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WOODLAND HISTORY IN SOUTH WEST NORWAY – COMPARATIVE INSIGHTS FROM A PARALLEL UNIVERSE

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Figure 1. *Fidjadalen, Rogaland (SW Norway) in 1927 and 2015. Underlying geology (Source: Norges geologiske undersøkelse) is gneisses and granites. The glen floor is at 300m asl. The climate is mild (July mean temperature band: +5 to +10C; January mean temperature band: 0 to +1C) and very wet (just under 4000mm/year on the glen floor; more at higher levels) (Source: Meteorologisk institutt). Peat from a bog located at 580m asl, above the cliffs to right, was the former source of domestic fuel at the farm, centre of pictures. Tree regeneration, all naturally seeded, largely dates to the 1960s and after. Scots pine has recently started to successionally invade the pioneering birch and aspen; rowan, juniper and bird cherry are also present. Photos: 1927 Stavanger friluftsråd; 2015 David Hetherington.*

Discussion on Highland woodland history and ecology has proceeded with surprisingly little comparative reference. When comparisons are made, they are frequently overgeneralisations, such as 'Norway' or 'Scandinavia'; of limited practical utility given the large variations in climate, considerably greater than that of the British Isles; in geology; and in landforms. Such overgeneralisations can be, and have been, misleading. The most important of these is that the climate, and hence vegetation, of Scandinavia is 'Boreal'.

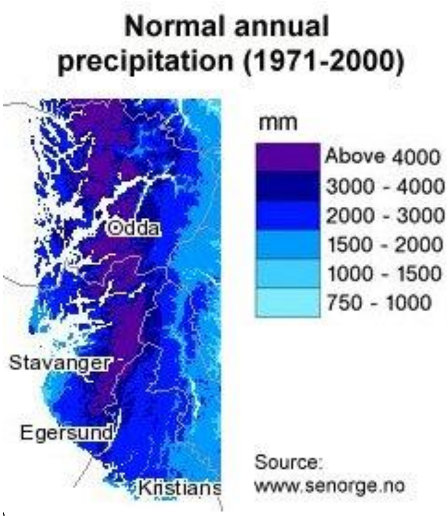
In this article I discuss woodland history and modern woodland regrowth in a region of Norway which, as precisely quantified and publically available meteorological and other data demonstrate, is closely similar in climate, geology, and landforms to the Scottish Highlands. Comparison can provide useful insights into the processes which have operated in Scotland, and which could operate in future if land management in Scotland resembled more closely in certain respects developments in Norway from the 1860s, and especially from the 1950s. Comparison can also usefully inform issues of current conservation importance.

SW NORWAY: GEOLOGY & CLIMATE

Southwest Norway (the provinces of Rogaland, Hordaland, and Vest Agder, with the upland part of Aust Agder) covers 33318km^2 (Highland, Western Isles and Argyll & Bute: 35639km^2). In latitude, the area ranges from that of Ullapool/ Dornoch to Hermaness. The geology is mainly hard, infertile, acidic gneisses, schists and granites, from the same orogenies that formed Highland Scotland (Ramberg et al 2008).

The climate is classified as 'hyperoceanic', and is dominated by the same southwesterlies as the Highlands. As a result, seasonal weather patterns are closely similar: mild, wet, and windy, with similar seasonal temperature ranges. Readers can compare climate statistics in detail at www.senorge.no and www.metoffice.gov.uk.

Annual precipitation is shown in Figure 2; wind at sea level in Figure 3; July mean temperatures in Figure 4; January mean temperatures in Figure 5. Data: Meteorologisk institutt (Norway) / Meteorological office (UK)



