LICHENS AND LICHEN HABITATS AT COUL LINKS

Prepared by Dr Brian Coppins on behalf of Not Coul and the British Lichen Society

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Dr Brian Coppins. I have been studying lichens for 53 years, 35 of which were as Ascomycete & Lichen Taxonomist at the Royal Botanic Garden, Edinburgh. My field experience in a wide-range of habitats extends to most parts of Britain and Ireland, as well as overseas. Among my 250 or so publications, I was co-author of the two comprehensive guides to the lichens of Britain and Ireland, as well as for the Red Data Book for Lichens, and the two subsequent Conservation Evaluations of British Lichens. In the 1980s I was co-author of the Survey and Assessment of Lowland Heath, Dune and Machair Lichen Habitats, prepared for the then NCC. Currently, I am the Database Manager for the British Lichen Society's Scottish Sites Lichen Database, which holds close to half a million records.

1 Reasons for this report

I have written this report to explain the national and international lichenological importance of Ferry Links SSSI of which Coul Links forms an integral part. Further, to redress the paucity of information regarding lichens provided by the Environmental Statement, and to outline the likely impacts of the current planning proposal on the lichen interest at Coul Links. My statements and opinions are shared by the British Lichen Society, and this report closely follows the letter of objection by that society (DPEA: 545795(1).pdf).

2 Lichenological importance of Loch Fleet SSSI

2.1 Coul Links forms an integral part of the Loch Fleet SSSI. The lichenological importance of Coul Links has long been known. In a report to the then Nature Conservancy Council, on a *Survey and Assessment of Lowland Heath, Dune and Machair Lichen Habitats in the UK*, the British Lichen Society (BLS) assessed "Ferry-Coul Links" as of National [UK] importance (Fletcher et al. 1984). Their closing comment was "The site is unique, of Oceanic Northern Dunes type and is reminiscent of some features of Culbin, Forvie and Cuthill Links.

It stands alone, however, no back-up sites can be suggested." After 35 years this assessment has not changed.

2.2 Coastal dune systems have developed around our coasts since the retreat of the ice some 10,000 years ago. They have been much reduced in extent since the late 19C for several reasons, mainly afforestation (to achieve sand stabilisation) and recreation (golf courses, caravan parks). By no means all sand dune systems support species-rich lichen assemblages, especially if most of the system consists of mobile dunes and wet slacks. Lichen diversity reaches its zenith where extensive areas of dune heath (H11, *Carex-arenaria – Calluna vulgaris* heath) and certain dune grasslands (SD11, *Carex arenaria – Cetraria aculeata* dune community and SD12, *Carex arenaria – Festuca ovina – Agrostis capillaris* dune grassland) co-exist (**Annex 1**).

2.3 We are left with few such lichen-rich examples, with Loch Fleet SSSI (comprising Ferry Links and Coul Links) being the most biodiverse in the British Isles in respect of terricolous lichens in coastal habitats (**Annex 2 – Table 1**). From my personal experiences and discussions with overseas colleagues, Loch Fleet SSSI may well have the highest diversity of terricolous lichens for any dune system in NW Europe, rivalled only by the dunes on the Danish islands of Anholt and Laesø.

2.4 The Loch Fleet SSSI, comprising both Ferry Links and Coul Links, has a combined total of 101 ground-inhabiting (terricolous lichens) recorded to date. Ferry Links has a total of 87 lichen species, with 31 not found on Coul Links, while Coul Links has a total of 71, with 14 not found on Ferry Links. Hence the two sites are complementary to each other, with some features not found in the other or equally represented in both (**Annex 2 – Table 1**).

2.5 Regarding a conservation evaluation of individual species within the UK, Loch Fleet SSSI has 27 notable species, seven of which are on the UK Red-list (Woods & Coppins 2012), and again the two parts of the SSSI can be seen to complement one another (Annex 3 – Table 2).

