The vegetation of grass roofs in the Faroe Islands and the surrounding grassland vegetation – a study from Sandoy

Gróðurin á flagtekjum í Føroyum og á graslendinum uttanum – ein kanning úr Sandoynni

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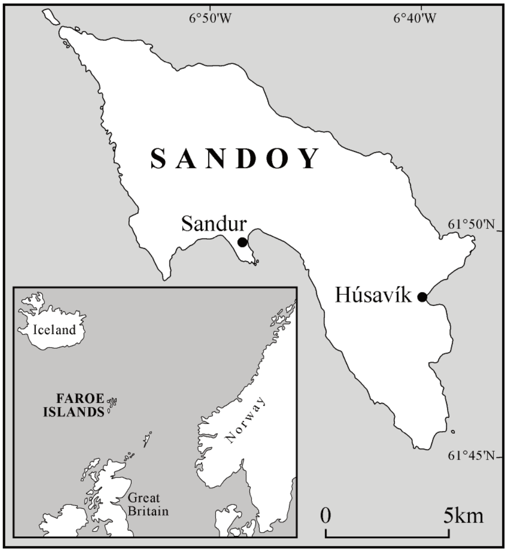

Figure 1. Map showing sampled settlements on Sandoy. The inset map shows the position of the Faroe Islands within the North Atlantic region.

Abstract

Vegetation samples were taken from grass roofs on buildings in Húsavík and Sandur, on the island of Sandoy, in order to determine the factors responsible for the low species diversity of the roof turfs. The variables of slope, aspect and grazing were also measured and in combination with statistical analyses of the data by detrended correspondence analysis, correlation and a measure of species richness, three different hypotheses for the low species diversity of the roof turfs were explored relating to summer drought, grazing and the deliberate selection of turfs. The data collected do not support the last two hypotheses, although the affect of summer drought on the vegetation can only be determined experimentally.

Úrtak

Ein roynd varð gjørd at kanna orsøkina til, at margfeldið av sløgum á flagtekjum er so lítið. Sýni vórðu tikin av gróðri á flagtekjum í Húsavík og heima á Sandi. Mált varð, hvussu ymist bitið og hallið var – bæði hvussu brøtt tekjan var og í hvørja ætt hon helti. Saman við hagfrøðiligari greining av dátunum við frá-

bregðandi samsvarsgreining (*detrended correspondence analysis*), samanfalli og máti av slagríkidømi vórðu trý ymisk hugsanarstøði fyri tað lága margfeldið av sløgum rannsakað, og varð hetta gjørt í mun til skerping á sumri, bit og slag av flagi. Savnaðu dáturnar stuðla ikki tvey tey seinastu hugsanarstøðini, hóast ávirkanin av skerpingi bert kann verða avgjørd við royndum.

Introduction

Prior to the advent of modern roofing materials it was customary for roofs in the Faroe Islands to be thatched with turf (Figs 1-3). In some comparable areas, such as Scotland, this layer of turf would have been overlain by rushes, straw or bracken to enhance the waterproofing (Holden, 1998). In the Faroes, barley straw would occasionally be used as a layer of thatch over the turfs (Stanley in West, 1976), but

Figure 2. Grass-roofed buildings in Húsavík.

Figure 3. Grass-roofed buildings in Húsavík with varying dominant taxa for each roof segment: closest to camera (*Poa pratensis*), middle segment (*Holcus lanatus* and *Rumex acetosa*), furthest from camera (*Poa pratensis* and *Agrostis* sp.).

more typically, birch (*Betula* spp.) bark was imported from Norway and placed beneath the turfs to provide a waterproof layer (Taylor, 1997). Constructed in this way the turf roofs would remain serviceable for 40 to 60 years whereas the barley thatch would be renewed at more regular intervals of 4-5 years (Stanley in West 1976).

At the start of the twentieth century, Ostenfeld (1905-1908, p. 1012) observed, "that nearly all the Færöese houses are thatched with turf." By the middle of the century, Williamson (1948) observed the removal of turfs from the roofs in Koltur and their replacement with asbestos sheets. This replacement of turf by more modern materials has continued throughout the Faroes, so that by the end of the twentieth century only outbuildings and occasional modern houses were roofed in such a way (*cf.* Hansen and Jóhansen, 1982). However, with a few exceptions (e.g. Dúvugardur museum in Saksun), the traditional appearance of these remaining roofs belies their more modern mode of construction that incorporates plastic sheeting in place of the more traditional birch bark (*næver*).

