), and aquatic taxa, micro-charcoal and other data are presented in Figure A3.6.5. Pollen concentration values were estimated but may not be reliable and so are not presented.

Pollen profile CRC1 spans most of the Holocene. The pollen and other data are summarised in Table 3 and interpretations are provided. In interpreting the data it is assumed that, given the rather small basin and the relative proximity of the core to the basin margin, the pollen diagram reflects mainly developments in the basin itself and its general vicinity (within ca. 1 km radius) (Jacobson and Bradshaw 1981). On the other hand, it is quite likely, given the rather exposed

Atlantic location, that wind-dispersed pollen and especially pollen of tall woody plants and grasses, etc. that are normally well dispersed, derive from a wider source area. It is reasonable, however, to assume that mainly developments at the southern end of the Carna peninsula, and especially changes near and within the lake basin are reflected by the profile.

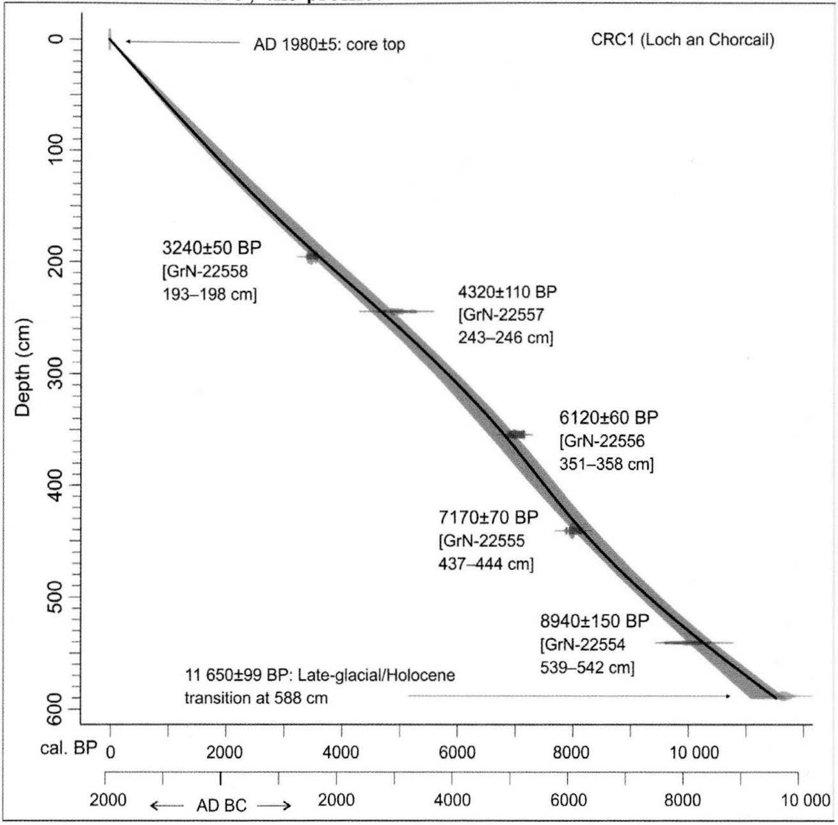
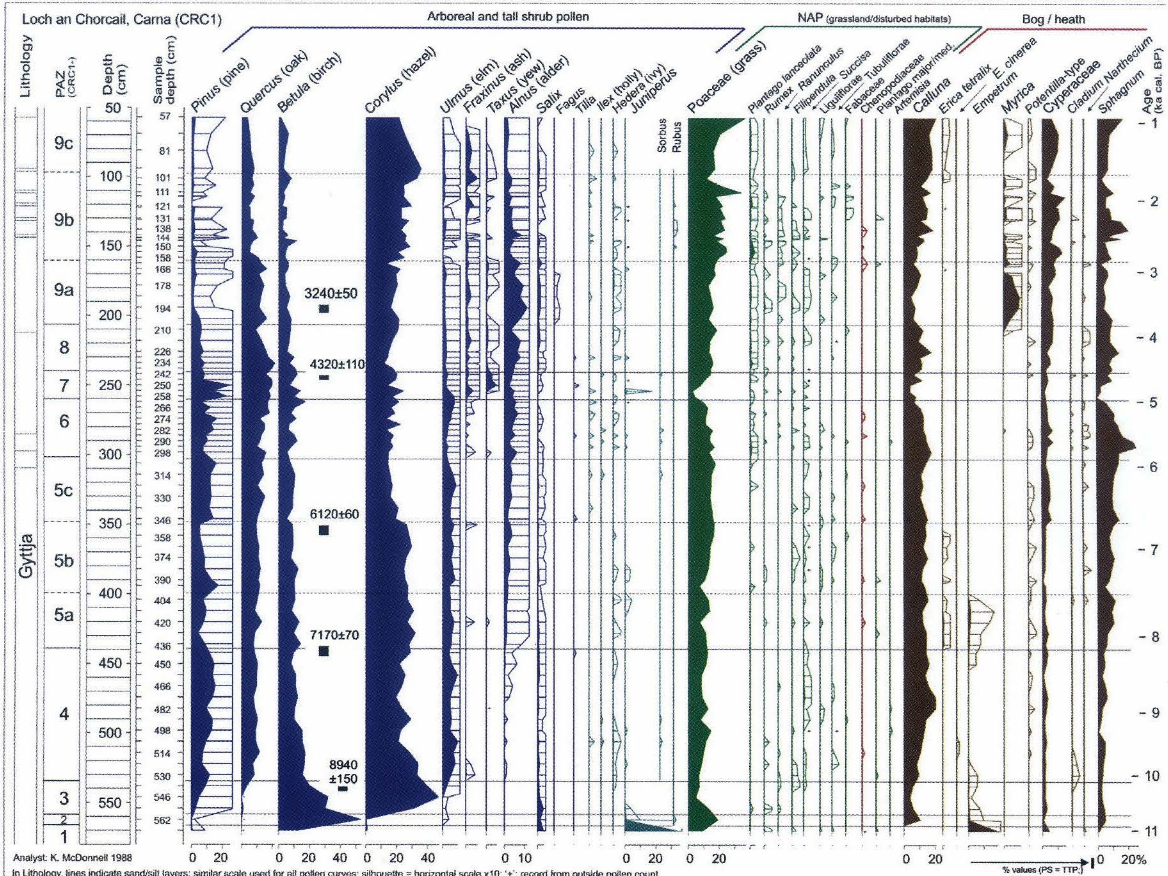


Figure A3.6.3 Age/depth relationship (smooth spine curve and associated 95% probability envelope) for profile CRC1 generated by CLAM (see Methods).

Figure A3.6.4 (over page) Percentage pollen curves, profile CRC1, Loch an Chorcail. Curves are drawn to a depth scale and the same horizontal scales are used throughout. A silhouette is used to shown x10 exaggeration. Records outside the pollen count are indicated by '+'; small values are indicated by a closed circle. Additional curves are shown in figure A3.6.5



Loch an Chorcail, Carna (CRC1)
Arboreal and tall shrub pollen
NAP (grassland/disturbed habitats)
Bog / heath
Lithology
PAZ (CRC1-)
Depth (cm)
Sample depth (cm)
Pinus (pine)
Quercus (oak)
Betula (birch)
Corylus (hazel)
Ulmus (elm)
Fraxinus (ash)
Taxus (yew)
Alnus (alder)
Salix
Fagus
Tilia
Ilex (holly)
Hedera (ivy)
Juniperus
Sorbus
Rubus
Poaceae (grass)
Plantago lanceolata
Rumex
Ranunculus
Filipendula
Succisa
Liguliflorae
Tubuliflorae
Fabaceae
Chenopodiaceae
Plantago major/med.
Artemisia
Calluna
Erica tetralix
E. cinerea
Empetrum
Myrica
Potentilla-type
Cyperaceae
Cladium
Narthecium
Sphagnum
Age (ka cal. BP)
Gyttja
9c
9b
9a
8
7
6
5c
5b
5a
4
3
2
1
3240±50
4320±110
6120±60
7170±70
8940 ±150
Analyst: K. McDonnell 1988
% values (PS = TTP)
In Lithology, lines indicate sand/silt layers; similar scale used for all pollen curves; silhouette = horizontal scale x10; '+': record from outside pollen count

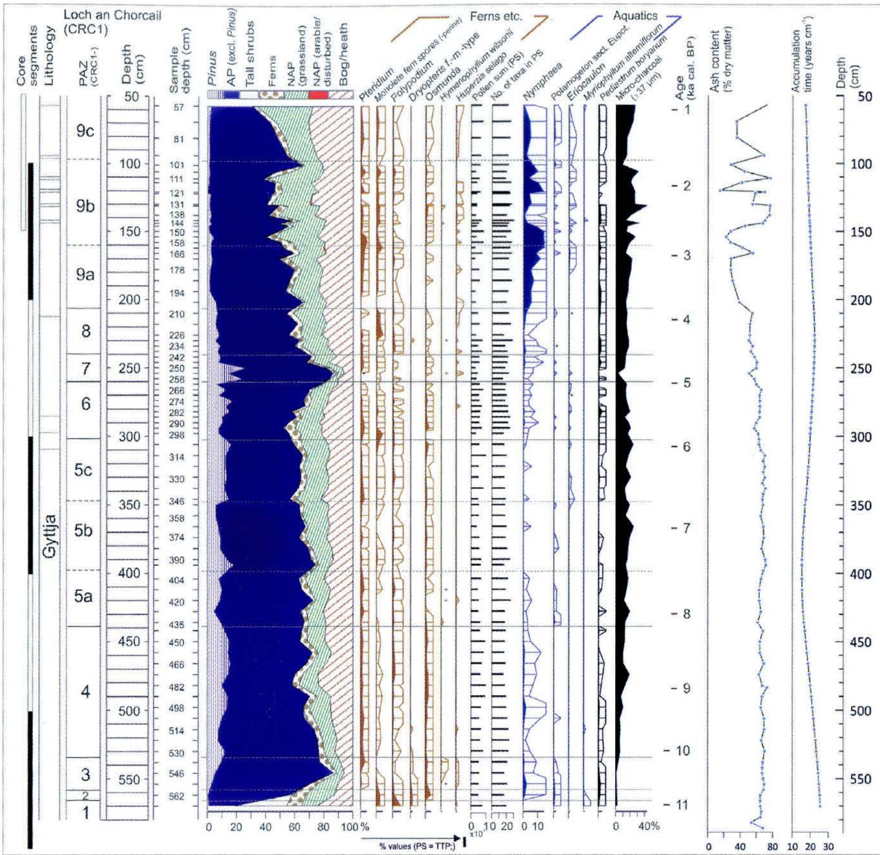


Figure A3.6.5 Percentage pollen curves (composite and individual curves), profile CRC1. Ash content and sediment accumulation time are also shown. Conventions followed are as in figure A3.6.4