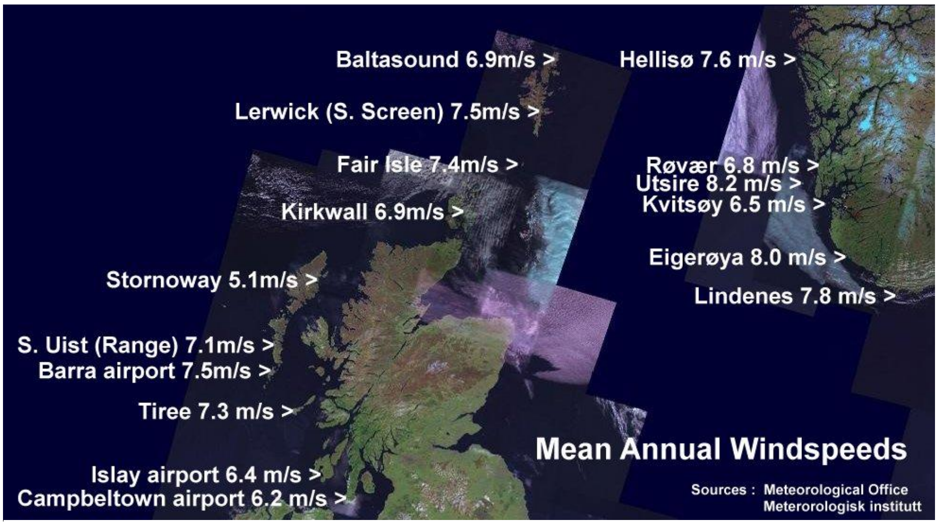
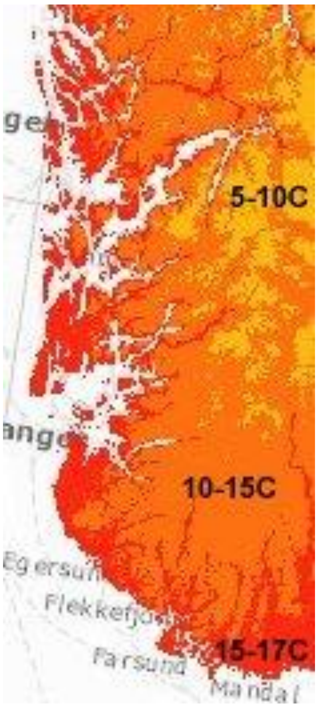


Figure 2. *Normal annual precipitation* **Figure 3.** *Mean annual windspeeds at coastal weather stations*



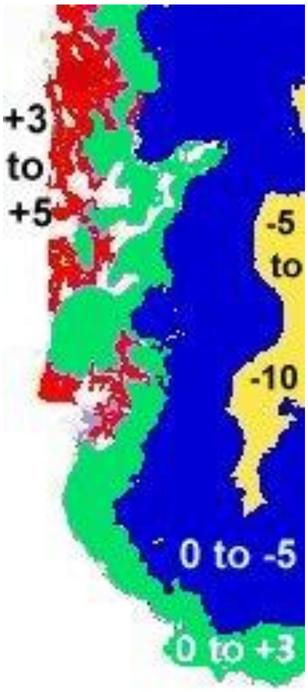


Figure 4. *Mean July temperatures*

Figure 5. *Mean January temperatures.*

Overall, SW Norway has slightly stronger winds at sea level than Scotland; and in some areas precipitation is higher than anywhere in Scotland, at over 4000mm (and up to 5000mm); both features sometimes asserted to cause or to maintain lack of woodland cover in Scotland. Winter temperatures are a little colder along the central mountain ridge, as it is rather higher (1500-1600m) than Scottish mountains. As in Scotland, rainfall peaks as weather systems rise over the mountains in the west; and then declines eastwards, with variations caused by local topography. Plants respond to local climate conditions; while in this paper regional summary is necessary, it is practical within the region to find matches to localities throughout Highland Scotland in geology, precipitation, and seasonal temperatures. See slide show and streaming video at http://tinyurl.com/zfvwbnh for detailed examples.

In summary, abundant and precisely quantified climatic and geological data indicate that the biophysical conditions of life in Highland Scotland and SW Norway do not differ in any ecologically significant respect.

WOODLAND HISTORY

People arrived in SW Norway at about the same time as in the Highlands, at the end of the last Ice Age; and they introduced agriculture and domestic animals, and started using metal tools and other technological developments, at about the same times. In the very similar climate, geology, and landforms, the effect was also very similar: deforestation, “anthropogenic in origin”, was mostly complete in coastal areas by the Bronze Age. Three main Neolithic-Bronze Age clearance pulses are identifiable, coinciding with changes in material culture and/or social organisation evident in the archaeological record. Deforestation inland continued for many centuries, and reached its greatest extent in the 19th century (Prøsch-Danielsen & Simonsen 2000a, b for review).

Woodland history in Highland Scotland (e.g. Birks 1996) and SW Norway remained similar, for the same underlying reasons, throughout the period in which landuse was dominated by subsistence pastoralism. By the 19th century, both SW Norway and the Highlands had been strongly deforested for a long time. As in the Highlands, peat was the main fuel in SW (and W) Norway, and drystane dykes were built for miles across the treeless glens and hillsides. Wood for fuel or fencing was unavailable locally, and too expensive to import. Photographs from the late 19th and early 20th centuries look strikingly like many parts of the Highlands.