2.6 Although Loch Fleet SSSI supports several rare and notable species it is the species-rich lichen assemblages that are just as important. By analogy, Salisbury Cathedral is built of mostly common rock types, it is only when they are put together do they make a

magnificent building. The situation is similar at Loch Fleet SSSI, where nature has done the 'building' over several millennia, creating a very special dune system.

2.7 In the recently published SSSI Guidelines for the selection of SSSIs concerning lichens (Sanderson et al. 2018), a Heathland, Moorland and Coastal Heath Index (HMCHI) is recommended for assessment of the biodiversity importance of heathlands. A score of 20 or more is stated to merit SSSI designation.

2.8 Both Coul Links and Ferry Links have an HMCHI far in excess of this threshold, with scores of 37 and 43, respectively, 46 when combined (**Annex 4 – Table 3**). This total is exceeded only by Culbin (49); other high HMCHI scores are Cuthill Links (43), Findhorn Dunes (35), Kinnaber Links, Barry Links and Tentsmuir (each 34), and Sands of Forvie (30). Sites on the Lothian coast fail to exceed a score of 13, reflecting heavy fragmentation by developments for recreational activities (especially golf courses), conifer plantations and agricultural improvements.

2.9 Application of the HMCHI is for heathland habitats only, so does not pick up on other vegetation types supporting lichen-rich assemblages, such as the extensive areas of SD12 grassland found at Ferry Links.

2.10 The records on which the above analyses are made were obtained from the British Lichen Society's Scottish Site Lichen Database, which includes validated data from the two commissioned lichen surveys (Coppins & Coppins 1998, Fryday 1992), BLS field excursions, SNH staff and individuals. It should be emphasised that until recently most of the recording effort has concentrated on Ferry Links, with the two commissioned surveys including only brief visits to the northern part of Coul Links. Indeed, a one-day visit by four members of the BLS in 2018 discovered 14 additional species for Coul Links, and as much of this site is still to be explored lichenologically more species can be expected to occur there.

3 Why does the Ferry/Coul dune system have such biodiverse lichen assemblages?

3.1 Size: there is a large extent and variety of nutrient-poor vegetation types, and their associated niches, that can to support lichens. These vegetation types include dune

heath, acid and calcareous grasslands and co-occurring areas of stabilised or semi-stabilised shingle and shell-sand.

3.2 Is a habitat, or rather mosaic of habitats, of long ecological continuity, enabling the accrual of species over time. Indeed, what we have today would have been part of a larger system that would have included what are now the Kart Track and the Golspie Links golf course, and perhaps further back in time, adjacent farm land and Ferry Wood.

3.3 Has been relatively free of major disturbances but has a sufficiently large area to allow for processes of vegetational change following localised disturbances (e.g. wind-blows and rabbit scrapes). Has a "stability of the instability".

4 Stability of the instability

4.1 Ground inhabiting (terricolous) lichens are not found everywhere, at least not in large numbers (as species or individuals) because either the soils are too nutrient-rich, or because there is no room for them as they are outcompeted by vascular plant vegetation (grasses, herbs, shrubs or trees) in the succession from bare ground. To succeed, these lichens require gaps in the vegetation to allow them to colonise. In a dune heath such gaps are provided by periodic disturbances, which can vary from major dune blow-outs and sand accretion to minor blow-outs and rabbit scrapes (**Annex 5 – Figs 3–4)**.

4.2 However, disturbance events must be followed by periods of stability to allow recovery, enabling bare sand to be colonized by a biological crust of lichens and associated micro-algae, cyanobacteria and bryophytes (**Annex 5 – Fig. 7)**. Eventually, higher plants such as *Calluna* or *Empetrum* will out-compete the lichens, and to maintain a long-term lichen interest the habitat requires a continuum of localised disturbance and recolonization. The larger the extent of the dune heath the more opportunity there is of allowing for these dynamic processes to occur over long periods of time - in other words, provide a "stability of the instability".