Discussion

Profile CRC1 from Loch an Chorcail complements and supplements earlier pollen analytical investigations carried in the Carna and Roundstone peninsulas. Joyce (1976) investigated freshwater deposits at Mweenish, 3 km south-east of Loch an Chorcail, that are now subject to inundation during spring tides as a result of rising sea-level (O'Connell and Molloy 2017). A summary version of the pollen profile, which does not have ^{14}C dates, is available in O'Connell (1988). This shows elevated *Pinus* values near the base of the profile (peak of ca. 17% at 211 cm). *Pinus* pollen was not recorded above 135 cm (O'Connell 1988). These developments, datable to ca. 5000 cal. BP ('pine flush') and 3600 cal. BP (pine population greatly reduced), respectively, more or less bracket several records for *Eriocaulon* (the record ceases at 148 cm, i.e. ca. 3800 cal. BP, based on above tentative dating).

More detailed and longer records — without ^{14}C dates but with age-diagnostic pollen features — are available for Roundstone peninsula. Jessen (1949) carried out investigations at two sites, i.e. Roundstone I and Roundstone II (Figure A3.6.1). The former related to intertidal deposits and peat-embedded pine stumps in inner Roundstone Bay, north of Letterdyfe House. Investigations at Roundstone II, however, are the more relevant in the present context (see photograph in Figure A3.6.6). The main core, Roundstone II (11), is based on a ca. 6 m long core consisting mainly of gyttja and *Phragmites* peat with ca. 1 m of *Molinia* (blanket bog) peat at the top. This core gave a pollen diagram that reflects local (lake/bog vegetation) and local/regional change (woodland and land-use) over most of the Holocene (Figure A3.6.7). The data have been recalculated so as to facilitate general comparison with profile CRC1. It should be borne in mind that various pollen taxa, including *Juniperus, Fraxinus* and *Taxus*, were not counted so the percentage representation of taxa that are included in the PS may be exaggerated (Figure A3.6.7). Ages for pollen features that are of regional significance are based on profile CRC1, which, while based largely on ^{14}C dates (Figure A3.6.3), agree with the generally accepted dating ascribed to those features in the wider region (cf. O'Connell *et al*. 1988; Molloy and O'Connell 2014).

Features of note in the Roundstone II profile include substantial *Empetrum* values at the beginning of the Holocene (given the role *Juniperus* plays in early Holocene succession in most Irish pollen diagrams, it can be assumed to have been of importance here also), relatively high values for *Pinus* and *Quercus*, early expansion of *Ulmus* (but representation remains modest overall) and high values for Poaceae and Ericaceae, a well-defined Elm Decline, no evidence for Neolithic

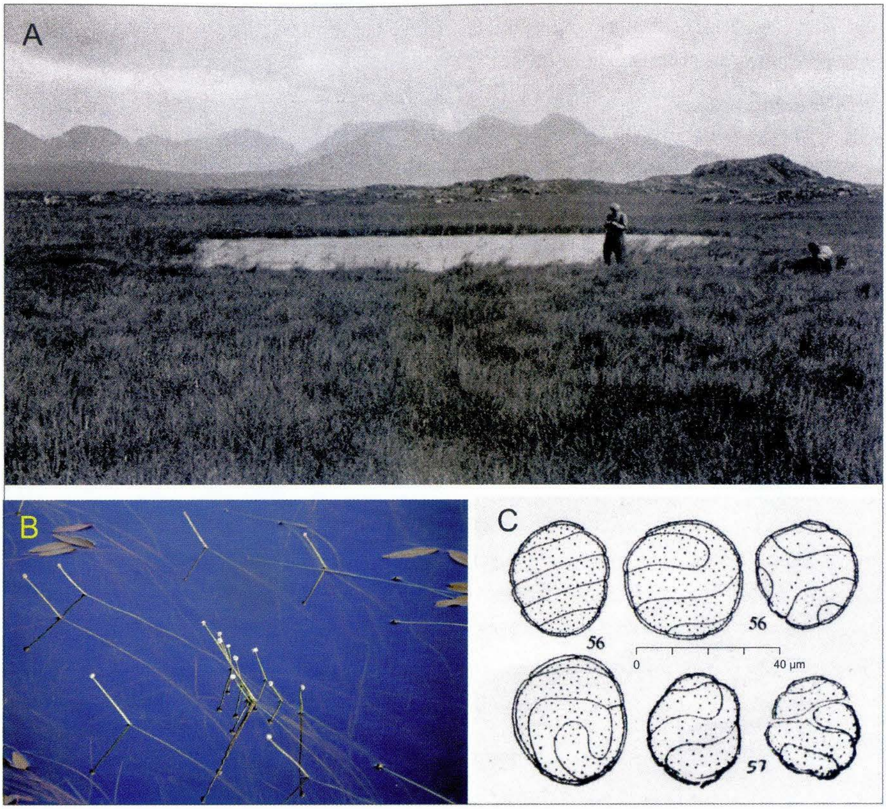


Figure A3.6.6 Blanket bog at coring site Roundstone II, with Twelve Bens in the background (photo: H. Johassen ca. 1930s; from Jessen 1949, Plate III). B. *Eriocaulon aquaticum* (flowering heads) and *Potamogeton polygonifolius* in a shallow lake, north of Loch an Chorcail (photo: M. O'Connell, 27/07/2007); C. Drawings of *Eriocaulon* pollen from Roundstone; No. 56: four pollen from recent material; No. 57: two fossil pollen from profile Roundstone II (mid-Holocene, pre-Elm Decline; after Jessen 1949, Plate IV).

Landnam (*P. lanceolata* is poorly represented throughout), a pronounced peak in pine indicative of a 'pine flush', and substantial *Myrica* values in the upper part of the profile. These features, apart from the well-defined Elm Decline, are shared with profile CRC1.

Jessen (1949) indicates that his Ericaceae curves consist predominantly of *Calluna* (as is expected) but also includes *Erica* spp. There are macrofossil records for *E. tetralix* and *E. cinerea,* and also *E. mackayana* for Roundstone II that relate to the early and mid-Holocene, i.e. Boreal and Atlantic periods (pre-

Elm Decline). The records for *E. mackayana* (leaves) are, however, no longer regarded as certain because of the difficulty in distinguishing the leaves of this heather from the common and closely related species, *E. tetralix* (Webb 1955; Sheehy Skeffington and Van Doorslaer 2015).

The emphasis that Jessen (1949) attaches to the post-Elm Decline pine peak at Roundstone is particularly noteworthy. Commenting on profile Roundstone I, he states (p. 169):

> The great crest of the pine-curve at the transition VIIa /VIIb is almost certainly to a high degree due to local influence as pine at this time was growing on the bog but a similar crest was seen at the same time at Roundstone II w[h]ere no pine was growing on the bog and it is clear that pine must have been common in the locality ... . In the course of Sub-boreal time the surface of the bog at Roundstone I became so dry that the pine could spread out over its central low-lying sector but soon afterwards the wood was displaced by a *Sphagnum-Molinia* vegetation.

Given the considerable information on this pine-on-peat phenomenon that, in the meantime, is now available (see below; also O'Connell *et al.* 1988) and which points to a development of regional significance, the emphasis placed on it by Jessen (1949) showed considerable perspicacity.

Teunissen and Teunissen-van Oorschot (1980) published a pollen profile, referred to as Dolan, from the south-western part of Roundstone Bog, north-west of Errisbeg (pollen diagram in Figure A3.6.8; age estimates are based on pollen features and are similar to those suggested by the authors). The 525 cm-long profile derives from lake followed by sweedswamp deposits that gave way to a blanket peat deposit in the late Holocene (after ca. 3000 cal. BP). As the profile opens, *Betula* is already the dominant pollen taxon so it is likely that an early Holocene phase with *Juniperus* and *Empetrum* has gone unrecorded. *Osmunda* and also *Cladium* are already present during the birch phase (Pre-boreal; PAZ D-2; ca. 10 970 cal. BP). Later, birch is displaced by hazel and pine, while oak and elm expand slowly and at about the same time. Poaceae and *Calluna* are already well represented which point to presence of bog/heath vegetation and incomplete woodland cover or at least an open woodland structure that is rather early in the Holocene for such a feature. Interestingly, Teunissen and Teunissen-van Oorschot favour the idea of expansion of *Calluna* in dry peaty areas with *Sphagnum* rather than development of heathy vegetation in the context of woodlands with an open structure as favoured by Jessen (1949). In the Dolan profile, as in the other profiles from the region, the expansion of *Alnus* is slow indicating a slow spread and increase in alder. In general, the vegetational