Figure 6. *Peat drying stacks, Romsdal, 1940s. Photo: Romsdalsmuseet*

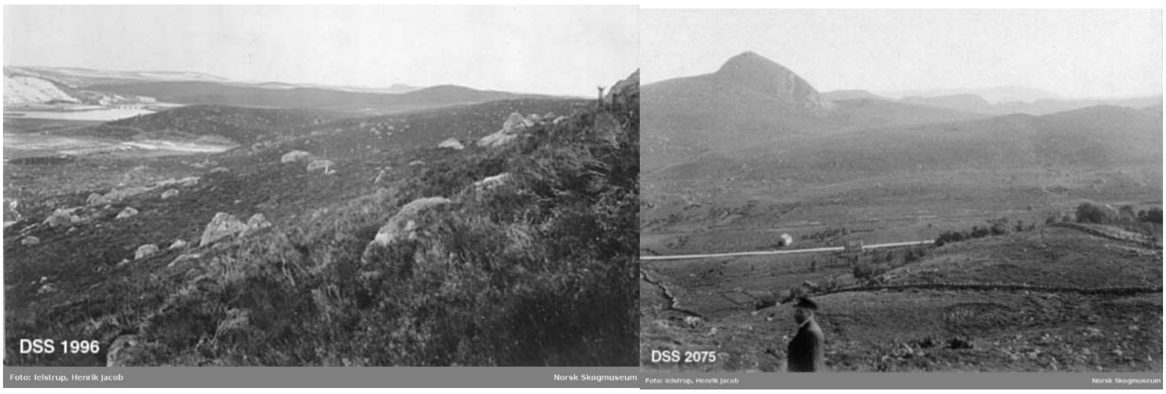


Figure 7a & 7b. *Two views of SW Rogaland near modern Sandnes/Ålgård (SSW of Stavanger), taken in 1905 (left) and 1911. Drift geology partly “thick moraine”, partly “peat and bog”; bedrock dioritic to granitic gneiss / migmatite. Elevations c. 50-180m. Photos: H.J. Ielstrup/ Norsk Skogsmuseum*

In the Highlands, subsistence pastoralism was replaced as the dominant landuse by commercial sheep *Ovis aries* ranching from the later 18th century, joined by recreational hunting in the 19th century; but did not start to decline in Norway until the 1860s.

Since the 1860s the landscape histories of the two areas have diverged radically, in what amounts to a landscape-scale ‘natural experiment’ (albeit that it occurred for human social and economic reasons). In the Highlands, apart from commercial forests which started to be established after the First World War, no significant expansion of woodland occurred in the 20th century, and in general the state of remaining seminatural woodlands continued to decline (Wilson 2015). In SW Norway, new woodlands began naturally regenerating from the 1860s on; and especially from the 1950s. In recent decades the landscape has changed from one which was mainly unwooded within living memory, to one where most of the land below the treeline is now wooded once again. This process is continuing at a very rapid rate. In Rogaland, the most deforested province of all, in the far SW, woodland cover is predicted to increase from 24% in 2007 to 52% over the next few decades, with most of the remaining area being arable farmland, inbye fenced and drained grazings, or high mountains above the natural tree line (Bryn *et al*. 2013). In West Norway statistical region (Rogaland, Hordaland, Sogn & Fjordane and More & Romsdal provinces), at present 2.6% of the land area is changing from open ground to woodland every 5 years (Data: Statistics Norway).

What caused this? Much research has been done, and the answer is clear: reductions in browsing pressure, and associated land use practices such as muirburn (e.g. Ålmås & Gjerdåker 2004, Bryn 2008, Hofgaard 1997, Hofgaard *et al*. 2010, Olsson et al 2000, Rössler et al 2008). This was because of two main waves of reduction in the intensity of grazing on the land. The first was from the 1860s to 1914, due to mass voluntary emigration to the United States; the second from the 1950s on as other ways of making a living other than hill farming became widely available, and were considered more attractive; with a pause or perhaps slight reversal in the 1930-40s as the economic and political conditions of the Great Depression and WWII resulted in many people staying on or returning to their parental hill farms. The process is continuing, with some extension in woodland area, and much development in structure, still to come.