The species composition of the turfs initially reflects that of the vegetation it is removed from, usually within the outfield or *hagi* (Ostenfeld, 1905-08). Attention has been drawn to the decreasing plant diversity of the turfs once they are lain upon the roof and this has been presumed to be a consequence of summer drought conditions favouring a predominance of grasses over the other phanerogams and associated cryptogams (Lyngbye, 1822; Ostenfeld, 1905-08; Hansen, 1966; Hansen and Jóhansen, 1982). In some cases, the vigorous growth of the grasses could be harvested to supply hay (Hansen and Jóhansen, 1982) and chickens would also exploit the roofs as they searched for food (Williamson, 1948).

The grass species prevalent on the roofs are those that are best able to tolerate the presumed limiting factor of summer drought, such as *Anthoxanthum odoratum*, *Festuca rubra* var. *fratercula* and *Poa trivialis* (Jóhansen, 1985). While some or all of these taxa may have been present in the vegetation of the original turf, and it may have been chosen for this reason, it was a common practice to collect seeds or grown plants of desirable species for incorporation into the roof. *F. rubra* var. *fratercula* or *Poa trivialis* were especially favoured, presumably because of the waterproofing provided by the long, procumbent and "flowing" habit of the leaves of these grasses.

Aims and hypotheses

The first aim of this paper is to offer some observations and data on an interesting aspect of traditional Faroese building that is currently in the process of becoming lost to more modern materials and methods. In so far as the data sets allow, the paper also intends to test three hypotheses concerning the lower species diversity of the roof turfs in comparison to the ground vegetation from which they were probably derived:

Hypothesis one: there is a reduction of species diversity due to summer drought conditions (this was proposed informally by Hansen and Jóhansen (1982) and Jóhansen (1985)).

Hypothesis two: the decline in species diversity is a result of freedom from grazing on the roof-top turfs (which then allows a small number of more competitive species to predominate).

Hypothesis three: the low species diversity arises from the selection of species-poor turfs for roofing.

Materials and Methods

The vegetation of 13 grass roofs displaying a variety of dominant species, was assessed in 76 randomly placed, 1 m^2 quadrats. Multiple quadrats were used for each roof segment in order to ensure that the direction faced by each part of the roof (aspect) was included.

The abundance of each plant taxon (including cryptogams) was determined on a percentage scale. Measurements were also made of the aspect of each roof segment, and its slope, but soil samples were not removed to prevent damage to the fabric of the roofs. All of the samples were derived from buildings in Húsavík (6 buildings) and Sandur (7 buildings) on the island of Sandoy (Figs 1-3), where a reasonable number of turf-roofed buildings still exists.

The vegetation of the infield (*bøur*) and outfield (*hagi*) areas in the vicinity of the turf-roofed buildings was sampled (39 quadrats) in the same manner, for comparison with that of the roofs, and the same environmental variables (aspect and slope) were also recorded.

The presence of grazing in field and roof samples was determined from the presence of dung and a score of 1 was given to those samples were grazing was evident (by sheep) and a score of 0 given where grazing animals were unlikely to gain access and/or dung was absent. Vascular plant nomenclature follows Jóhansen (2000) and Smith (1978) for the mosses.

Fieldwork took place in August 2003. A major problem met with by the authors was that householders (where resident at the time of surveying), often had an imprecise idea of when the roofs – or segments of the roofs – had last been replaced. Furthermore, they had no idea of where the individual roofing specialists had obtained their turf. The difficulty of locating individual householders with a view to increasing the number of roofs examined and thus increasing the level of independence of the data, was exacerbated by the fact that a number of houses were not permanently inhabited.

Statistical methods

A wide range of measures of diversity are now in existence that measure both the number of species present and taxon homogeneity. Separation of these two components in the number expressed by the method chosen is difficult (Hayek and Buzas, 1997; Magurran, 1988) and in this instance, a more straightforward comparison of species richness (a simple count of the number of species) is used to assess any difference in diversity between the roof and ground vegetation.

Detrended correspondence analysis (DCA; Hill and Gauch, 1980) is used to determine the possible ecological factors underlying the distribution of the plant taxa present on the turf roofs. The roof data are also combined with that of the ground vegetation in order to determine the relationships between the types of plant community represented by these data sets. Correlations were then performed between the DCA sample scores and the variables aspect, grazing and slope in order to determine their influence upon the vegetation.