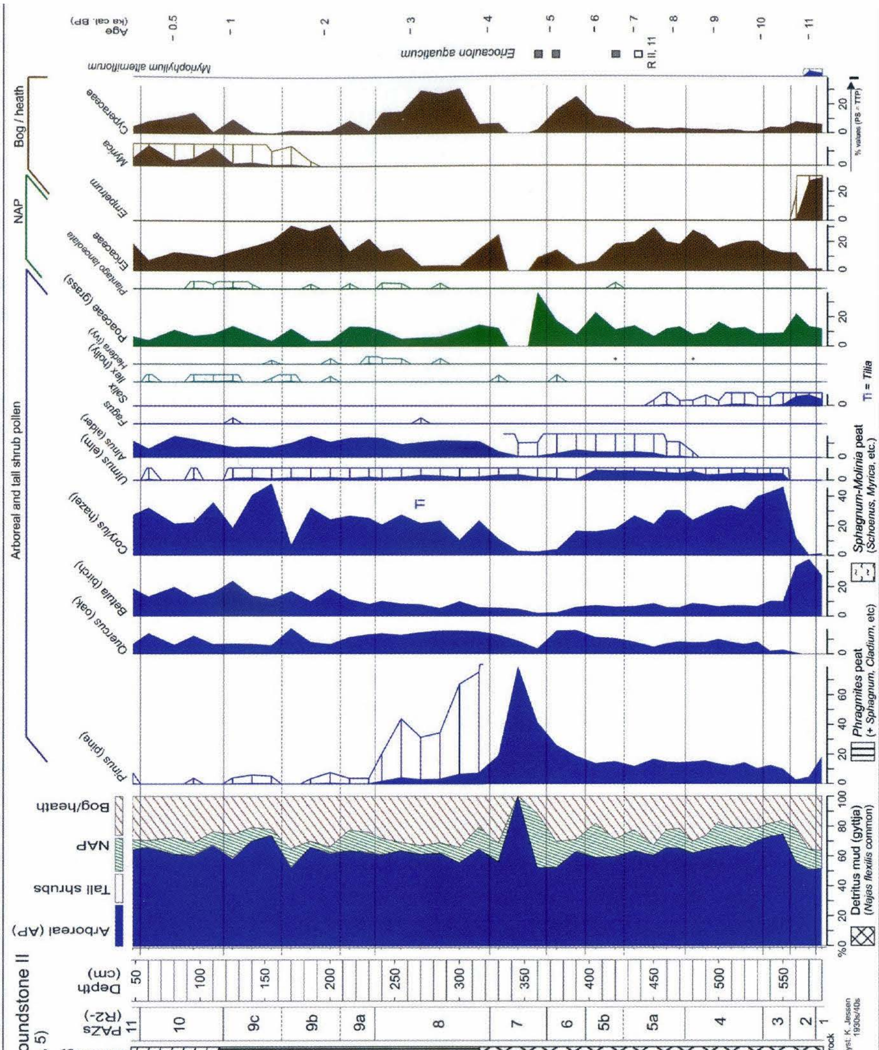


Figure A3.6.7 Percentage pollen diagram from Dolan, Roundstone Bog plotted to a depth scale (after Teunissen and Teunissen-van Oorschot 1980). All curves are drawn to the same horizontal scale, except *Narthecium* and *Sphagnum* where the scale is halved. The *Plantago* curve includes *P. lanceolata* (1.2%/16), *P. maritima* (0.2%/14) and P. coronopus (0.2%/14) (average value/no. of counts in parentheses). Small cereal-type pollen (37–39 μm; recorded mainly in the four uppermost spectra) are included in the Poaceae curve. The profile is rezoned. The PAZs are broadly similar to those recognised in profile CRC1; numbering begins with D-2 as the earliest Holocene is not reflected in the profile. Ages are best estimates based on comparison of key palynological features in CRC1 profile. Conventions followed are as in 3.4.4.

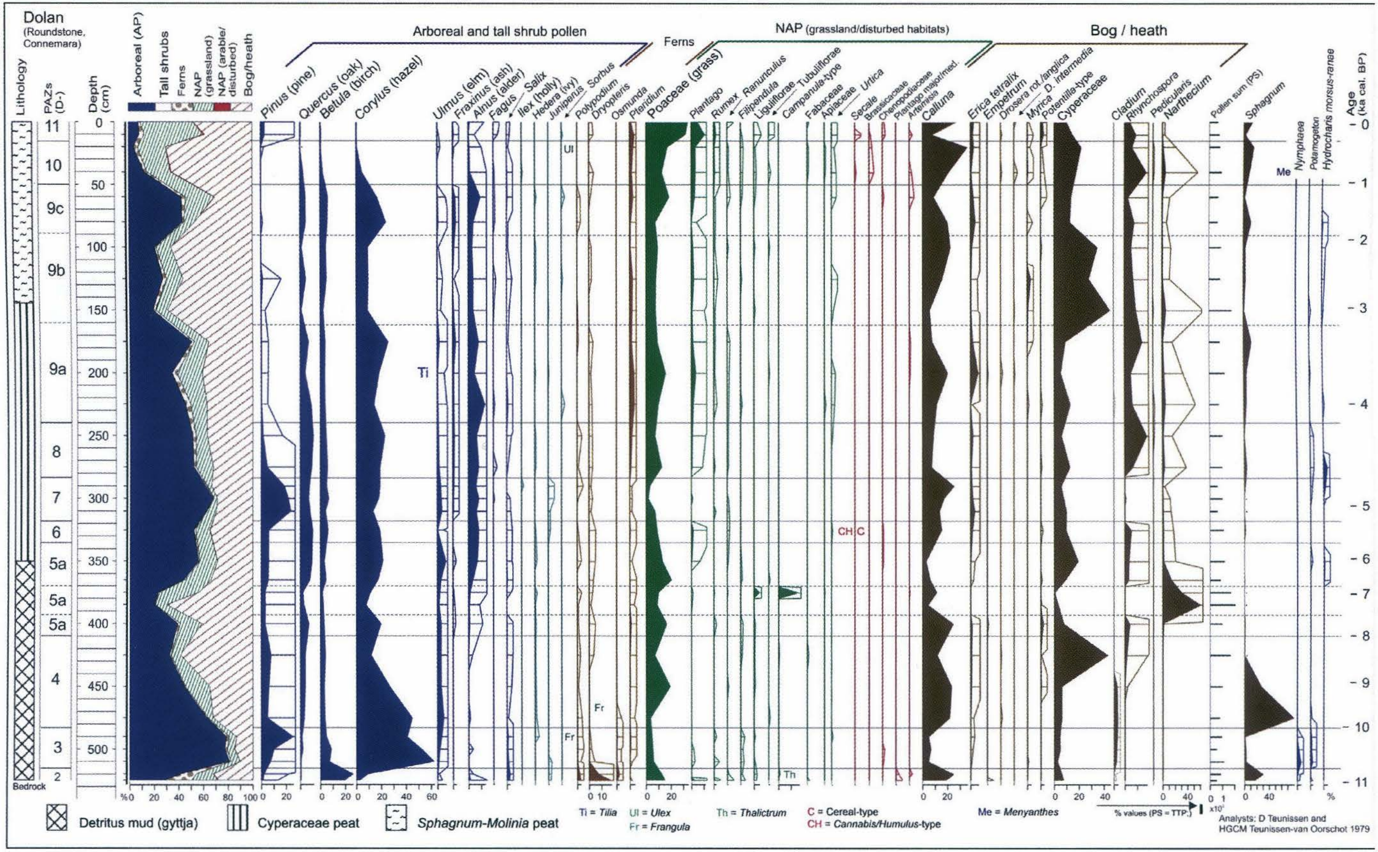
changes recorded at Dolan are similar to those recorded at Loch an Chorcail.

The Elm Decline is well defined but, unfortunately, the sampling interval in that part of the Dolan profile is large and so detail is lacking. A pronounced increase in *Pinus* follows that reflects a 'pine flush', i.e. widespread colonisation of peat surfaces by pine (see comment by Jessen (1949) that is quoted above). A slender *Pinus* curve persists until ca. 4300 cal. BP, when pine probably became extinct locally and rare at a regional level. There are no records for *Taxus*. Given the important role played by yew in the wider region post-Elm Decline (cf. O'Connell *et al*. 1988; Molloy and O'Connell 2014), it is likely that *Taxus* pollen in the Dolan profile was not recognised. The uppermost pollen spectra reflect substantial farming activity (high *P. lanceolata*; also pollen of cereals and ruderals), and in the two uppermost spectra *Pinus* has modest values probably reflecting afforestation of the late nineteenth and early twentieth centuries.

Teunissen and Teunissen-van Oorschot (1980) discuss in considerable detail development of wetland vegetation based on their own investigations and those of Jessen (1949). As at Loch an Chorcail, there are early Holocene records (pollen/spores) for *Cladium*, *Nymphaea*, *Erica tetralix* and *Osmunda* which suggests that *C. mariscus*, *N. alba*, *E. tetralix* and *O. regalis* were common in south-west Connemara from the early Holocene onwards.

Eriocaulon pollen is recorded from the Atlantic period and later in Roundstone II (Jessen 1949) but there appear to be no records at Dolan (Teunissen and Teunissen-van Oorschot 1980) which may be due, in part, to under-representation of *Eriocaulon* in the pollen record (cf. O'Connell and Ní Ghráinne 1994). Joyce (1976) recorded *Eriocaulon* pollen in several spectra in the Mweenish profile, starting with the peak in *Pinus* (ca. 5000 cal. BP) and ending as *Pinus* declined to low values. This suggests local presence at/near that site for about a millennium. At Loch an Chorcail, *Eriocaulon* has a short curve (four successive spectra in the interval 6730–6390 cal. BP) and, after interrupted records, is regularly represented from ca. 3230 cal. BP to the penultimate spectrum. It appears to have become extinct in the basin relatively recently due to loss of suitable habitat following lake infilling.

