

CHANGE AND CRISIS IN UPLAND FARMING FROM POLLEN ANALYSES ON BEN LAWERS c.AD1200 TO c.AD1700

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Summary

This paper describes the principal events impacting on the upland landscape, above 18th century head dykes, of the south-facing slopes of the Ben Lawers mountain range above Loch Tay. The interpretations come from pollen analysis, a rarely used source for medieval and post-medieval landscape change. The interpretations from four pollen sites are merged to give a narrative of change from the high medieval period c.AD1200 until the beginning of the 18th century. The analyses show an open woodland to have existed alongside the transhumant shieling economy in the hills until the mid-16th century when an intensification of the practice of shieling led to rapid woodland demise. Factors in this intensification may have been economic or climatic. The analyses from one key site also describe an early, remarkable but short-lived attempt at agricultural 'improvement' in the growing of buckwheat, possibly a response to very intense climatic deterioration in the later 17th century.

Introduction

Writing a detailed environmental history of the upland landscapes of central Scotland is difficult because very few documentary sources consider in depth the hills themselves. It is the lowlands and valley floors that interested contemporaries (Dodgshon 2004). One alternative approach is to use pollen analysis to describe changes in the flora. This paper reports on some major findings from new pollen analyses in the south-facing uplands of Ben Lawers, owned in perpetuity by the National Trust for Scotland (NTS). They have high scenic value and are of international ecological conservation significance. The present landscape is, however, almost entirely cultural, changed by millennia of human settlement.

The north shore of Loch Tay is dominated by the two mountain ranges of Ben Lawers and Tarmachan, separated by the north-south through-valley of the Lochan na Lairige. Ben Lawers is the higher at 1214 m OD and is the highest in the Breadalbane district, with Meall nan Tarmachan rising to 1044 m OD. Both ranges are made of an east-west trending series of metamorphosed Dalradian rocks. Slopes lower than 400 m OD are mantled by variable thicknesses of glacial till and, more commonly, glacialfluvial sand and gravel.

The Ben Lawers Historic Landscape Project was a partnership between Scottish Natural Heritage, the National Trust for Scotland, the Carnegie Trust for

the Universities of Scotland and Historic Scotland. Pollen analysis was a key technique, and in the course of the project, seven different sites were sampled, analysed with high temporal resolution and dated by ^{14}C (radiocarbon), ^{210}Pb (lead-210) and other markers. This paper focuses on the data spanning the periods from the 'high' Middle Ages to the beginning of the 19th century from four upland pollen sites, all above the head dykes of 19th century farms. These are:

1. a narrow peat-filled basin at NGR NN 62528 37755, at 320 m OD, the T16 Gully, named from a complex multi-period archaeological site excavated in the project by Guard Archaeology (Figure 1)

2. Leacann Ghlasa is the name of the broad, smooth, steep south-facing hillside of Beinn Ghlas between the Burn of Edramucky and Coire a' Chommaidh. It is also the name given here to a small peat accumulation on the lower slopes of this hillside at NN 6270 3775, around 300m OD

3. Allt a' Mhoirneas, a small mire at 456 m OD between bedrock mounds at NGR NN 6054 3821, a few hundred metres south of the dam that now impounds the Lochan na Lairige (Figure 2)