Results

Diversity

Species richness comparison shows a difference between the plant diversity of the turf-roof and ground vegetation (Fig. 4). The average number of species per quadrat is 5.6 (n=76; SD 2.4) for the roofs and 17.6 (n=39; SD 7.17) for the ground vegetation. A t-test confirms that this difference is very significant (at the 0.001 level; t=9.2; df=42.).

An additional z-test (that allows for differences in the size of the two sub-sets) of the grazed and non-grazed roof vegetation was undertaken to determine whether the number of quadrats (11 for grazed and 65 for non-grazed) might be responsible for a difference in diversity. The results of this test confirmed that no significant difference could be found between these two sets of roof samples (at the 0.05 level; z=-1.9; df=11).

Ordination

The sample and taxa ordinations produced by DCA of the roof-turf and the infield and outfield ground vegetation are presented in Figures 5 and 6. In Figure 6, polygons are drawn around samples from the same habitat, i.e. the infield (A), outfield (C) and roof (B) turfs. For the sake of clarity, only taxa whose abundance is greater than 10% in at least one quadrat are labelled.

The DCA analysis of the turf-roof vegetation (Fig. 5) reveals a gradient of inferred condition (which may be a function *inter alia* of factors such as maintenance, aspect

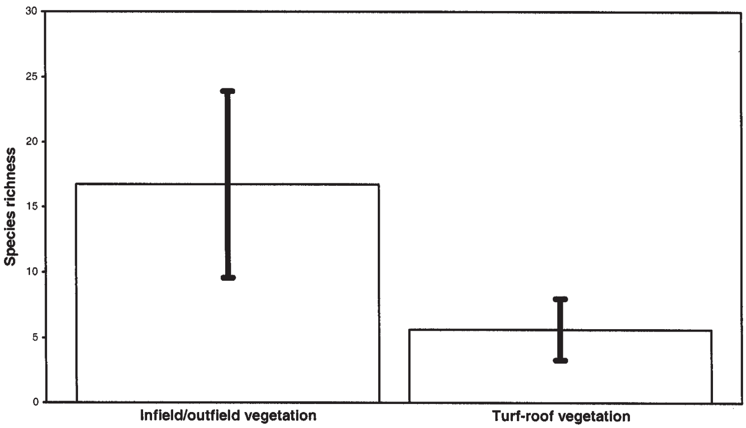

Figure 4. Comparison of species richness between infield/outfield vegetation and turf roof vegetation on the island of Sandoy. Error bars indicate two standard deviations.