E. aquaticum is an amphi-Atlantic species that has its European centre of distribution in Connemara (Preston and Croft 1997), and is common in shallow parts of lakes and occasionally water-bodies in old peat cuttings in Carna (including near Loch an Chorcail) and Roundstone. It has been recorded in interglacial sites in Ireland (also in Scotland) that are ascribable to the Gortian/Hoxnian interglacial period (Coxon and Waldren 1995). Jessen suggested on the basis of the larger size of fossil and recent pollen from Roundstone (Figure A3.6.6B; size measurements: 28–40 μm (recent pollen from Roundstone); 30–35



Dolan
(Roundstone, Connemara)
Lithology
PAZs (D-)
Depth (cm)
Arboreal (AP)
Tall shrubs
Ferns
NAP (grassland)
NAP (arable/disturbed)
Bog/heath
Arboreal and tall shrub pollen
Ferns
NAP (grassland/disturbed habitats)
Bog / heath
Pinus (pine)
Quercus (oak)
Betula (birch)
Corylus (hazel)
Ulmus (elm)
Fraxinus (ash)
Alnus (alder)
Fagus
Salix
Ilex (holly)
Hedera (ivy)
Juniperus
Sorbus
Polypodium
Dryopteris
Osmunda
Pteridium
Poaceae (grass)
Plantago
Rumex
Ranunculus
Filipendula
Liguliflorae
Tubuliflorae
Campanula-type
Fabaceae
Apiaceae
Urtica
Secale
Brassicaceae
Chenopodiaceae
Plantago major/med.
Artemisia
Calluna
Erica tetralix
Empetrum
Drosera rot./anglica
Myrica
D. intermedia
Potentilla-type
Cyperaceae
Cladium
Rhynchospora
Pedicularis
Narthecium
Pollen sum (PS)
Sphagnum
Nymphaea
Potamogeton
Hydrocharis morsus-ranae
Age (ka cal. BP)
Ti
Ul
Fr
Th
CH C
Me
Bedrock
Detritus mud (gyttja)
Cyperaceae peat
Sphagnum-Molinia peat
Ti = Tilia
Ul = Ulex
Fr = Frangula
Th = Thalictrum
C = Cereal-type
CH = Cannabis/Humulus-type
Me = Menyanthes
% values (PS = TTP)
Analysts: D Teunissen and HGCM Teunissen-van Oorschot 1979

μm (fossil pollen, Roundstone II); 21–28 μm (recent pollen, North America) that the populations on either side of the North Atlantic have been separated for a long time, a view supported by chromosome data (2n = 64 and 32 for European and North American populations, respectively; Löve and Löve 1958). There is, however, some doubt as regards the size differences of North American versus Irish material as suggested by Jessen (Furness 1988). Watts (1959), however, gives measurements for modern (Irish and North American) and interglacial (from Kilbeg, Co. Waterford) material that are similar to those given by Jessen (1949). Joyce (1976) gives sizes for six *Eriocaulon* pollen recorded in the Mweenish profile as follows: mean and range of shortest and longest axis (grains are often off-spherical in preparations) 23 μm, 18.5–26.6 μm, and 24 μm, 20.6–28.8 μm, respectively. McDonnell (1988) gives 23.3 μm (mean) and 16.7–27.8 μm (range) for 25 fossil pollen in profile CRC1, that were sufficiently intact to facilitate measurement. These measurements for fossil material from Carna (treated with 10% KOH and acetolysed; mounted in glycerine jelly and glycerol, Mweenish and CRC1, respectively) appear to be closer to modern North American material than to the measurements reported by Jessen (1949) and Watts (1959) for modern and fossil Irish material. Furness (1988) gives the size range for *Eriocaulon* pollen as 17-(32)-42 μm (mean within brackets; glycerine jelly mounted; material from herbarium specimens, British Museum). This large size range suggests that pollen-grain size alone may not be a reliable basis for distinguishing pollen of North American versus western European origin. Summing up, it is clear that *Eriocaulon* has a long history in Ireland (Holocene and also interglacial), the details of which require further elucidation before a full understanding of its history can be achieved.

Insights into recent woodland history of lake-islands in Roundstone Bog (north-eastern part) are provided by two short pollen profiles, i.e. Oak Island in Lough Anessaundoo and Birch Island in Derrycunlagh More (Hannon and Bradshaw 1989). In both profiles, yew played a dominant role and holly was also important in the regenerated woodlands. The investigations suggest that present-day, lake-island woodlands in Connemara (cf. Webb and Granville 1961) result from regeneration rather than continuous woodland cover, regeneration undoubtedly being facilitated in the last hundred and fifty years by reduced

Figure A3.6.8 (previous page) Percentage pollen diagram Roundstone II (5) plotted to a depth scale (after Jessen 1949). All curves are drawn to the same horizontal scale. Taxa that were not counted include *Fraxinus*, *Taxus*, fern spores, etc. Presence of *Eriocaulon* pollen is indicated by closed (profile Roundstone II (5)) and open (profile Roundstone II (11); depth is approx.) rectangles, respectively.

grazing pressure as a result of a decline in rural population and farming activity. The importance of *Taxus* in these and other profiles (e.g. Loch an Chorcail and also Lough Namackanbeg near Spiddal; O'Connell *et al.* 1988) suggest that yew has played an important role in the mid Holocene (shortly after 5000 cal. BP; see Table 3) in at least parts of Connemara and also on lake-islands in recent times.

Conclusions

A ^{14}C-dated pollen profile from Loch an Chorcail, southern Carna peninsula provides a detailed record of vegetation and land-use change that spans most of the Holocene.

Pine (*P. sylvestris*, i.e. Scots pine), oak (*Quercus*; most likely *Q. petraea* which characterises present-day western oak woodlands) and hazel (*Corylus*) are the dominant woody species for much of the Holocene. Pine declines after a pronounced phase of colonising bog surfaces during the so-called 'pine flush' that lasted from ca. 5000–4750 cal. BP. The final decline in oak took place shortly after 3000 cal. BP.

Bog/heath taxa are already locally present and common in the early Holocene (*Calluna* from ca. 9700 cal. BP; *E. tetralix* from ca. 8100 cal. BP). The fern, *Osmunda regalis,* was already frequent by 10 800 cal. BP, and *Hymenophyllum wilsonii* spores are first recorded at ca. 10 400 cal. BP indicating local presence of this filmy fern since the early Holocene.

Eriocaulon pollen is recorded with relatively high consistency from ca. 6730 cal. BP until recent times which suggests continuous presence of *E. aquaticum* (American pipewort) at Loch an Chorcail over this period. As far as we are aware, this is the longest Holocene record for Ireland and indeed Europe.

The micro-charcoal record indicates that fire was important from at least 10 000 cal. BP onwards. Sandy layers are recorded in the centuries around the Elm Decline (dated to 5870 cal. BP) which suggest soil erosion but there is no evidence for a pronounced Neolithic Landnam event as at other sites in Connemara (e.g. Lough Sheeauns; Molloy and O'Connell 1991).

Major changes in woodland composition and also woodland extent began at ca. 3830 cal. BP, i.e. in the early Bronze Age, and led to lake infilling and shallow lake conditions that favoured aquatic plants. Considerable soil erosion, which manifested itself as sandy layers in the lake sediment, was a feature of the early and mid-Iron Age (ca. 2500–1800 cal. BP).

Cereal-type pollen is not recorded and pollen of ruderals are poorly represented so it seems that there was little or no cereal cultivation in the vicinity of the lake due probably to unfavourable edaphic conditions caused by bog/heath development.

Pollen profiles from the nearby Roundstone peninsula show similar vegetation history. A key mid-Holocene feature is the widespread but short-lived colonization of peat surfaces by pine (*Pinus sylvestris*) that was probably mediated by climate change, i.e. drier/warmer followed by wetter/cooler conditions.

The data provide evidence for considerable change not only in woodland composition and extent, but also bog/heath development and loss of open water bodies and reedswamps, especially in the later Holocene as sediment-infilling progressed apace, furthered by increased human impact.

Acknowledgements
We thank Sinéad Keane and Pat O'Rafferty for assistance with coring Loch an Chorcail, and Siubhán Comer and Christine Loughlin for help with the site map. The Royal Irish Academy is thanked for permission to reproduce illustrations from *Proceedings of the Royal Irish Academy, Series B*.

