LOCH SIONASCAIG

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Highlights

The sediments on the floor of Loch Sionascaig and in a bog on Eilean M¢r provide detailed pollen records, supported by radiocarbon dating, of vegetational changes in Scotland during the Lateglacial and Holocene. The Holocene record is particularly important for the environmental changes it demonstrates.

Introduction

Loch Sionascaig (NC 120140) is a large (6.1 km²), deep (maximum depth 184 m, mean depth 70 m), oligotrophic (alkalinity 6 ppm CaC0, pH 6.4–6.6) and nutrient-poor loch within the Inverpolly National Nature Reserve, west of Elphin in Sutherland. The reserve is primarily moorland and blanket-bog developed over Lewisian gneiss, interspaced by numerous small lochs and wet and soligenous valley mires, with Loch Sionascaig and its wooded islands dominating the central part. The area is mainly treeless, although small areas of birch wood persist locally on steep, rocky slopes and on islands in the larger lochs. It is "a good example of this kind of submontane moorland and wetland complex so characteristic of west Ross and west Sutherland' (Ratcliffe, 1977).

Detailed palaeoecological and palaeolimnological studies of the sediments of Loch Sionascaig (Pennington *et al*., 1972) and of a small bog (0.42 m deep) (NC 120139) on Eilean M¢r (Kerslake, 1982), its largest woodland island, provide important evidence on the Lateglacial and Holocene ecological history of this internationally biologically important and unique landscape.

Description

The shore of Loch Sionascaig is mainly bare Lewisian gneiss and sediments are absent over much of the loch floor. In the southern arm of the loch, where the bedrock is Torridonian sandstone, up to 5.5 m of sediments occur overlying glacial clays and sands. These comprise a succession of clay, silt, sand and gyttja deposits (Figure 6.17).

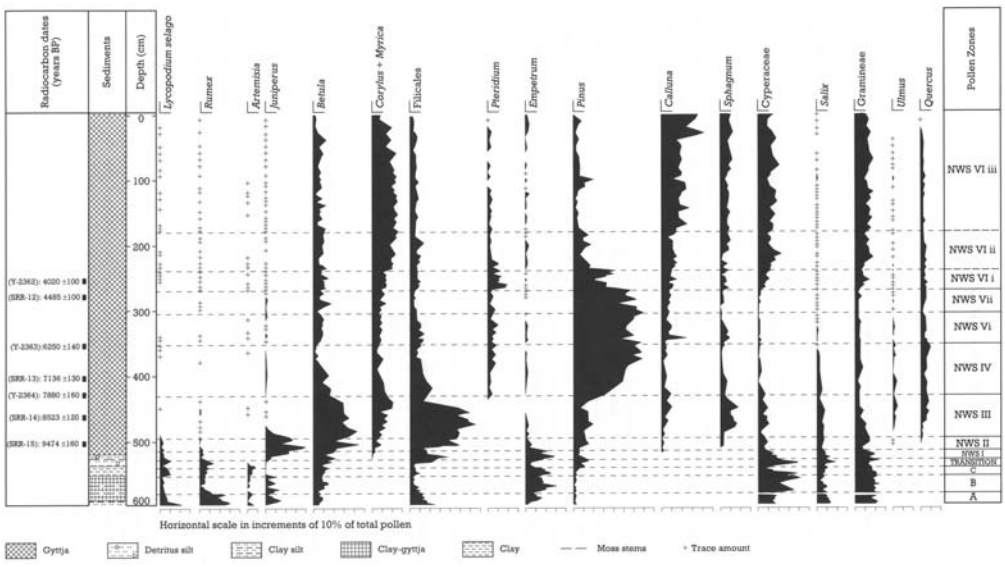

Figure 6.17: Loch Sionascaig: relative pollen diagram, showing selected taxa as percentages of total pollen (from Pennington et al., 1972).