SOME COMPARATIVE INSIGHTS

A feature of woodland growth pertinent to discussions of woodland history in Scotland is the climates in which woodland of relevant tree species is observed to grow, to regenerate itself, and to recolonise. Observation and data on distribution in SW Norway (mapping data: https://artskart.artsdatabanken.no) and other places, of e.g. Scots pine *Pinus sylvestris*, downy birch, aspen *Populus tremula*, juniper *Juniperus communis*, alder *Alnus glutinosa*, rowan *Sorbus aucuparia*, and bird cherry *Prunus padus* shows each growing and regenerating, and recolonising ground deforested for millennia, in climates both significantly wetter than, and as cool as without any appreciable winter snow cover, anywhere in Scotland at any period in the last 7500 years (ie, after the onset of ‘Atlantic’ conditions, Lowe 1993; Peterken 1993). The same is true for climates appreciably colder in winter, elsewhere in Norway. The climate thus remained well within the fundamental niche (Allaby 2010) of all of these species over most of the land area of Highland Scotland, except for some high mountain tops. Changes in climate would be likely to alter the balance of tree species within woodland (the 'realised niche' for each, *op. cit.*) through interspecific competition, but not the extent of woodland cover. Much of the initial regrowth in SW and W Norway observed in recent decades has occurred directly on peat.

Figure 8. *Woodland regeneration on wet peat over granite, c. 800m, Berdalen, Aust Agder. Maps and placenames indicate the area was unwooded to at least the early 20th century.*

It is sometimes stated, or assumed, in Scotland that native woodland is not capable of regenerating on peat; this can even be found in official documentation. However, ‘Myrskog’ (*‘(Peat) bog forest’*) is so common as to be a standard vegetation class in Norway (Type K1, Framstad 1997; Type 8b, NIBIO classification http://www.skogoglandskap.no/Artsbeskrivelser/myrskog). It is “Forested bog on deep, nutrient-poor peat where the peat layer has built up so that vegetation has lost contact with groundwater” and is found “throughout Norway” including the SW. Downy birch (the usual pioneer) and Scots pine are the usual dominant species. Much regeneration in SW Norway has happened in recent decades on peat, often wet and deep, formed as a result of anthropogenic deforestation (Moore et al 1984; Kalad 1986; Prøsch-Danielsen &

Simonsen 2000a, b). Trees regenerate strongly (and often form a new, non-peat, soil layer so that the area may no longer be classified as bog woodland; e.g. Perala & Alm 1990) so long as the soil is not permanently waterlogged. Even on flat blanket bogs, trees are usual on any raised or slightly drier patch. Over 90% of the former coastal heather moorland in Norway, much on peat, has rewooded in recent decades, after millennia of deforestation (Miljødirektoratet 2013).

Figure 9. *Peat bog in More, west Norway, 440m asl. Flat glen floor is permanently saturated; tree regeneration on all drier patches and slopes. Inset: willow/ juniper/birch association on a drier patch in the bog shown. Underlying geology quartz diorite. Photo: Author*

Figure 10. *Old peat digging on blanket bog cleared for archaeology. Note thick birch regeneration growing directly on the peat behind the cleared area. Photo: Riksantikviteten*

Figure 11. *Airphoto of regenerating birch on upland blanket peat over granite, 800-830m, Slåttlian, Aust-Agder. Climate similar to the central Cairngorms. Wetter patches and runnels now form forest bog. 'Slåttlian' translates as 'fodder cutting hillside', with an implication of scything; grasses, sedges etc. were formerly cut for winter fodder here in later summer; the peat is too wet for heather. Note former seter (sheiling, summer farm) building, bottom right; domestic stock was seasonally grazed at this site, and generally across upland Norway, for many centuries in a similar way to former upland grazing practices in Scotland. Maps indicate unwooded to at least early 20th century. Source: Statens kartverk.*

These data are incompatible with theories (e.g. Tipping 2008) that naturally-caused peat buildup converted woodland to open ground in Scotland on a large scale; the argument depends on the hypothesis that “the likelihood is that individual localities crossed as yet poorly defined environmental thresholds” (*op. cit*.) which are assumed to exist and to explain the shift from woodland to open peat landscapes. In fact, in climates as cool as and as wet or wetter than anywhere in Scotland since the onset of the Atlantic phase, naturally regenerating woodland is observed both to maintain itself (and its soils); and to reinvade any blanket peat not permanently saturated whenever anthropogenic browsing intensities relax.