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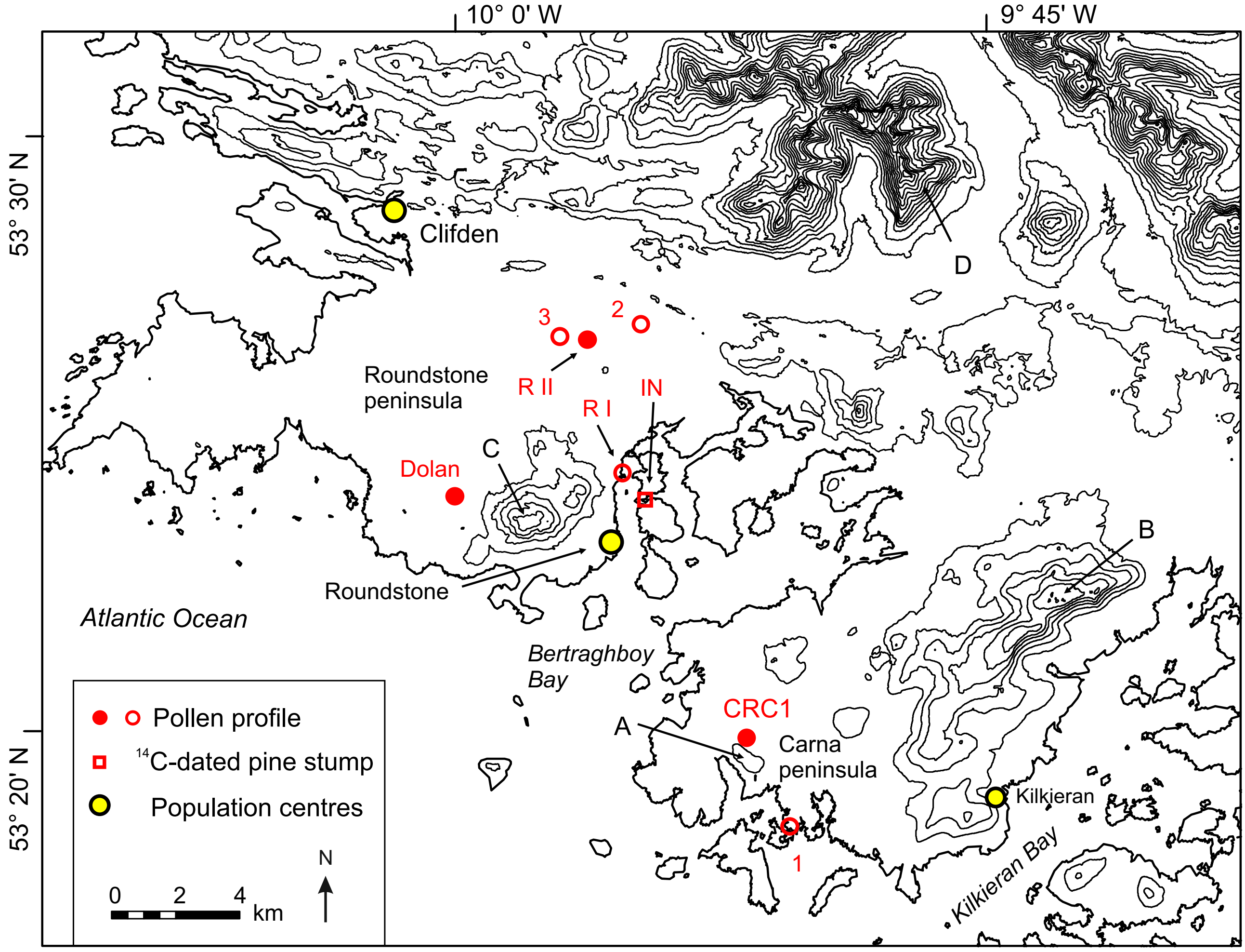
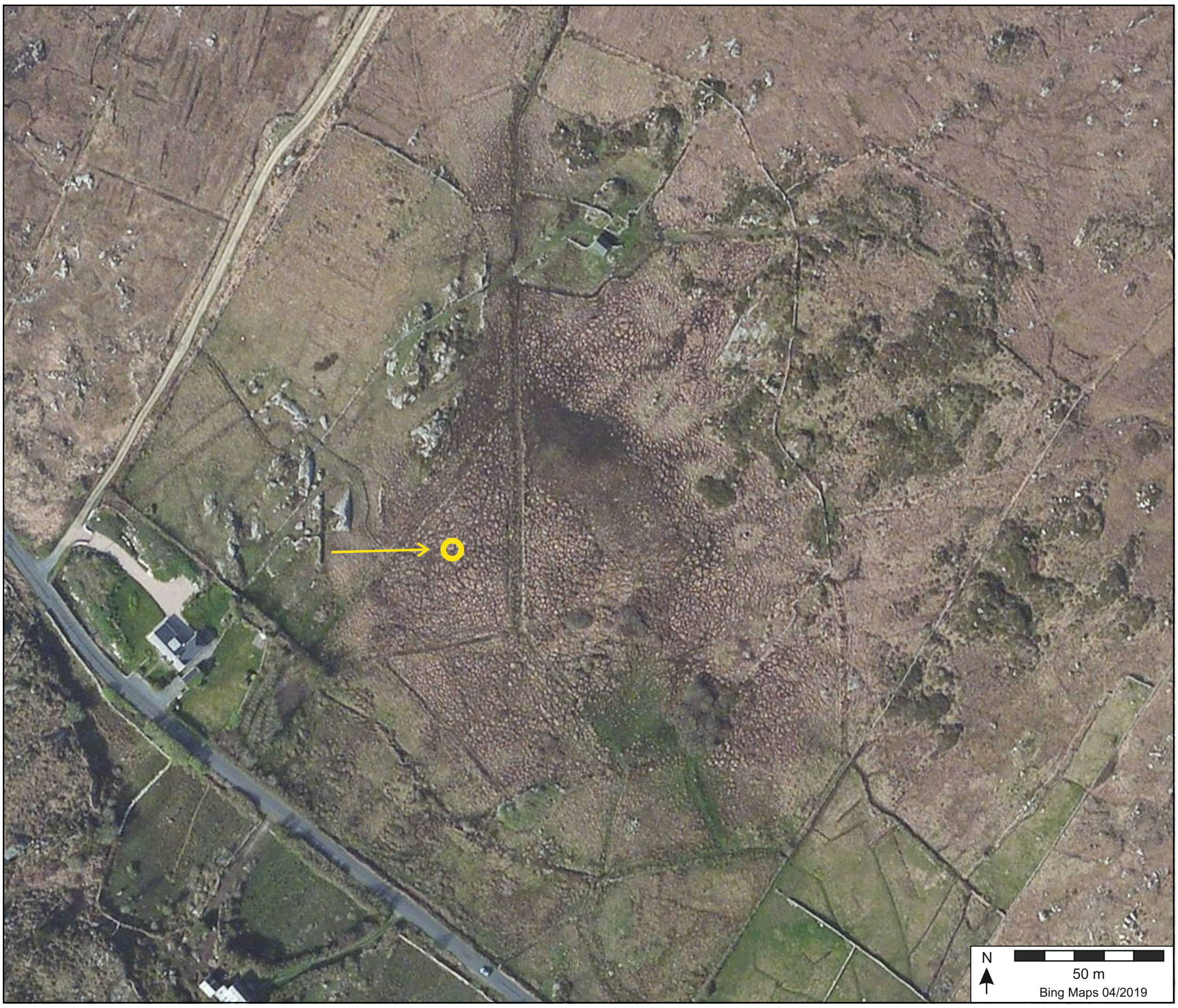


10° 0' W
9° 45' W
53° 30' N
53° 20' N
Clifden
D
3
2
R II
Roundstone
peninsula
R I
IN
Dolan
C
B
Roundstone
Atlantic Ocean
Bertraghboy
Bay
CRC1
A
Carna
peninsula
Kilkieran
1
Kilkieran Bay
Pollen profile
14C-dated pine stump
Population centres
0 2 4 km
N