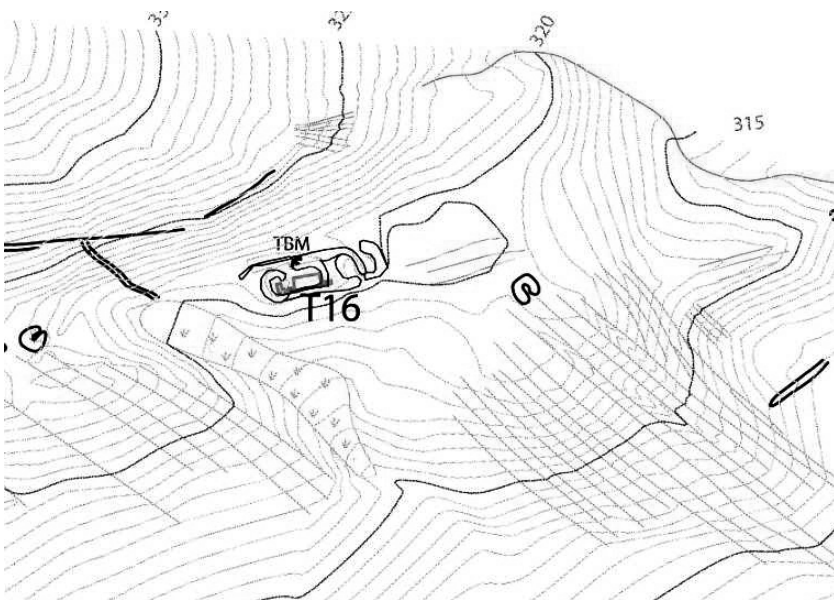


Figure 1. A map of the medieval and post-medieval archaeological structures at T16 and the peat-filled marsh to their south west. The length of the baseline is around 150m. The contour interval is 0.5m. At T16 itself is a high medieval 'long-house', overlain by two later, 15th-16th century AD shieling huts. The horse-shoe shapes are other shieling huts. The parallel lines crossing the contours south east of T16 are cultivation traces, of unknown age.

4. Tarmachan, a very small peat accumulating on the surface of a stabilised debris cone at the base of the imposing cliffs of the Tarmachan range (Figure 3), just above the Lochan na Lairige at 540 m OD (NGR NN 59265 40847).

Upland land use in the Medieval period

Agriculture was well-established by the Medieval period on Loch Tayside. Atkinson (2000) emphasises the survival along the northern side of the loch of a relict archaeological landscape on upper slopes above the head dyke boundaries of 18th century farms. These upper slopes have also preserved small huts interpreted as shielings. These were huts used when tending livestock that were moved uphill from early May until late summer to take advantage of slower growing grassland at high altitudes, to ease the pressure on lowland meadow and to avoid damage to growing crops (Bil 1990; Atkinson 2000; Boyle 2003). Livestock on the hill were principally cattle (dairy cows were the core of the shieling stock) but included sheep and horses (Dodgshon 2004). Shielings are recorded from the early 16th century AD (Bil 1990) but may have had prehistoric origins (Miller 2002).



Figure 2. This photograph looks west across the Meall nan Tarmachan range from the Loch Tay-Loch Lyon road (foreground), showing a fenced enclosure to protect young native trees from sheep grazing. Inside this enclosure is the pollen site of Allt a' Mhoirneas.



Figure 3. The forbidding cliffs of Tarmachan above the waters of the Lochan na Lairige reservoir. The lower slope is the location of the pollen site of Tarmachan, and close by is a group of shieling huts.

Upland woods in the Medieval period

Beneath Tarmachan, away from the intermittently unstable talus cones and slopes, birch grew in some abundance in a rather scrubby open wood in the 13th century AD, accompanied by some hazel, rowan and hawthorn. Willow was rare but perhaps grew on the gentler slopes rather than confined as it is today to rock ledges (Mardon 1990). There were no oaks or elms in the woodland around Tarmachan by the 13th century AD, though by comparison with the sequence at Allt a' Mhoirneas, oak trees may have been lost only a century or so before this, almost certainly through low-intensity grazing pressures. Woodland persisted on the lower slopes around Leacann Ghlasa. These analyses describe open, secondary, scrubby birch or birch-hazel-alder woods with grassy ground floras. They may well be depicting the high Medieval development of wood pasture throughout the region (Smout *et al* 2005, 165). Pollen diagrams from the region have not demonstrated this before, though few are sufficiently detailed in the historic period, but these new data support, firstly, Smout *et al*'s (2005, 43) speculation that much semi-natural woodland remained in upland Scotland in the Middle Ages, and secondly, the contrasts between lowland and highland noted by Sylvius in c.AD1430 (in Smout *et al* 2005, 39), "the one cultivated, the other covered with forests". The extensive open woods draping the shoulders of Ben Lawers were certainly more akin to montane scrub than "forests of original splendour" (Smout *et al* 2005, 52).