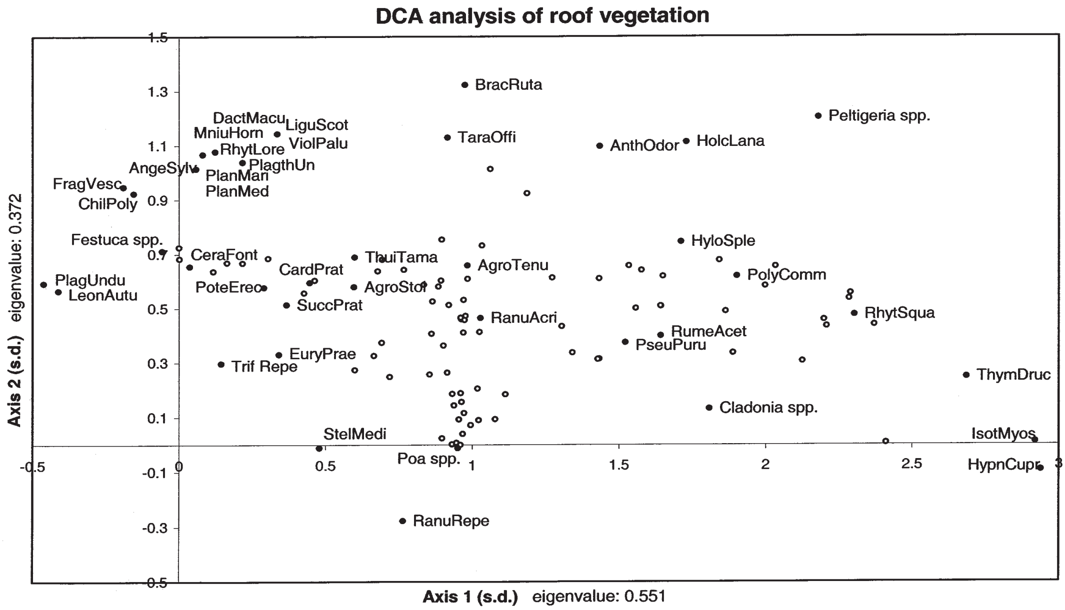

Figure 5. DCA scatterplot of roof samples and taxa. Key: samples – open circles; taxa – filled circles. Abbreviations: AgroStolo, *Agrostis stolonifera*; Agro spp., *Agrostis* spp.; AgroTenu, *Agrostis tenuis*; AngeSylv, *Angelica sylvestris*; AnthOdor, *Anthoxanthum odoratum*; BracRuta, *Brachythecium rutabulum*; CallVulg, *Calluna vulgaris*; CardPrat, *Cardamine pratensis*; CarePani, *Carex panicea*; CeraFont, *Cerastium fontanum*; ChilPoly, *Chiloscyphus polyanthus*; DactMacu, *Dactylorhiza maculata*; ErioAngu, *Eriophorum angustifolium*; EuryPrae, *Eurynchium praelongum*; Fest spp., *Festuca* spp.; FragVesc, *Fragaria vesca* (presumed to be planted); HolcLana, *Holcus lanatus*; HyloSple, *Hylcomium splendens*; HypnCupr, *Hypnum cupressiforme*; IsotMyos, *Isothecium myosuroides*; LeonAutu, *Leontodon autumnalis*; LiguScot, *Ligusticum scoticum*; LopheBide, *Lophocolea bidentata*; MniuHorn, *Mnium hornum*; NardStri, *Nardus stricta*; Pelt. Sp., *Peltigeria* spp.; PlagthUn, *Plagiothecium undulatum*; PlagUndu, *Plagiomnium undulatum*; PolyJuni, *Polytrichum juniperinum*; PlanMari, *Plantago maritima*; PlanMajo, *Plantago major*; PoteErec, *Potentilla erecta*; PolyComm, *Polytricum commune*; PrunVulg, *Prunella vulgaris*; PseuPuru, *Pseudoscleropodium purum*; RanuAcri, *Ranunculus acris*; RanuRepe, *R. repens*; RhizPunc, *Rhizomnium punctatum*; RhytLore, *Rhytidiadelphus loreus*; RhytSqua, *R. squarrosus*; RumeAcet, *Rumex acetosa*; StelMedi, *Stellaria media*; SuccPrat, *Succisa pratensis*; TaraSp, *Taraxacum* spp.; ThuiTama, *Thuidium tamariscinum*; ThymPrae, *Thymus praecox*; TrifRepe, *Trifolium repens*; ViolPalu, *Viola palustris*; ViolRivi, *Viola riviniana*.

or age) on the first axis. Scoring most highly on the first axis are cryptogamic species that become more prevalent as the turfs age or deteriorate and the grasses and other tall vascular taxa are lost from the roof. The grasses (especially *Poa* and *Festuca* spp.) appear with lower scores on axis 1, where they occur with a wide range of tall herbs that are able to compete with them.