N
50 m
Bing Maps 04/2019

Fig. A3.6.1

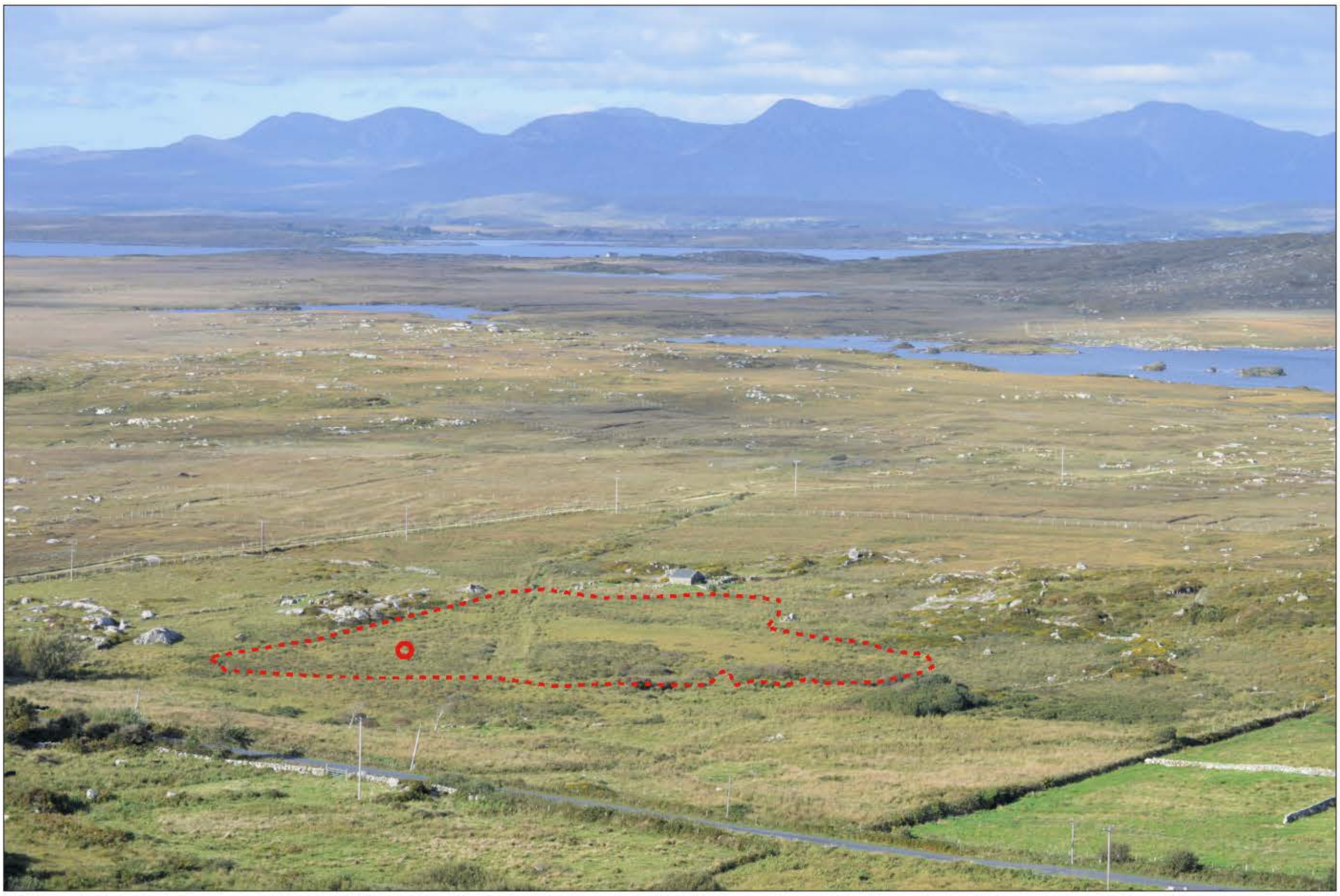


Fig. A3.6.2

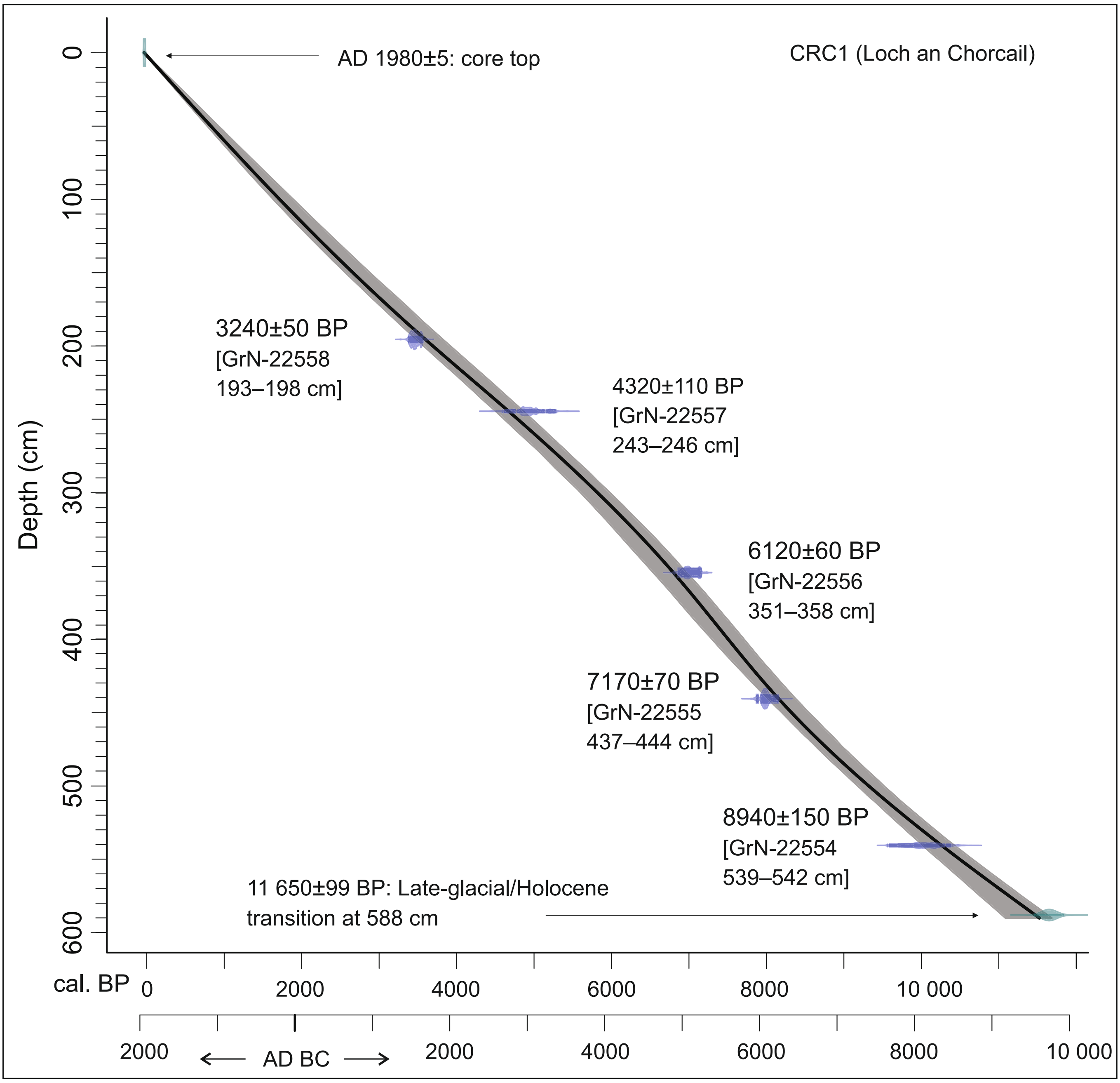
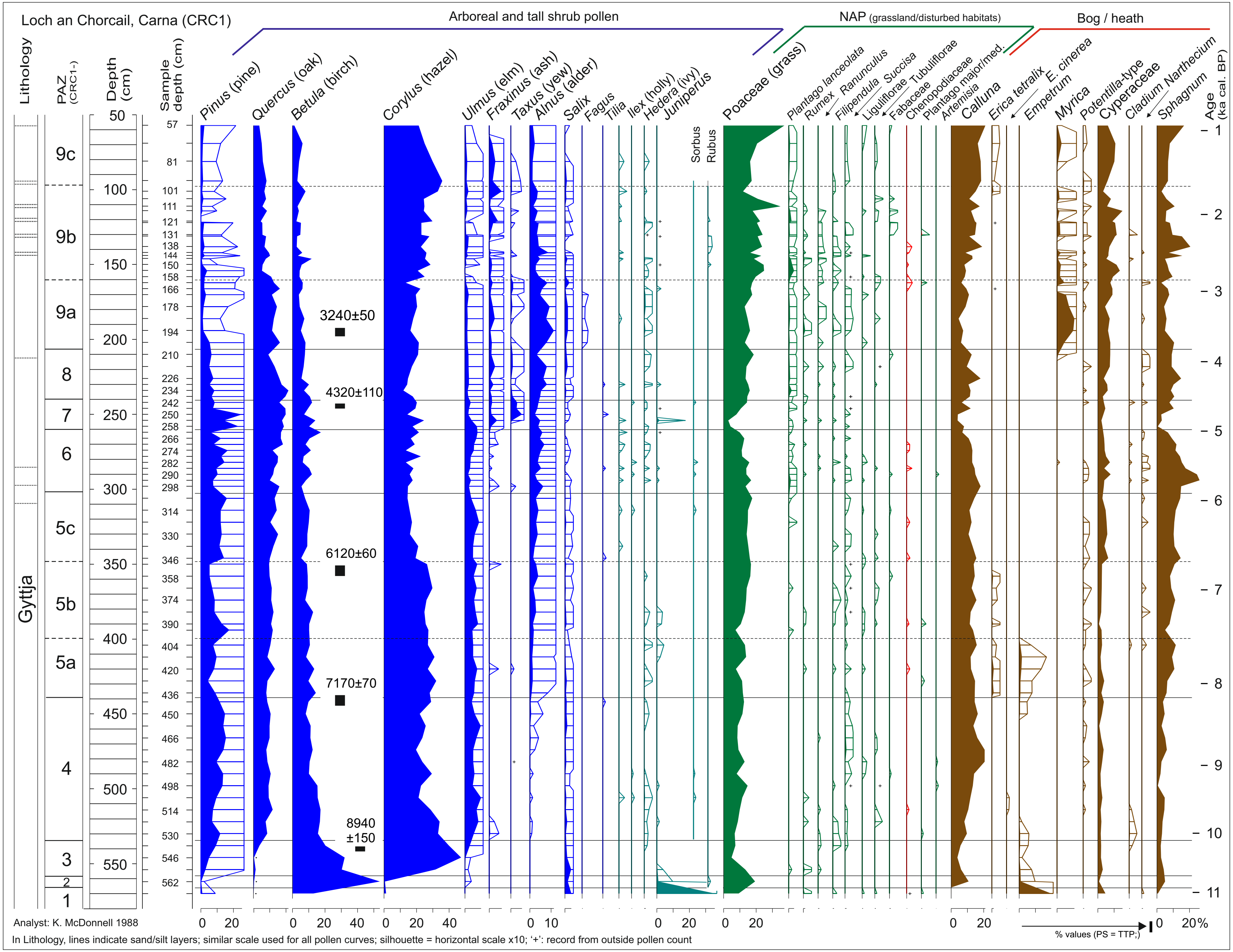
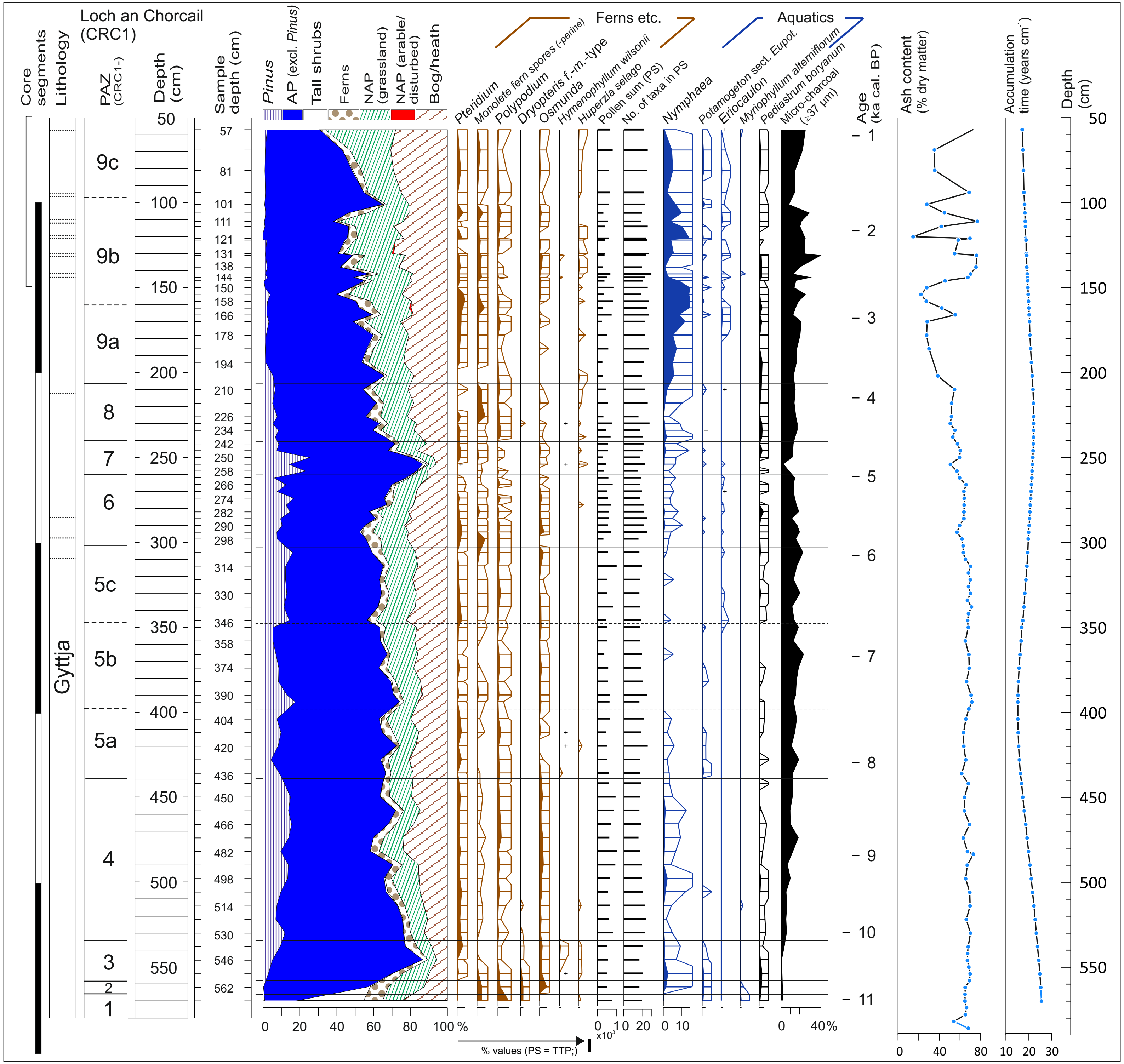