This upland landscape of open, lightly grazed woodland was probably that in which the shieling economy was situated. Hamilton & Davies (2007) imply that shieling-related grazing led to woodland loss at Leadour but this was not the case on Ben Lawers. The palaeoecological evidence suggests that there was no 12-13th century AD “high water mark” of upland settlement on Ben Lawers that may be seen in southern Scotland (cf. Parry 1978; Tipping 1999) and no high Medieval penetration of the uplands seen in northern England (Dunsford & Harris 2003).

The probable absence of permanent Medieval settlement in the uplands of Ben Lawers made easier the development of shieling grounds. Low stocking densities may also have been important in conserving woodland, or perhaps in this period shieling grounds were not so pressured as to require regulation, such that animals could be moved over the hillside with less concern for territorial constraint than shown later in the 18th century AD (Bil 1990). Dodgshon (1983) identified the 14th century AD as one when common upland grazings were made more exclusive by estates, and this control might have prevented grazing pressures. Attentive herding of animals may also have allowed trees and animals to co-exist on the hill.

There were considerable advantages in maintaining woods near shielings. Grasses not sheltered by woodland were either impoverished in nutrients or physically sparser. Shelter from summer storms for people and animals may have been valued (Smout & Watson 1997). But it is probably to their use as a fuel source or for supplying constructional timbers that we might look to understand the maintenance of these woods (Bil 1990, 242). There may, nevertheless, have been an increased attention to woodland conservation in the 13th century AD. Birch trees were probably selectively removed around Leacann Ghlasa after c.AD1250 but they had become re-established by AD1500. Woodland regeneration within an agrarian landscape must have required the management of this resource, a response by the estate or individual tenant farmers to local shortages of, in particular, birch trees by protecting seedlings or planting, an activity in which legislation encouraged conservation and planting (Crone & Watson 2003).

***Calluna* heath on the slopes of Ben Lawers**

Together with birch, *Calluna* (ling) heath also expanded at Leacann Ghlasa after c.AD1450 to cover within a century around 10 % of the hill. *Calluna* populations did not expand from beneath tree canopies: grassland is on Ben Lawers the vegetation cover that benefitted from woodland loss. Seed sources for *Calluna* already existed on Ben Lawers, on the highest slopes where some blanket peat had been established from c.2000 BC (Donner 1962).

The recognition that heathland is not simply a product of woodland loss means that its expansion needs to be explained. One explanation has been the

use of fire. Fire and the deliberate burning of vegetation (muirburn) is a commonly cited cause of heath development but many analyses (Tipping 2000) have pointed out the 'chicken-&-egg' problem, that this is a way of improving an unwanted vegetation type only when it is established. Fire cannot be an explanation on Ben Lawers because there is no evidence from the charcoal record at Leacann Ghlasa and other sites in this period for burning. Grazing pressures were slight through a multitude of factors including the seasonality of the shieling routine, low stocking densities and herds being more-or-less constantly moved by herders). In similar settings on the Cheviot Hills (Tipping 2000) the appearance of *Calluna* heath was linked to long-term soil acidification coincident with increased grazing pressures. Lageras (2006, 136-8) saw the same combination of factors in the 18th century AD expansion of *Calluna* heath in southern Scandinavia.

Intensification of the upland agrarian economy in the later 16th century

There is abundant and quite striking palaeoecological evidence that the upland woods on Ben Lawers were sharply cut back in the decades after c.AD1550.