Figure 12. *Example of native woodland regeneration on a west coast peat bog, Austrheim, Hordaland. The site is just above sea level and was deforested for >5000 years until recent decades. Peat was formerly extracted (fuelwood is now cut). The area enclosed by the white line is classified as “peat/bog” drift geology by the Norwegian Geological Survey (NGU). Bedrock is dioritic to granitic gneiss and migmatite. Note the effect of the road and property boundaries on stage of regeneration, reflecting differences in date and intensity of reductions in grazing pressure. Some patches are too wet for woodland, as can be seen in the south central area, where regeneration is longest established; but this is not the general case. Re-generation alters and dries soils over time; this can lead to progressive spread at the edges into areas where the soil is initially too wet.*

Figure 13. *Natural regeneration on upland blanket peat, Sollia hill farm, west Norway. The water body is a coastal fjord. Underlying geology quartz diorite. Note the young ages of all of the trees. The farm (right edge of field, centre) is at 310m asl. Historical records and old peat diggings demonstrate that peat was the fuel source for centuries. The former farm building (inset; now rebuilt as a hiker’s association cabin) was of drystane and sod construction owing to the lack of available timber; walls remain partly drystane, with sod cavity fill. Regeneration at the site dates primarily to the 2nd half of the 20th century. Photo: author.*

This falsifies the view that climate changes towards cooler and wetter conditions in the Neolithic could by themselves, or in combination with peat development, have caused the extensive reductions in woodland cover in the Highlands (and elsewhere) at that time. The relevant tree species remained well within their observed fundamental climatic niches, and are observed to invade all except permanently saturated peat soils in climates as cool and as wet or wetter, in the absence of anthropogenic browsing, felling, and/or muirburn.

A point of some importance in conservation is that the absence or severe modification of their natural habitats, and a failure to study the ecology of species in similar climates and geologies outside Scotland, has led to the habitat requirements of various species of conservation concern being misdescribed. This has sometimes been called the 'refugee habitat' problem (Caughly 1994). For example, in the eastern Cairngorms it was recently proposed to destroy a patch of naturally regenerating native woodland on the grounds that it 'threatened' a patch of NVC H16 bearberry *Arctostaphylus uva-ursi* heath. The patch concerned is a 'survivor assemblage' of a highly artificial burning regime, of a kind only practised in Scotland since the later 19th century; that is, it is a listing of some plant species found together given a recent form of British upland land management intervention. As a supposed entity it is a reification; imposing some other novel system of intervention could similarly create new 'communities' not now existing just as quickly, and no more (or less!) deserving of protection as a unit.

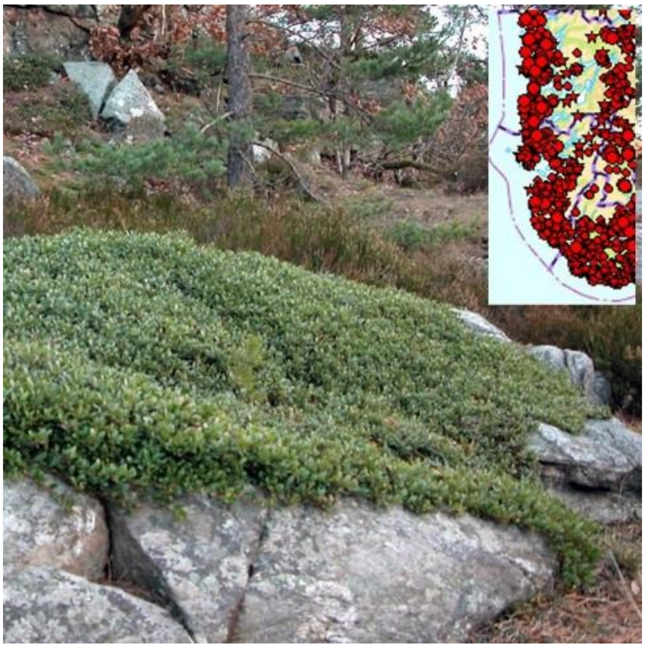


Figure 14. *Bearberry growing in seminatural Scots pine woodland, Norway; with distribution in SW Norway inset. Source: Norwegian species database*

Given the lack of frequent rotational burning in bearberry history, one would expect that it is not dependent on it. And it is not. The first line of the standard habitat description for bearberry in Norway is "Bearberry grows in drier (*ie relatively well-drained*) woodland, most often pine, and drier heath". It is, like most heathland plants, a woodland understory plant that can tolerate open ground. Heath burning is little practised in modern SW Norway. Natural reforestation of the region has not threatened bearberry; it remains common in its real natural habitat, and is designated 'Least Concern' (LC), the most favourable of all IUCN conservation status designations.