AD 1980±5: core top
CRC1 (Loch an Chorcail)
3240±50 BP
[GrN-22558
193–198 cm]
4320±110 BP
[GrN-22557
243–246 cm]
6120±60 BP
[GrN-22556
351–358 cm]
7170±70 BP
[GrN-22555
437–444 cm]
8940±150 BP
[GrN-22554
539–542 cm]
11 650±99 BP: Late-glacial/Holocene
transition at 588 cm
Depth (cm)
0
100
200
300
400
500
600
cal. BP
0
2000
4000
6000
8000
10 000
2000
AD BC
2000
4000
6000
8000
10 000

Fig. A3.6.3



Loch an Chorcail, Carna (CRC1)
Arboreal and tall shrub pollen
NAP (grassland/disturbed habitats)
Bog / heath
Lithology
PAZ (CRC1-)
Depth (cm)
Sample depth (cm)
Pinus (pine)
Quercus (oak)
Betula (birch)
Corylus (hazel)
Ulmus (elm)
Fraxinus (ash)
Taxus (yew)
Alnus (alder)
Salix
Fagus
Tilia
Ilex (holly)
Hedera (ivy)
Juniperus
Sorbus
Rubus
Poaceae (grass)
Plantago lanceolata
Rumex
Ranunculus
Filipendula
Succisa
Liguliflorae
Tubuliflorae
Fabaceae
Chenopodiaceae
Plantago major/med.
Artemisia
Calluna
Erica tetralix
E. cinerea
Empetrum
Myrica
Potentilla-type
Cyperaceae
Cladium
Narthecium
Sphagnum
Age (ka cal. BP)
Gyttja
3240±50
4320±110
6120±60
7170±70
8940 ±150
Analyst: K. McDonnell 1988
% values (PS = TTP;)
In Lithology, lines indicate sand/silt layers; similar scale used for all pollen curves; silhouette = horizontal scale x10; '+': record from outside pollen count

Fig. A3.6.4



Loch an Chorcail (CRC1)
Core segments
Lithology
PAZ (CRC1-)
Depth (cm)
Sample depth (cm)
Pinus
AP (excl. Pinus)
Tall shrubs
Ferns
NAP (grassland)
NAP (arable/disturbed)
Bog/heath
Ferns etc.
Aquatics
Pteridium
Monolete fern spores (-perine)
Polypodium
Dryopteris f.-m.-type
Osmunda
Hymenophyllum wilsonii
Huperzia selago
Pollen sum (PS)
No. of taxa in PS
Nymphaea
Potamogeton sect. Eupot.
Eriocaulon
Myriophyllum alterniflorum
Pediastrum boryanum
Micro-charcoal (≥37 μm)
Age (ka cal. BP)
Ash content (% dry matter)
Accumulation time (years cm⁻¹)
Gyttja
9c
9b
9a
8
7
6
5c
5b
5a
4
3
2
1
% values (PS = TTP;)
x10³