On stable slopes beneath Meall nan Tarmachan an open scrub woodland was rapidly cleared at c. AD1530. There is evidence for increased burning but this may be related to microscopic charcoal being transferred more easily to the pollen site as a consequence of woodland loss, and trees were probably cut rather than burnt down. Grazing pressures may also have increased. The open woodland around Leacann Ghlasa was lost at around AD1560. Land around the T16 gully was probably treeless at c.AD1550 when pollen analyses commence. At Leadour on the south side of Loch Tay the birch woodland was cut down at c.AD1614, the documentary records making it clear that unapproved destruction by local tenants was causal (Hamilton & Davies 2007).

It is likely that trees were cleared around Tarmachan to create more grazed grassland. Some grassland herbs that had survived protected beneath the open woodland canopy were lost as the sward was trimmed to a short, clipped turf, perhaps retreating then to rock ledges inaccessible to animals where they survive today. Grazing pressures appear to have intensified between c.AD1580 and c.AD1630, and led after c.AD1630 to substantial losses in herb diversity and of ribwort plantain. But species-rich grass communities dominated the landscape around the T16 gully, maintained not just by the natural high base-status of the soils but also by the constant replenishment of minerals as soils were eroded. Grazing pressures in gullies and wet areas were sufficiently intense, however, to have effectively eliminated patches of tall herbs.

This major transformation was almost certainly related to the shieling economy. Bil (1990, 256) identified an increasing demand by tenant farmers in upland Perthshire for new shielings after AD1600. He also argued that the developing long-distance droving trade may have led to the need for more

grazing land to feed larger cattle herds, but woodland clearance on Ben Lawers in the mid-16th century AD appears too early to relate to the expansion of the droving trade (Haldane 1997, 14). Stocking densities on shieling grounds may have increased: overstocking was certainly a problem in north Lochtayside in the early 17th century, with 'soumsters' expected to inspect and count stock before they went to the shielings (Harrison pers. comm.). Population expansion in townships may have led to new pressures, or more townships may have gained access to existing shieling grounds, forcing division of shielings and tree loss on increasingly smaller shieling grounds. The more frequent warm summers of the mid 16th century AD, before c.AD1560, may also have encouraged townships to increase herd sizes. The chronology of landscape change on Ben Lawers is not sufficiently precise in this period to identify the decades this intensification of shieling activities occurred, and it may equally have been a response to the earliest phase of a climatic extreme from c.AD1570 to c.AD1630 (Dodgshon 2006). Parry (1978) argued for abandonment by farmers of hills in south east Scotland between AD1300 and AD1530, although a strong degree of social cohesion may have prevented such a disaster (Outhwaite 1985; Whyte 2008, 129-31). Abandonment is a last-resort strategy. On Ben Lawers there seems to have been no permanent settlement and no crop growing on the higher slopes of Ben Lawers and so in some senses nothing to be abandoned. But shieling grounds could be made to provide more income as the weather of the later 16th century deteriorated, as Bil (1990, 256) argued. This may be the context in which upland trees on Ben Lawers were cut down, the extent of grazing increased, or more ground given over to hay production as the productivity of fodder for over-wintering livestock declined.

Buckwheat, agricultural innovation and human responses to the Maunder Minimum

The ground around the T16 gully carried, certainly within the 17th century AD, a significant new crop, buckwheat (*Fagopyrum*), estimated from our dating controls to be in the period c.AD1630 to c.AD1670. Buckwheat has never been a staple crop in the British Isles (Thirsk 1997), its pollen is exceptionally rare in British pollen diagrams (Greig 1988) and the plant is absent from descriptions of historic crops or garden plants in Scotland).