5 Role of rabbits

5.1 Following on from the above, I will quote (Houston 2008: 9):

"Rabbit activity, including grazing, burrowing, trampling and dunging, are all important factors in the maintenance of the habitat and its heterogeneity."

and:

"The loss of rabbits from the dune systems of north west Europe has led to a decrease in the small-scale dynamics of the grey dunes (van Til and Kooijman 2007). Species richness is highest at intermediate levels of rabbit pressure (Zeevalking and Fresco 1977, Isermann *et al.,* submitted). This grazing activity induces spatial heterogeneity and maintains succession stages with high numbers of species (Gibson 1988). It is rabbits, therefore, which have an indispensable role to play in the recovery of such dunes."

5.2 During the 2018 visit to Coul Links by BLS lichenologist, areas of rabbit activity were found to be the key or main niche for most of the more notable species in the dune heath, namely *Leptogium palmatum*, *Massalongia carnosa*, *Moelleropsis nebulosa*, *Peltigera malacea* and *Stereocaulon condensatum* (DPEA ref. 545795(1)),(**Annex 5 – Fig. 3 & 8**).

6 Nutrient status of dune heath

Where lichens can avoid competition from higher plants, they have in general evolved to cope with high levels of stress. In the case of heathland lichens the stresses provided by the habitat are a low nutrient status, combined with often rapid fluctuations from wet to dry conditions. Fertilisers are toxic to lichens (e.g. Remke et al. 2009, Vagts & Kinder 1999), and furthermore the nutrient input encourages growth of coarse grasses and reduces the amount of open ground (e.g. Houston 2008).

7 Comments on the Environmental Statement (ES) with regard to lichens

7.1 On pp 50 and 211 of the ES it is stated "Lichen assemblages have been included in the assessment as part of the dune heath assessment". However, no such assessment is given, other than mention of *Cladonia mitis* from a desk study, and references to the report by Fryday (1992). No lichen survey was commissioned, and the British Lichen Society was not approached for any further information or advice regarding the expediency of a more

detailed survey. On page 184 - "During 2016 surveys, lichen species were identified to the genus *Cladonia*" is far from adequate for making any kind of meaningful assessment; it is rather like saying "grass is present". There are 30 species of *Cladonia* known from Coul Links.

7.2 Fryday's (1992) comment that Coul Links "*was rather disappointing*" was based on a brief visit to the northern part of Coul Links and perhaps a walk further south close to the shore where "*elsewhere lichens were restricted to the edge of grassy knolls, but were often completely absent*" is still true today. It is clear to me that he did not venture into the more inland dune heath areas on the higher ground.

7.3 In my opinion, a lichen survey to adequately cover Coul Links would require at least four 'fine weather' field days by an experienced lichenologist.

7.4 There is no comparison of the lichen species and assemblages at Coul with those of other sites in eastern Scotland. The ES document makes only passing reference (p 185) to the UK-wide review of lowland heathland lichen habitats made to the Nature Conservancy Council (Fletcher et al. 1984) and failed to recognise that this review considered Coul Links (as part of "Ferry-Coul Links") to be of national importance.

7.5 Transplantation of dune heath is suggested (p 218). A few examples are given where this has taken place. All the sites are not known to have supported rich lichen assemblages, with the possible exception of Skibo Castle (adjacent to Cuthill Links). I have no previous knowledge of this or what was involved. Indeed, was it dune heath 'transplantation' or 'expansion'?

7.6 Transplantation of habitats is not proven as a successful mitigation and is not recommended by JNCC (*A Habitats Translocation Policy for Britain*, 2003). Such transplantations of terricolous lichens, to my knowledge, have all failed after two or three years (e.g. Lambley 2018). The lichen assemblages in the dune heath at Coul are found on more or less bare sand, and open areas adjacent to *Calluna* – and thus not physically possible to move without irreparable damage. Even if possible – where would the transplantations be to?

8 Impacts of current proposals

8.1 In my opinion, the current planning proposal would have the following negative impacts on the lichen assemblages at the site.