Fig. A3.6.5

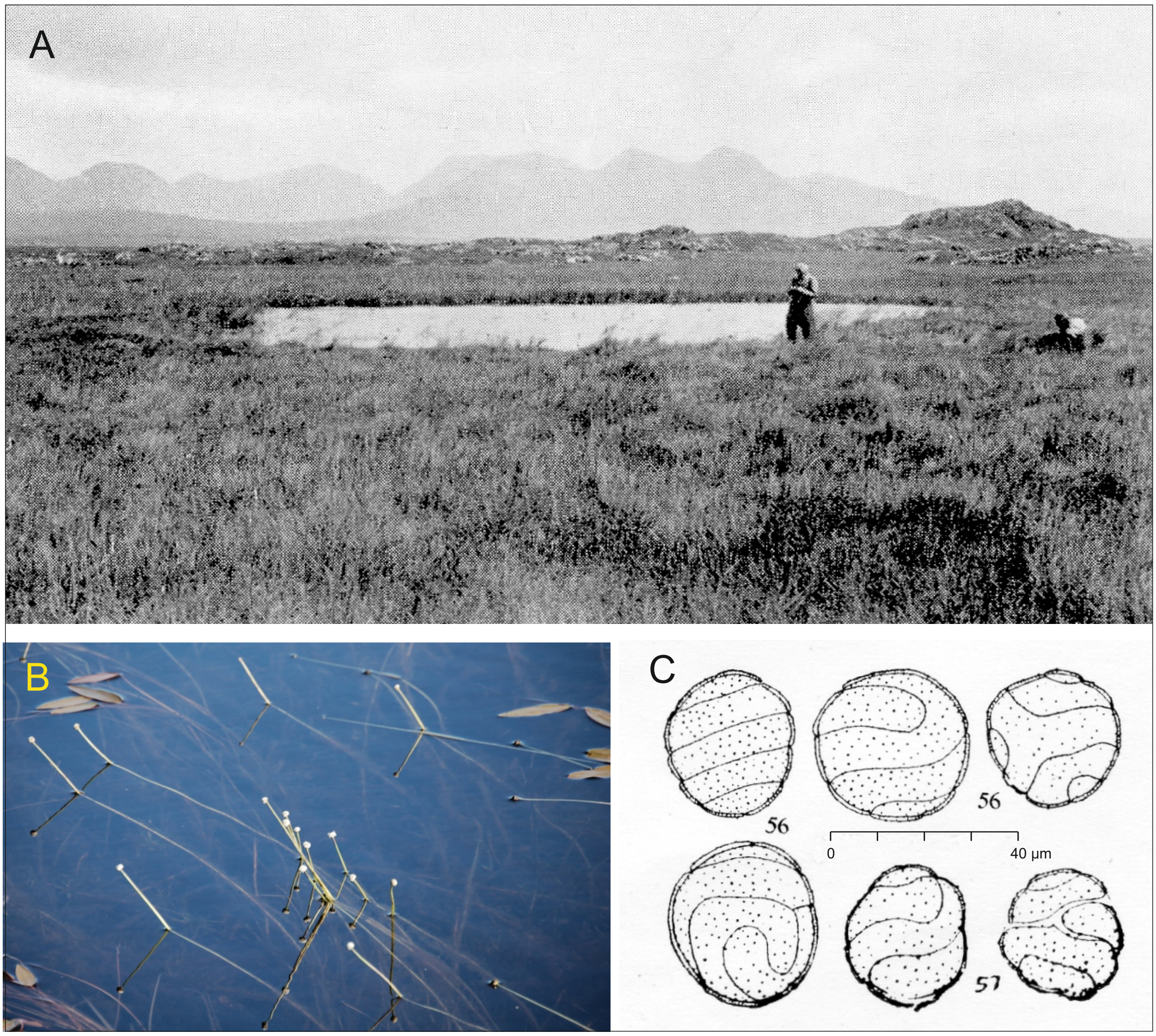
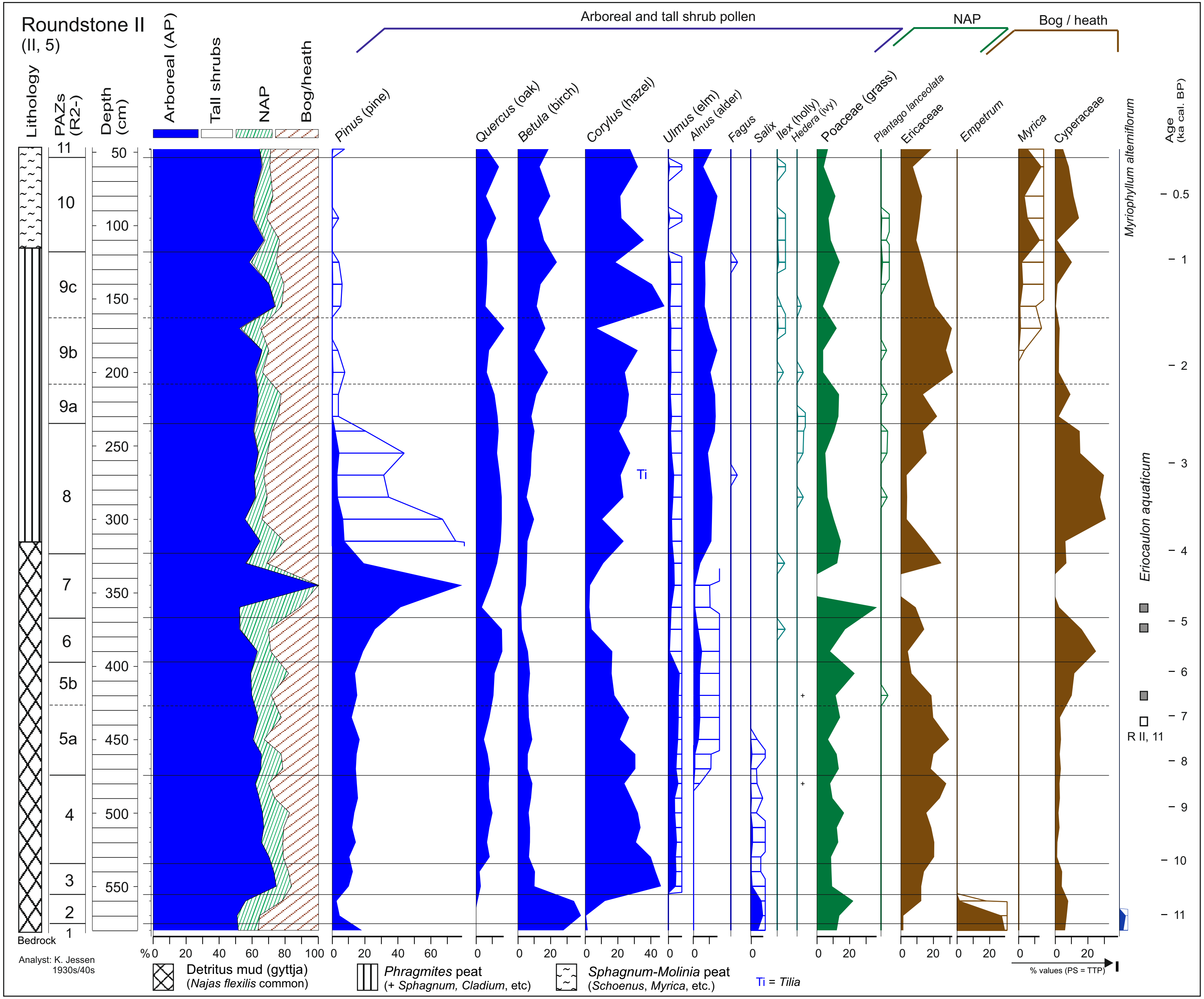
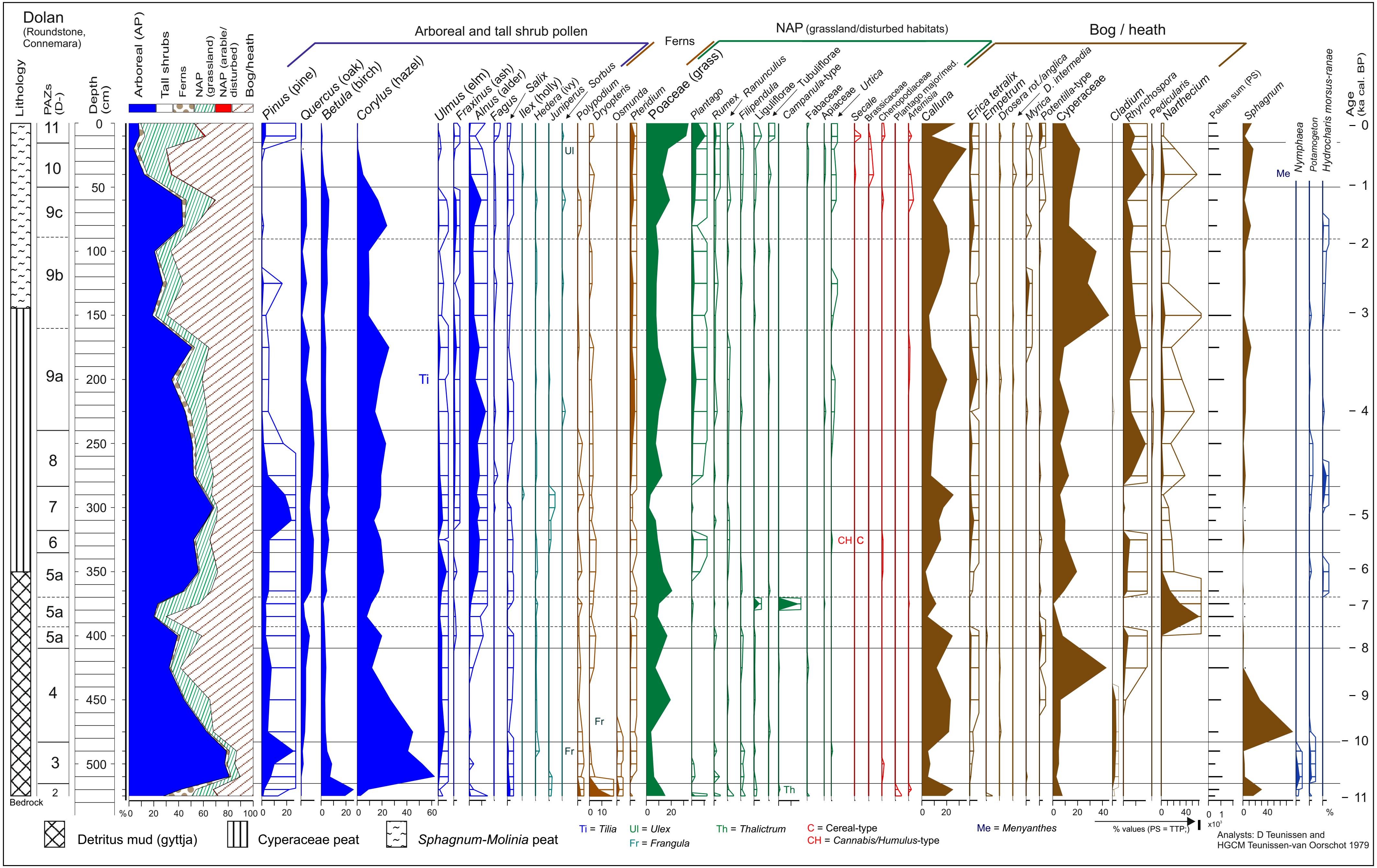


Fig. A3.6.6



Roundstone II
(II, 5)
Arboreal and tall shrub pollen
NAP
Bog / heath
Lithology
PAZs (R2-)
Depth (cm)
Arboreal (AP)
Tall shrubs
NAP
Bog/heath
Pinus (pine)
Quercus (oak)
Betula (birch)
Corylus (hazel)
Ulmus (elm)
Alnus (alder)
Fagus
Salix
Ilex (holly)
Hedera (ivy)
Poaceae (grass)
Plantago lanceolata
Ericaceae
Empetrum
Myrica
Cyperaceae
Myriophyllum alterniflorum
Eriocaulon aquaticum
Age (ka cal. BP)
Ti
R II, 11
Bedrock
Analyst: K. Jessen 1930s/40s
% values (PS = TTP)
Detritus mud (gyttja) (Najas flexilis common)
Phragmites peat (+ Sphagnum, Cladium, etc)
Sphagnum-Molinia peat (Schoenus, Myrica, etc.)
Ti = Tilia

Fig. A3.6.7



Dolan
(Roundstone, Connemara)
Arboreal and tall shrub pollen
Ferns
NAP (grassland/disturbed habitats)
Bog / heath
Lithology
PAZs (D-)
Depth (cm)
Arboreal (AP)
Tall shrubs
Ferns
NAP (grassland)
NAP (arable/disturbed)
Bog/heath
Pinus (pine)
Quercus (oak)
Betula (birch)
Corylus (hazel)
Ulmus (elm)
Fraxinus (ash)
Alnus (alder)
Fagus
Salix
Ilex (holly)
Hedera (ivy)
Juniperus
Sorbus
Polypodium
Dryopteris
Osmunda
Pteridium
Poaceae (grass)
Plantago
Rumex
Ranunculus
Filipendula
Liguliflorae
Tubuliflorae
Campanula-type
Fabaceae
Apiaceae
Urtica
Secale
Brassicaceae
Chenopodiaceae
Plantago major/med.
Artemisia
Calluna
Erica tetralix
Empetrum
Drosera rot./anglica
D. intermedia
Myrica
Potentilla-type
Cyperaceae
Cladium
Rhynchospora
Pedicularis
Narthecium
Pollen sum (PS)
Sphagnum
Nymphaea
Potamogeton
Hydrocharis morsus-ranae
Age (ka cal. BP)
Bedrock
Ti = Tilia
Ul = Ulex
Fr = Frangula
Th = Thalictrum
C = Cereal-type
CH = Cannabis/Humulus-type
Me = Menyanthes
% values (PS = TTP)
Detritus mud (gyttja)
Cyperaceae peat
Sphagnum-Molinia peat
Analysts: D Teunissen and HGCM Teunissen-van Oorschot 1979

Fig. A3.6.8