The local archaeological setting of its cultivation at T16 is of shieling huts, two of which were built after the 15th century AD (Atkinson submitted). Buckwheat is a summer-sown crop, and its sowing might have coincided with the move in late spring to the shieling ground. The local economic context was one of grazing at low intensities, sufficient to have removed trees by c.AD1550 but not yet enough to have led to the loss of tall and grassland herbs, leaving a species-rich grassland promoted by soils of high nutrient status and their frequent erosion (above). Associated with buckwheat at the T16 gully are unusually high proportions of the pollen of the perennial herb, *Rumex acetosella* (sheep's sorrel). This grows in moderately grazed, short-turf dry grassland,

most abundantly on disturbed ground. Sheep's sorrel responds favourably to nitrate deposition, on heavily manured soils, and it seems likely that around the T16 gully buckwheat and sheep's sorrel grew together on patches of ground akin to outfield, that may not have been cultivated every year, but where nutrients were added from animal dung in the process of tathing as described by an early 18th century 'improver' (Bil 1992, 39). *Hordeum* type pollen grains (barley type) are recorded in the same samples as those of buckwheat: they may represent barley grown in the same nutrient-enriched soils as buckwheat.

How the farming communities of Lochtayside came to understand the value of buckwheat is unknown. Buckwheat originated in eastern Europe and was taken up by farmers on the continent in the 14th century AD: Thirsk (1997, note 35) reports one Medieval reference to it from Wales in AD1326. Its use in England increased after c.AD1650 when stagnating prices for conventional crops encouraged experimentation, and when information on new crops was more widely disseminated (Thirsk 1997, 43). Thus it may have been that the estate encouraged this endeavour: Macinnes (1996, 147-8) argued that agricultural expansion in Breadalbane after AD1660 was directed by the first Earl. Other Perthshire estates took a very active role in the colonisation process in the hope of increased rentals (Bil 1992; Macinnes 1996, 147-8). On the other hand, Bil (1990, 259-263) argued that tenants were themselves pioneers. By the mid-17th century AD the distinction between shieling grounds and outfield was being purposefully blurred by tenants. Shieling grounds were becoming synonymous with outfield, because since outfield was cropped, albeit infrequently, so might shieling grounds without this change in land use resulting in increased rents.

What buckwheat was used for around the T16 Gully can only be guessed. Lord Ernle (1919, 95) recorded one 17th century AD recommendation for buckwheat, a "miserable" one, he thought, whereby the crop should be sown and grown on, to be then ploughed into the soil as a fertiliser. The practice proved sufficiently common for Kerridge (1967) to record it in eastern and southern England, particularly on nutrient-poor sandy soils, where buckwheat was sown and ploughed under when in flower, with inputs also from farmyard manure and marl, to improve pasture for sheep (pp. 77, 241), or as a fallow crop in arable fields, succeeding wheat or barley, or preceding barley, and grown to be fed to poultry (p. 85). The fertilising quality of buckwheat, whether true or perceived (Ernle 1919), provides one interpretation for its use on the shieling grounds of Ben Lawers, one that accords in chronology with evidence from the 1650's AD for shielings in Perthshire to have been converted to cultivated farmland (Bil 1990, 259-263; Bil 1992). North of Ben Lawers, some shielings in Glen Lyon were described as 'home shielings' in documents of AD1670, AD1681 and AD1710, argued to be the initial stage in permanent colonisation, though Bil's (1992) map of new settlements (his figure 2: p. 43) shows no such colonisation along Loch Tayside. The T16 gully venture, if that is what it was, is unrecorded, perhaps because it failed. In this interpretation it is buckwheat's

fertilising quality that was valued, in enabling cereal crops to be established, such as barley at the T16 gully.