Pollen analyses of the Sionascaig sediments (Pennington *et al.*, 1972) show that the sequence represents a complete Lateglacial and Holocene record. This has been divided into three Lateglacial regional pollen assemblage zones (A, B, C) and six Holocene regional pollen assemblage zones (NWS I–NWS VI) (Figure 6.17). Seven radiocarbon dates (SRR-12 to SRR-15 and Y-2362 to Y-2364) (Figure 6.17) indicate a remarkably constant sediment accumulation rate for the Holocene.

Interpretation

The Lateglacial pollen stratigraphy is typical for north-west Scotland, with a pre-Lateglacial Interstadial assemblage dominated by *Rumex*, grasses and sedges, including a wide variety of other herbs characteristic of open, pioneer vegetation. During the interstadial closed-heath vegetation with *Empetrum* and *Juniperus communis*, developed on humus-rich acid soils. The overlying Loch Lomond Stadial deposits are characterized by increased values of *Artemisia* (including *A. norvegica*), Cruciferae, and Caryophyllaceae, suggesting open disturbed soils.

The boundary between the Devensian and the Holocene is marked by a series of rapid changes in the pollen record, with successive peaks of *Rumex*, *Lycopodium selago,* Gramineae, *Empetrum* and *Juniperus*, representing the characteristic vegetational succession from stadial to interglacial conditions. At about 9500 BP *Betula* woodland, with some *Corylus avellana* and abundant ferns, developed. *Pinus* sylvestris expanded at about 8000 BP, early by comparison with England and elsewhere in Scotland, with the exception of the Loch Maree area (Birks, 1972b; Birks, 1989). Open pine-dominated woodland, with abundant *Pteridium aquilinum* and some *Betula* and *Calluna vulgaris*, was the major regional vegetation from about 7500 BP to 4500 BP (Pennington, 1986). Mires were locally present in the catchment, presumably in waterlogged areas. *Alnus glutinosa* expanded locally about 6000 BP, but, as elsewhere in the north-west Highlands, it was never an important forest component (Bennett and Birks, 1990). *Ulmus* and *Quercus* were also present, but in low numbers throughout the Holocene. At about 4500 BP pine underwent a major decline here, as elsewhere in north-west Scotland (Birks, 1972b, 1975; Birks, 1977, 1989; Bennett, 1984; Gear and Huntley, 1991), probably as a result of rapid climatic change with a shift towards wetter and windier "oceanic' conditions. Such a shift would, on the leached, acid soils of the area, inhibit the natural regeneration of pine and lead to the widespread development of blanket-bog on flat and gently sloping areas. The decline of *Pinus* pollen in the sediments at Loch Sionascaig is accompanied by rises of Cyperaceae, Gramineae and *Calluna* pollen and of *Sphagnum* spores, all suggestive of peat development and the spread of blanket-mires. *Pinus* sylvestris died out locally sometime in the last 4000 years, as it did in much of north-west Scotland (Birks, 1989). Its former widespread occurrence is strikingly evidenced by the abundant pine stumps within the blanket-peats of the Inverpolly area.

Sediment–chemical analyses provide independent evidence for soil changes within the Sionascaig catchment (Pennington *et al.*, 1972). There is a close correspondence between the pollen-record and sediment–chemical changes, suggesting important vegetation–soil relationships over the last 13,000 years (Pennington, 1986). During the Lateglacial there was progressive soil development until the later part of the interstadial with humus accumulation, nutrient leaching and chemical weathering leading to clay-mineral formation. Soils became less organic and more nutrient-rich in the Loch Lomond Stadial. However, the soils were quickly leached and were forming acid humus before the expansion of birch about 9500 BP, as shown by electron spin-resonance studies of the humic acids preserved in the early Holocene sediments.

Chemical analyses suggest that between 8000 and 6000 BP the soils were acid but well-drained. At about 6000 BP the soils appear to have become increasingly waterlogged, as evidenced by changes in the iron and manganese contents of the sediments. By 5000 BP blanket peat was common, and by 4000 BP it was widespread.