An eigenvalue of 0.551 indicates that a

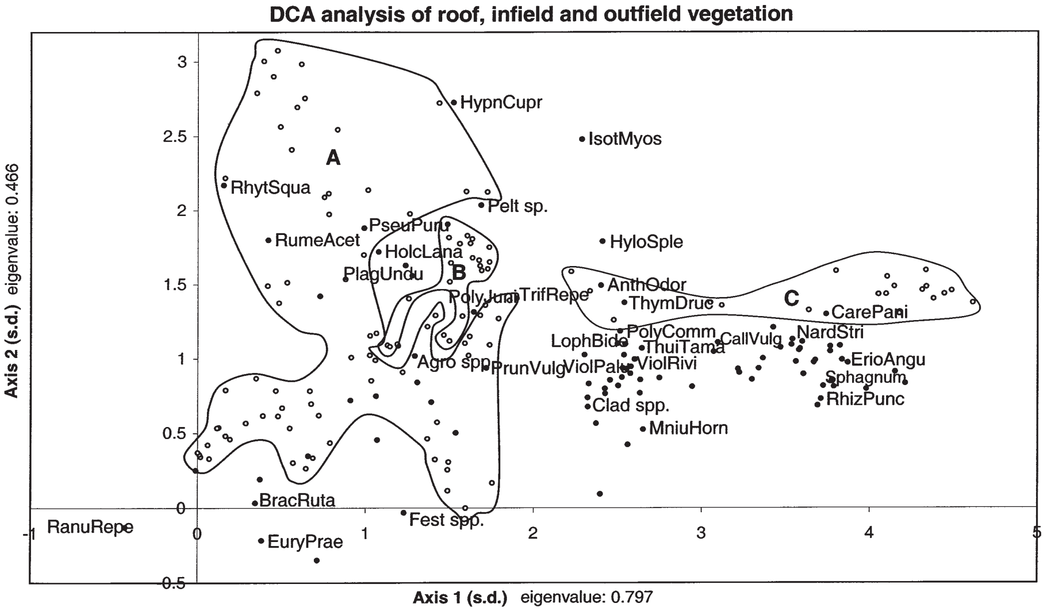

Figure 6. DCA scatterplot of roof, infield and outfield samples and taxa. Key: samples - open circles; taxa - filled circles. See Figure 4 legend for taxon abbreviations. A: infield samples; B: turf roof samples: C: outfield samples.

considerable amount of the variation in the turf-roof data set is explained by axis 1 (in Fig. 5), and its length of 3.5 S.D. suggests that there is not a complete 'turnover' of species (which would be indicated by a value of ≥4) within the turf roofs, and therefore, that despite differences in presumed condition, some species are common to all roofs.

The second axis in Figure 5 explains a smaller amount of variation in the turf-roof data set (eigenvalue of 0.372), and with no trend apparent, it will be discussed no further.

Very clear separation of three vegetation types is apparent in Figure 6, which ordinates turf-roof, infield and outfield vegetation. To the right, the samples from the outfield vegetation are clearly grouped together and characterized by mire taxa such as *Calluna*, *Nardus* and *Sphagnum* spp. Appearing more centrally on the first axis are *Prunella vulgaris* and *Viola* spp., indicative of better-drained outfield samples where grazing has resulted in the prevalence of grasses. The high eigenvalue for the first axis (0.797) indicates that it represents much of the variation in the data and its length (4.644 SD) shows that there is a complete turnover of species between the mire outfield samples and those from the turf roofs (i.e. the floristic composition at the extremes of these two habitats is completely different). The infield samples, appearing with low scores on axis 1, are dominated by the grass species for which this area is managed. They may also include taxa derived from the bryophyte layer that is most commonly dominated by *Plagiomnium undulatum* amongst other mosses and liverworts.

Correlations of DCA axes with slope, aspect and the presence of grazing

Correlations (Pearson product moment) of the DCA axes with slope, aspect and grazing reveal no significant result (Table 1) when the turf-roof data alone are analysed. A relationship becomes more apparent (axis 1 only) when the data from the infield and outfield areas are included, for the factors of slope (infield-outfield samples $\mu=12.3$ $\sigma=9.0$; roof samples $\mu=39.9$ $\sigma=2.4$) and grazing, but not aspect. However, these correlations remain statistically insignificant at the 95% confidence interval.

Table 1. R-values of correlations between the sample DCA scores and the variables aspect, grazing and slope for the roof data alone, and in combination with data derived from the infield and outfield. All values insignificant at the 95% confidence.

	Variable	Axis 1	Axis 2
Roofs only	Aspect	0.013	0.106
	Grazing	0.195	0.086
	Slope	0.192	0.169
Roofs and fields	Aspect	0.162	0.004
	Grazing	0.672	0.256
	Slope	0.637	0.238

Discussion

The significant and marked difference in the diversity of the ground and roof-turf data suggests that even if relatively homogeneous turfs dominated by favoured species were specially chosen, the diversity of the original turfs would have been higher prior to their incorporation into the roof. The ratio of plant species richness between the ground and roof vegetation is around 3:1, and the most species-poor ground quadrats contain more species than the most species-rich turf-roof quadrats. This observation refutes the third hypothesis (that the species-poor nature of roof turfs is a consequence of selection); this negative inference is supported by the limited literature which relates that the propagules of desirable species would be incorporated into the roofs but not that turfs were specifically cultivated for dominance by those species. A certain degree of turf selection remains a reasonable assumption, but the diversity of the ground vegetation, as measured within $1m^2$ quadrats, is such that it is unlikely that sufficiently large areas would have been available for the easy selection of homogeneous turfs for roofing *en masse*.