8.2 Reduction of available habitat and fragmentation of an intact dune system of national and international importance. Given that the Ferry/Coul dune system has already been reduced in area over the past 150 years, the current proposal would greatly diminish the area of lichen-rich dune heath, thus reducing the potential for dynamic vegetational processes to continue without a loss in biodiversity.

8.3 Destroy most of the area occupied by the red-listed lichens *Leptogium palmatum* and *Peltigera malacea*, as well other notable species such as *Bryobilimbia sanguineoatra* and *Stereocaulon condensatum* (**Annex 5 – Figs 1 & 2**).

8.4 Additional reduction of small scale, localised disturbance from control of rabbits.

8.5 Increased nutrient input into the system through fertiliser treatment, for vegetation that is dependent on a low nutrient status.

8.6 Possible impact of fungicide treatment. Lichens are symbiotic organisms between fungi and algae. Hence, any fungicidal treatment of the playing area would kill them, and there would always be the danger of accidental drift.

9 - References

British Lichen Society (May 2018) *Registered objection to the proposed planned 18-hole golf course at Coul Links, part of Loch Fleet SSSI* (Highland Council Planning Application 17/04601/FUL). Included in DPEA ref. 545795(1).pdf.

Coppins, A.M. & Coppins. B.J. (1998) *Loch Fleet NNR (East Sutherland VC 107) Lichen Survey and Permanent Lichen Quadrats.* Unpublished report for Scottish Natural Heritage. Order No. E007007. 152 pp.

Fletcher, A., Coppins, B.J., Gilbert, O.L., James, P.W., & Lambley, P.W., (1984) *Survey and Assessment of Lowland Heathland Lichen Habitats.* Report to the Nature Conservancy Council [Contract No HF3/03/266]. http://www.britishlichensociety.org.uk/sites/www.britishlichensociety.org.uk/files/about-lichens-downloads/Lichen%20Habitats%20-%20Lowland%20Heath%2C%20Dune%20And%20Machair-pp1to58.pdf and www.britishlichensociety.org.uk/sites/www.britishlichensociety.org.uk/files/about-lichens-downloads/Lichen%20Habitats%20-%20Lowland%20Heath%2C%20Dune%20And%20Machair-pp59-113.pdf

Fryday, A.M. (1992) *The Lichen Flora of some Maritime Heaths in East Sutherland.* Report to Scottish Natural Heritage.

Houston, J. (2008) *Management of Natura 2000 habitats. 2130 *Fixed coastal dunes with herbaceous vegetation ('grey dunes')*. European Commission. ec.europa.eu/environment/nature/natura2000/management/habitats/pdf/2130_Fixed_coastal_dunes.pdf

JNCC (2003) *A Habitats Translocation Policy for Britain*. 16 pp. http://jncc.defra.gov.uk/pdf/habitats_policy.pdf

Lambley, P. (2018) The demise of the Breckland lichen flora. *Journal of Breckland Studies* **2:** 39–51.