The ring ouzel (*Turdus torquatus*) is also LC in Norway, but is Red Listed in Scotland because of a severe decline in populations (> 50%), and a very marked contraction in range (Rollie 2007). The same subspecies (*T.t. torquatus*) breeds in Scandinavia, including SW Norway, and winters in the same regions as the Scottish population; populations appear to be slowly increasing as suitable habitat continues to reestablish. There it is "common in the willow region (*ie the upper zone of montane shrub vegetation*) …it also breeds at many sites right out on the coast…The ring ouzel prefers hilly areas with rocky terrain and mixed grass and shrub vegetation... It does not like barren areas with little vegetation, either on the coast or in the mountains" (Pedersen 1994).

In Scotland ring ouzel habitat is described as "open heather clad moorland and mountains with only very sparse or stunted tree cover" (Rollie 2007). Montane/coastal scrub as a major feature of the core habitat mix is not mentioned in Scottish habitat descriptions because it hardly exists in Scotland.

Other examples include Netted Mountain moth *Macaria carbonaria*, a mainly upland bog species common in Norway (LC) and feeding as a larva on bog rosemary *Andromeda polifolia*; but which can also eat bearberry. In the Highlands bog rosemary is extinct (or almost so; one record, a patch recorded at 735m on Mount Keen in 1979), because it is both palatable to sheep and deer and vulnerable to muirburn in dry conditions. Being a species of bogs, it does not have cliff ledges as a refuge. Bog rosemary occurs quite widely on raised bogs protected from heavy grazing in S. Scotland, England, and Ireland; and is widespread and common (LC) on bogs of all kinds throughout Norway including the SW. It is not absent from the Highlands for climatic reasons, since it is widespread in regions warmer and wetter; warmer and drier; cooler and wetter; and cooler and drier than anywhere in the Highlands. Comparative evidence thus suggests that *M. carbonaria* is restricted in the Highlands to a secondary food plant, growing in a recent survivor assemblage. Its rarity is a function of this.

Alpine blue sow-thistle *Cicerbita alpina* is confined in Britain to four rock ledges, inaccessible to deer and sheep, in southeastern Cairngorms NP. Plants on each ledge may be vegetatively-reproduced clones. They rarely set seed, usually deformed. Conservation action plans in Scotland (Plantlife 2006) until recently incorrectly described *C. alpina* as a species of 'continental climates' and so at the western limit of its tolerances in eastern Scotland. In Norway it is common (LC) and widespread, from sea level - including some of the most oceanic locations in the world such as the Stad peninsula - to the upper limit of montane scrub. It is an understory plant of hill woodland, requiring moderate shade and soils that are always moist to wet, but not permanently saturated; and seeds prolifically. It is a highly palatable food plant for sheep and deer.

Figure 15. *Alpine blue sow-thistle (foreground) at the upper limit of montane shrub vegetation, 1100m on peat over granite, Berdalen, Aust-Agder, in August 2016; climate similar to the central Cairngorms. Maps and place names indicate the location was deforested to at least the early 20th century. Photo: Rob Dewar.*

In response to comparative data from SW Norway, reintroductions to woodland in the Abernethy-Glenmore-Glenfeshie area are now being considered. Norwegian seed has been collected by the Royal Botanic Garden, Edinburgh and genetic studies are underway to compare with the surviving Scottish specimens (Aline Finger *pers comm*).

Aspen throughout its wide montane range, except for Britain, is an aggressive pioneer species. Its basic life history strategy is rapidly to exploit temporarily bare ground from e.g. landslips, or windthrown trees, by producing large amounts (c. 1.6 million per adult female in its N. American sibling species, *P. tremuloides*) of tiny windblown seeds. It allocates resources to rapid growth- longitudinally by suckering to cover the open area; and vertically to outcompete other plants for access to light. This means it has low density wood and little chemical defence; and is very palatable to browsers. Most often other tree species, more tolerant of shade, grow successionally below it; assisted in pioneer stands by the shelter and soil development provided. In Scotland aspen appears to seed rarely, and reproduces mainly by suckering. This prevents it fulfilling its usual ecological role, as a pioneer/ nursery species (e.g. Wilson 2015). The oceanic climate is sometimes suggested to cause infrequent seeding (Worrell 1995), but this cannot be correct as the species seeds normally, and is a common and conspicuous pioneer, in the rapidly regenerating and highly oceanic landscapes of SW Norway. The climate is in some areas considerably wetter than anywhere in Scotland (Fig 2). This suggests that the reasons the species is failing to fulfil its usual ecological role in Scotland should be investigated further.