Diatom analyses provide data about the loch's water chemistry and nutrient status (Haworth, 1976). The Lateglacial diatom flora is unusual within the British Isles in that it contains numerous planktonic taxa (Pennington *et al.*, 1972). The pre-interstadial assemblage suggests a high base status, with many alkaliphilous taxa, including some species that occur near glaciers today. In the interstadial there was a decline in these alkaliphilous taxa and an

increase in taxa characteristic of acid water, suggesting a decline in lake nutrient status. Loch Lomond Stadial sediments contain terrestrial diatoms, suggesting inwashing and erosion of terrestrial soils. At the Devensian–Holocene boundary, the diatoms indicate a return to nutrient-rich conditions, presumably as a result of soil rejuvenation during the stadial. During the early Holocene there is a marked change in the diatoms, indicating a major and rapid reduction in the base status of the loch. By the time of the expansion of pine at about 8000 BP, the loch was acid, with very few alkalibiontic and alkaliphilous taxa, and large numbers of acidophilous and acidobiontic taxa. This trend towards loch acidification stabilized at about 4500 BP and the loch remained weakly acid until the present day. There is no evidence that the major decline of pine at about this time had any effects on the loch's water or sediment chemistry. There is also no evidence for recent lake acidification inLoch Sionascaig (Atkinson and Haworth, 1990), suggesting that it is still a "pristine' lake ecosystem.

Pollen assemblages from a large loch such as Sionascaig are derived from a large source area, the size of which is not known. They provide a record of regional vegetational history. In contrast, pollen spectra from small lakes and bogs (<100 m radius) reflect a local, spatially restricted vegetational history. Kerslake's (1982) pollen diagram based on samples from a small bog on Eilean M¢r provides a record of local vegetational history on the largest island in Loch Sionascaig. The basal sediments from the bog have yielded a radiocarbon date of 7400 BP. A series of 11 dates provides an internally consistent chronology for the sequence. The pollen record is of particular interest in that it suggests that Eilean M¢r has been dominated by *Betula* with some *Corylus*, *Salix* and, from 6000 BP, *Alnus* for much of the Holocene. *Pinus* has never been a major component of the island's vegetation. From about 2500 BP alder disappeared and a series of alternating phases of birch dominance and*Calluna* dominance occurred, suggesting a natural alternation between birch woodland and heathland. The Eilean M¢r profile is so strikingly different from theLoch Sionascaig pollen diagram and from a diagram from Lochan Dubh to the west of Sionascaig (Kerslake, 1982), that it is clear that there may have been major vegetational mosaics within the Inverpolly area through much of the Holocene.

Loch Sionascaig is one of the most intensively studied Lateglacial and Holocene sites in Scotland, with pollen analysis, diatom analysis, sediment geochemistry, local studies of peat stratigraphy and radiocarbon dating. These various lines of evidence provide important insights into the ecological history of this extreme oceanic landscape. The palaeoecological record shows very clearly the rapidity of soil leaching and accumulation of acid humus in the earliest Holocene, a feature of the extreme oceanic situation of the site. It illustrates the delicate balance between open pine woodland and blanket bog and how this balance was changed by rapid and abrupt climatic change about 4200 BP. It also shows the close interrelationship between vegetation, soils and sediment chemistry in a landscape where human disturbances have been relatively minimal compared with the extreme dominance of climate and geology. Its sedimentary record provides clear and unambiguous evidence of how the remarkable blanket-bog and loch landscape of north-west Scotland came into being. As blanket bog is better developed and more abundant in the British Isles than elsewhere in Europe, the environmental history of Loch Sionascaig and its catchment provides a detailed historical background for understanding the history and development of a landscape dominated by blanket-bog. It also demonstrates that the loch has not been affected by recent increased atmospheric acidification and is thus still in a "pristine' condition; such lochs are becoming fewer in northern and western Britain. Loch Sionascaig is thus a site of great palaeoecological and palaeolimnological importance.

Conclusions

Loch Sionascaig is a reference site for reconstructing the environmental history of north-west Scotland, during approximately the last 13,000 years, that is, in Lateglacial and Holocene times. Particularly important is the intensively studied Holocene record contained in the loch bed sediments and in a peat bog on Eilean M¢r. The demise of pine around 4200 years ago, following rapid climatic change to wetter and windier conditions, and the subsequent development of blanket bog are clearly demonstrated.

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