Another interpretation focuses on the value of buckwheat as a famine crop. Although buckwheat is not a cereal, on the continent it was commonly cultivated from the high Medieval period for human consumption as a supplement to grain (Braudel 1981, 112), either as a flour substitute in bread or as gruel. With the failure of the principal bread grains in 'little ice age' climatic extremes, as in the later 16th century crises, buckwheat was integrated into peoples' diets (Pfister 2005). Late 17th century AD population stresses were probably driven by bad weather, such as the 'resting' of rentals in Glen Orchy, west of Ben Lawers (Figure 3.1) in most years between AD1668 and AD1708, and tenant farmers being permitted to withhold meal payments in the 1690s AD on Rannoch Moor, north and west of Ben Lawers (Dodgshon 2006). The Breadalbane estate itself supported tenants in the years after AD1683 by supplying meal in times of scarcity (Harrison pers. comm.). The financial effect of this and very high rent arrears (Cullen 2010, 51-52) was thought by Cullen, Whatley & Young (2006, 264) "to have been little less than catastrophic" to the estate. Whyte (1979, 1981) argued that the major economic impacts were not on lowland crop production but on hill farms, which experienced difficulties from the mid-1670's AD, more sharply after AD1695, though this is not supported by Cullen's (2010) analysis. The repeated famines of the 'seven ill years' led to increased emigration to Ulster (Cullen 2010), where famine was, extraordinarily, almost absent (Crawford 1989). Upland farms as low as 250 m OD in the Lammermuir Hills were predicted by Parry (1978) to have failed through bad weather in AD1674-1675 and again in AD1694-95. From this association it might be that cultivation of buckwheat was as a famine food, and possibly grown slightly later in the 17th century AD than defined from our dating controls, after c.AD1675. In this context the association of buckwheat with sheep's sorrel might be telling: Sir Robert Sibbald's (1699) list of famine foods included on page 10 of that pamphlet "all sorts of Sorrell", but buckwheat itself was not mentioned in his otherwise exhaustive list of wild and garden plants recommended to alleviate severe famine.

Conclusions

Shieling, the summer movement of domestic animals to the uplands, went through a number of critical changes on the south-facing slopes of Ben Lawers between c.AD1200 and c.AD1700. Crises in the management of these hills occurred, most notably within the 16th century, when the birch-hazel woodland resource was first stretched and eventually lost, through an intensification of what had been a system in delicate balance. This crisis may have been economic in origin, through the perceived need for greater profits, or social as rural populations increased, or climatic as extremes of the 'little ice age' caused people to 'dig deep'. Climatic stresses may also have been behind a novel innovation in upland agriculture, the introduction with sheep's sorrel of buckwheat, a continental import.

References

- Atkinson JA. 2000. Rural settlement on north Lochnagside: understanding the landscapes of change. In: Atkinson JA, Banks I, MacGregor G eds. *Townships to Farmsteads: Rural Settlement Studies in Scotland, England and Wales*. Oxford: British Archaeological Reports 293, 150-160.
- Bil A. 1990. *The Shieling 1600-1840: The Case of the Central Scottish Highlands*. Edinburgh: John Donald.
- Bil A. 1992. The formation of new settlements in the Perthshire highlands, 1660-1780. *Northern Scotland* **12**, 35-63.
- Boyle S. 2003. Ben Lawers: An Improvement Period Landscape on Lochnagside, Perthshire. In: Govan S. ed, *Medieval or Later Rural Settlement in Scotland: 10 Years On*. Edinburgh: Historic Scotland, 17-30.
- Braudel F. (trans Reynolds S.) 1981. *The Structures of Everyday Life*. London: Collins.
- Crone A., Watson F. 2003. Sufficiency to scarcity: medieval Scotland, 500-1600. In: Smout TC ed, *People and Woods in Scotland*. Edinburgh: Edinburgh University Press, 60-81.
- Cullen KJ. 2010. *Famine in Scotland: The 'ill years' of the 1690's*. Edinburgh: Edinburgh University Press.
- Cullen KJ, Whatley CA, Young M. 2006. King William's Ill Years: new evidence on the impact of scarcity and harvest failure during the crisis of the 1690s on Tayside. *Scottish Historical Review* **85**(2), 250-276.
- Dodgshon RA. 1983. Medieval rural Scotland. In: Whittington G, Whyte ID. eds, *An Historical Geography of Scotland*. London: Academic Press, 47-71.
- Dodgshon RA. 2004. The Scottish highlands before and after the Clearances: an ecological perspective. In: Whyte I, Winchester AJL. eds, *Society, Landscape, Environment in Upland Britain*. Birmingham: The Society for Landscape Studies, 67-78.
- Dodgshon RA. 2006. The Little Ice Age in the Scottish highlands: documenting its human impact. *Scottish Geographical Journal* **121**, 321-337.
- Donner JJ. 1962. On the post-glacial history of the Grampian Highlands of Scotland. *Commentatore Biologiske* **24**, 5-29.
- Dunsford HM, Harris SJ. 2003. Colonisation of the wasteland in County Durham, 11-1400. *Economic History Review* **56**, 34-56.
- Ernle Lord. 1919. *English Farming Past and Present*. London: Longman, Green & Co.
- Haldane ARB. 1997. *The Drove Roads of Scotland*. Edinburgh: Birlinn.
- Hamilton A, Davies A. 2007. 'Written in the Hills': an environmental history project in the Scottish uplands. *History Scotland* **7**(3), 25-32.
- Kerridge E. 1967. *The Agricultural Revolution*. London: Allen & Unwin.
- Lagerås P. 2006. *The Ecology of Expansion and Abandonment. Medieval and Post-Medieval Land-use and Settlement Dynamics in a Landscape Perspective*. Stockholm: National Heritage Board.
- Macinnes AI. 1996. *Clanship, Commerce and the House of Stuart, 1603-1788*. East Linton: Tuckwell Press.
- Mardon DK. 1990. Conservation of montane willow scrub in Scotland. *Transactions of the Botanical Society of Edinburgh* **45**, 427-436.
- Miller J. 2002. The Oakbank crannog: building a house of plants. In: Ballin Smith B., Banks I. eds, *In the Shadow of the Brochs – The Iron Age in Scotland*. Stroud: Tempus Publishing, 35-43.