Figure 16a &b. *Natural regeneration at Fonnes, Hordaland. A coastal site facing the open Atlantic, on dioritic to granitic gneiss and migmatite. The roof ridge of the shed in the 1971 image is c. 2m high. The copse of Scots pine in the 1971 photograph was planted in 1907. Reduction in grazing pressure at the site dates to 1975. From Miljødirektøratet, 2013; Photos: Peter Emil Kaland*

Examples could be multiplied, and are only those which circumstances have so far brought to light. More systematic comparison would be illuminating in many ways, and of benefit both to the Highlands, and to Norway.

SW Norway is more open to natural recolonisation by species it may have lost than is Highland Scotland given its land connection to other areas in related ecological zones. Known examples include lynx *Lynx lynx*, moose *Alces alces*, roe deer *Capreolus capreolus*, and capercaillie *Tetrao urogallus*, formerly regionally extinct and now spreading back from central regions of Scandinavia. It can hardly be doubted that a number of woodland species of fungi, plants, invertebrates, and birds will have become extinct unrecorded in the Highlands; for birds see Halley 2011.

CONCLUSION

The climates, geologies, and landforms of Highland Scotland and of SW Norway are closely similar. Their woodland history until comparatively recently has been similar in consequence of this fact, and of the similar patterns and timings of human impacts from the end of the Ice Age onwards. The modern large differences in landscape, and in particular of woodland cover, are a consequence of significant divergences in land management practices beginning in the 18th-19th centuries.

The landscapes of both Highland Scotland and of SW Norway are primarily cultural landscapes, and have been since the Neolithic. The desirable landscape for the Highlands (or for SW Norway) is open to a variety of opinion. However, hypotheses that the open landscapes of the Highlands are natural in origin (e.g. Fenton 2008; Tipping 2008); and/or that current landscapes are, to any significant extent, intrinsically unable to reafforest by natural means assuming reductions in anthropogenic browsing pressure and associated impacts such as muirburn, are falsified. They are incompatible with primary data on, and observation of, the climates and soils in which woodlands of the relevant tree species can and do grow and persist; and have been observed to recolonise by natural regeneration over wide areas, after centuries to millennia of deforestation.

If considered desirable, reafforestation by seminatural woodland in Scotland could be accelerated greatly by management interventions, as compared to the largely unmanaged process observed in SW Norway. Data indicates that following decline in grazing pressure and associated anthropogenic impacts, such as muirburn, "how rapidly regrowth (*of woodland*) occurs is first and foremost dependent on the distance to the nearest seed source" (Miljødirektoratet 2013).

AFTERWORD

The comparative data in this paper is summarised from material presented at the Scottish Woodland History Conference in October 2015, and in expanded form (to include modern landuse practices in SW Norway) at a Nordic Horizons event at Holyrood later that year. Climate data and other comparisons were developed in more detail in those talks, including examples of areas similar in detailed climate and geology to various parts of the Highlands. As presented at Holyrood, the talk may be downloaded as a slide show, or seen as a streaming video, at http://tinyurl.com/zfvwbnh.

Norway is no longer, since the recent steep decline in oil prices was mirrored by a decline in the krone exchange rate, a particularly expensive country to visit, especially self-catering, including the Norwegian Hiker's Association cabin network (click language bar top right for English). The SW Norwegian region is a 55 minute flight from Aberdeen airport. Readers are strongly urged to visit, and see for themselves.

REFERENCES

Allaby, M. 2010. A Dictionary of Ecology. Oxford University Press.

Ålmås R.& Gjerdåker B. 2004. *Norwegian agricultural history.* Tapir, Trondheim

Birks, HJB. 1996. Great Britain – Scotland*. Pp 95-143 in:* Berglund, B.E., Birks, H.J.B., Ralska-Jasiewiczowa, M. & Wright, H.E. (eds.): *Palaeological events during the last 15 000 years: Regional syntheses of palaeoecological studies of lakes and mires in Europe*. John Wiley & Sons Ltd, 95-143.

Bryn, A. 2008. Recent forest limit changes in south-east Norway: Effects of climate change or regrowth after abandoned utlisation? *Norw. J. Geogr*. 62: 251-270.

Bryn, A. Dourojeanni, P, Østbye Hemsing L, & O'Donnell S. 2013.A high-resolution GIS null model of potential forest expansion following land use changes in Norway. *Scand J Forest Res* 28: 81-98

Caughley G. 1994*.* Directions in conservation biology*. J. Anim. Ecol. 63: 215–244.*

Framstad, E 1997. Norges vegetasjonstyper (Norway's vegetation types). NINA thematic publicaton 12.