The axis length of DCA axis 1 in Figure 5, indicates further the small amount of variation within the vegetation of the grass roofs as there is not a complete turnover of taxa. This small amount of variation is demonstrated yet further in Figure 6, in comparison with the samples from the ground vegetation, where the turf-roof samples form a relatively small, closely-related grouping nested amongst the infield samples. This proximity reflects the fact that there is low species diversity and that the original turfs may have come from the infield. This is, of course, in contra-distinction to Ostenfeld's (1905-08) observation that the turfs are removed from outfield sources. There is likely to have been much variation in such practices in the past and the present situation may not follow the same pattern anyway.

Although some of the grass roofs are subjected to grazing, the insignificant result obtained by the *z*-test suggests that this factor is not responsible for differences in diversity and that the second hypothesis is not therefore supported. In addition, grazing, slope and aspect appear to have no correlation with either of the DCA axes in the turf-roof ordination (Fig. 5). Slope and aspect only become significant when the ground, and especially the mire, vegetation is included in the ordination data set. Slope differentiates between the poorly drained mire samples to the right of Figure 6, and grazing separates the heath-like outfield from the infield vegetation. Despite an apparent hydrological gradient on this axis, improvement to the infield areas is responsible for this distinction and explains the position of these samples to the left of the relatively unimproved roof turfs.

The absence of a correlation between aspect, grazing, slope and the DCA axes, when the roof data alone are analysed, suggests that an unmeasured variable is responsible for the composition of the turf-roof vegetation. In light of this, the refutation of hypotheses two and three, and comments by previous authors, it would be reasonable to assume that summer drought is involved in the low species diversity. This may be expected to correlate with the slope of the roof and its aspect - in the absence of such a relationship, it may be presumed that the effect of a rapidly-draining substratum in an exposed situation is of greater significance than either of these two variables.

Some of the variation that does exist within the turf-roof vegetation, appears to be attributable to the senescence of the dominant grass species and the condition of the roofs, but this could not be tested in the absence of the necessary information. Observation of abandoned, turf-roofed buildings suggests that as they age or fall into disrepair, the roofs lose their dense grass cover and cryptogams, such as lichens of the genus *Peltigeria* sp. or hypnaceous mosses such as *Rhytidiadelphus squarrosus* and *Isothecium myosuroides*, become increasingly prevalent. In addition, shoots of the grasses *Anthoxanthum odoratum* and *Holcus lanatus* become more frequent amongst those of the favoured *Festuca rubra* var. *fratercula* and *Poa trivialis* as well as a number of herbs, especially *Rumex acetosa* and *Thymus praecox*. The diversity of the turfs increases as a more heterogeneous structure becomes available for colonisation by a range of species. The ensuing abundance of cryptogam and herbaceous species that are able to withstand drought conditions lends further support to the acceptance of hypothesis one, that the low diversity of the roofs is a result of summer drought conditions.

Conclusion

The observation that grass roofs have a lower diversity than the vegetation from which they were derived is confirmed by this study. Although no direct evidence exists, the difference in diversity between ground and roof quadrats, the absence of a correlation between the variation of the roof vegetation, and the factors of aspect, slope and the presence or absence of grazing, indicate that an additional factor is probably responsible for the lower floristic diversity of the grass roofs. This may be summer drought, although further research would be needed to confirm this.

It is a pity that circumstances prevented us from determining more fully the many factors that are likely to come into play regarding the floras of grass roofs, although various directions for future research might be suggested. What of the age of the roof turfs, and does aspect result in roof segments being replaced at different times? Where roofs are patched, does quantification of the flora become a near-impossible task? What is the precise geographical origins of the turfs and have these changed within living memory? How many species (wind-blown propagules) establish on the species-poor roofs compared with the surrounding vegetation where species competition is much higher? Would monitoring of local climates (including roof micro-climates along with roof drainage characteristics) reveal important influences on changing roof floras?

Just as difficulties now face an assessment of once widespread Faroese peat-cutting activities (Sigvurdsen 2006), it may be the case that the passage of time is making it almost impossible to compare floristic changes that have applied traditionally in the face of modern roofing practices. This factor alone may make the assessment of differences in roof vegetation between and within settlements, or even as a result of family tradition, a near-impossible task. Nevertheless, it is hoped that the present paper might encourage further investigation of a fascinating element of the Faroese settlement landscape.

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