- Outhwaite RB. 1985. Dearth, the English Crown and the 'crisis of the 1590s'. In Clark P. ed, *The European Crisis of the 1590s. Essays in Comparative History*. London: George Allen & Unwin, 23-43.
- Parry ML. 1978. *Climate Change, Agriculture and Settlement*. Folkestone: Dawson & Sons.
- Pfister C. 2005. Weeping in the snow. The second period of Little Ice Age-type impacts, 1570-1630. In: Behringer W, Lehmann H, Pfister C. eds, *Kulturelle Konsequenzen der "Kleinen Eiszeit"*. Göttingen: Vandenhoeck & Ruprecht, 31-86.
- Sibbald Sir R. 1699. *Provision for the Poor in Time of Dearth & Scarcity*. Edinburgh: James Watson.
- Smout TC, MacDonald AR, Watson F. 2005. *A History of the Native Woodlands of Scotland, 1500-1920*. Edinburgh: Edinburgh University Press.
- Smout TC, Watson F. 1997. Exploiting semi-natural woods, 1600-1800. In: Smout TC. ed, *Scottish Woodland History*. Edinburgh: Scottish Cultural Press, 86-100.
- Thirsk J. 1997. *Alternative Agriculture. A history from the Black Death to the present day*. Oxford: Oxford University Press.
- Tipping R. 1999. Towards an environmental history of the Bowmont Valley and the northern Cheviot Hills. *Landscape History* **20**, 41-50.
- Tipping R. 2000. Palaeoecological approaches to historic problems: a comparison of sheep-grazing intensities in the Cheviot Hills in the Medieval and later periods. In: Atkinson J, Banks I, MacGregor G. eds, *Townships to Farmsteads. Rural Settlement Studies in Scotland, England and Wales*. Oxford: British Archaeological Reports 293, 30-43.
- Whyte I. 1979. *Agriculture and Society in Seventeenth Century Scotland*. Edinburgh: John Donald.
- Whyte I. 1981. Human response to short- and long-term climatic fluctuations: the example of early Scotland. In: Delano Smith C, Parry ML eds, *Consequences of Climatic Change*. Nottingham: Nottingham University Press, 17-29.
- Whyte I. 2008. *World Without End? Environmental Disaster and the Collapse of Empires*. London: IB Tauris.