Fenton, JHC. 2008. A postulated natural origin for the open landscape of upland Scotland. *Plant Ecol. & Diversity* 1:115-27.

Halley, D. 2011. Common birds of montane scrub and their potential to recolonize restored habitat in Scotland. *Scrubber's Bulletin* 9, 22-35.

Hetherington, D. (this volume).

Hetherington, DA., Lord, TC., Jacobi, RM. 2005. New evidence for the occurrence of Eurasian lynx (Lynx lynx) in medieval Britain. *J. Quaternary Sci* 21:3-8

Hofgaard A. 1997. Inter-relationships between treeline position, species diversity, land use and climate change in the central Scandes Mountains of Norway. G*lob. Ecol. and Biogeog. Lett.* 6:419–429

Hofgaard A, Løkken JO & Dalen L. 2010. *Comparing warming and grazing effects on birch growth in an alpine environment–a 10-year experiment.* Plant Ecol. & Diversity 3:19–27

Hytönen, J & Aro, L 2012. Biomass and nutrition of naturally regenerated and coppiced birch on cutaway peatland during 37 years. *Silva Fennica* 46: 377–394

Kaland, PE 1986. The origin and management of Norwegian coastal heaths as reflected by pollen analysis.pp 19-36 in Behre, K.-E. (ed.) *Anthropogenic Indicators in Pollen Analysis*. A.A. Balkema, Rotterdam.

Kitchener AC, Bonsall C. 1997. AMS radiocarbon dates for some extinct Scottish mammals. Quaternary Newsletter 83: 1–11.

Moore, PD, Merryfield, DL & Price, MDR 1984. The vegetation and development of blanket mires. Pp 203-205 in: Moore, P.D. (ed.) *European Mires*. Academic Press, London.

Lowe JJ 1993. *Settting the scene – An overview of climatic change*. Pp1-16 in Smout TC (ed.) Scotland since prehistory – natural change & human impact. Scottish Cultural Press.

Miljødirektoratet 2013. Kystlyngheiene i Norge – kunnskapsstatus og beskrivelse av 23 referanseområder. *Report M23-2013.*

Olsson EGA., Austrheim G & Grenne SN. 2000. *Landscape change patterns in mountains, land use and environmental diversity, Mid-Norway 1960–1993.* Landscape Ecol. 15: 155–170

Pedersen, FH 1994. Ringtrøst (Ring ouzel) *Turdus torquatus*. pp 364-365 in: Gjershaug, J. O., Thingstad, P. G., Eldøy, S. & Byrkjeland, S. (eds.): Norsk fugleatlas (Norwegian Bird Atlas). Norsk Ornitologisk Forening, Klæbu.

Perala & Alm AA 1990. The reproductive ecology of birch – a review. *For. Ecol. & Man*. 32:1-38.

Peterken, GF 1993. *Woodland Conservation and Management*. Chapman & Hall.

Prøsch-Danielsen L. & Simonsen A. 2000a. Palaeoecological investigations towards the reconstruction of the history of forest clearances and coastal heathlands in south-western Norway. *Veget Hist Archaebot* 9: 189-204.

Prøsch-Danielsen, L & Simonsen, A. 2000b: *The deforestation patterns and the establishment of the coastal heathland of southwestern Norway.* Archaeological Museum Stavanger Publications15, 52 pp. Stavanger.

Plantlife 2006. Alpine blue sow-thistle dossier. Plantlife UK.

Ramberg, IB, Bryhni, I, Nottvedt, A & Rangnes, K (eds.) 2008 *The making of a land – the geology of Norway*. Norsk geologisk forening.

Rollie, C. 2007. Ring ouzel *Turdus torquatus.* pp 1130-1134 in: Forrester, RW, Andrews, IJ, McInerney, CJ, Murray, RD, McGowan, RY, Zonfrillo, B, Betts, MW, Jardine.DC & Grundy, DS (eds.) The Birds of Scotland. The Scottish Ornithologist‟s Club, Aberlady.

Rössler, O, Bräuning A & Löffler, J. 2008. *Dynamics and driving forces of treeline fluctuation and regeneration in central Norway during the past decades.* Erdkunde 62:117-128.

Tipping, R. 2008. Blanket peat in the Scottish Highlands: timing, cause, spread and the myth of environmental determinism*. Biodivers Conserv* 17: 2097-2113

Wilson, SMcG 2015. *The native woodlands of Scotland – ecology, conservation, and management.* Edinburgh University Press.

Worrel, R 1995. European aspen: a review with particular reference to Scotland. *Forestry* 68:93-105 and 68:231-43.