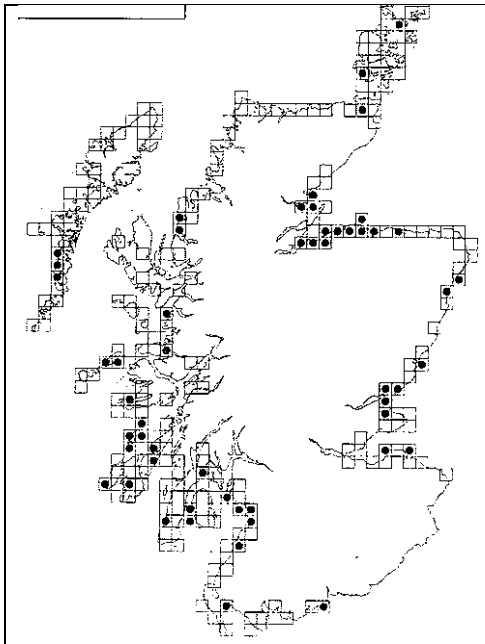
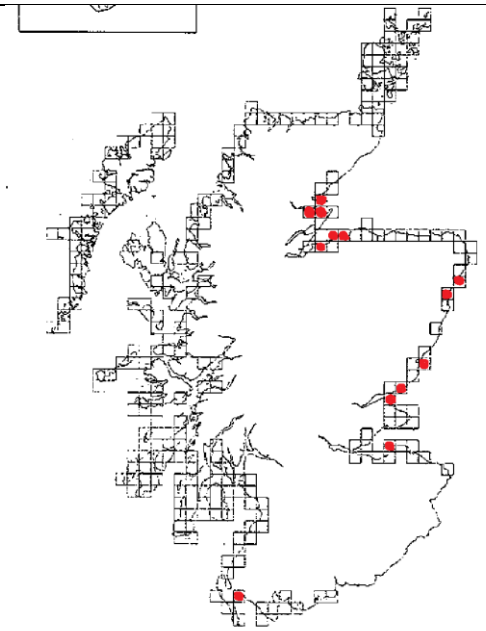
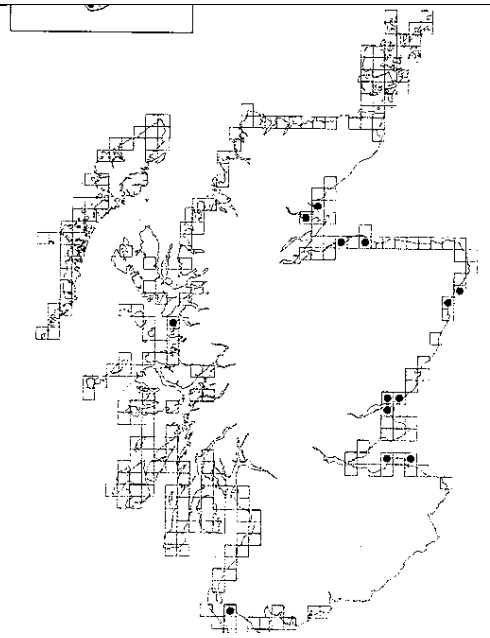
Remke, E., Brouwer,E., Kooijman, A., Blindow I. & Roelofs, J.G.M. (2009) Low atmospheric nitrogen loads lead to grass encroachment in coastal Dunes, but only on acid soils. *Ecosystems* **12**(7): 1173–1188. https://link.springer.com/article/10.1007%2Fs10021-009-9282-0

Sanderson, N., Wilkins, T., Bosanquet, S. & Genney, D. (2018) *Guidelines for the selection of* Biological *SSSIs. Part 2: Detailed Guidelines for Habitats and Species Groups. Chapter 13: Lichens and associated microfungi*. Peterborough: Joint Nature Conservation Committee. http://jncc.defra.gov.uk/pdf/SSSI_chapter13_Lichens_2018.pdf

Scottish Biodiversity List (2013). http://www.gov.scot/Topics/Environment/Wildlife-Habitats/16118/Biodiversitylist/SBL.

Vagts, I. & Kinder, M. (1999) The response of different *Cladonia* species after treatment with fertilizer or lime in heathland. *Lichenologist* **31:** 75–83.

Woods, R.G. & Coppins, B.J. (2012) *A Conservation Evaluation of British Lichens and Lichenicolous Fungi*. Species Status 13. Peterborough: Joint Nature Conservation Committee. http://jncc.defra.gov.uk/pdf/Lichens_web_Edits%2020%20Aug.pdf

		
H11 Dune Heath [*Carex arenaria – Calluna* vulgaris heath] in Scotland; from Dargie (2000)	Coastal lichen-rich heath. Sites with 25 or more ground inhabiting lichens. Data from BLS Lichen Database.	SDll *Carex arenaria – Cetraria aculeata* dune community in Scotland; from Dargie (2000)

Annex 1. Comparison of distribution of sites with species-rich coastal heath with the two main associated vegetation types. This demonstrates how scarce these biodiverse lichen sites are in the context of these two similarly scarce plant communities.

Annex 2

Table 1. Tabulation of number of terricolous lichens from a selection of important dune systems in UK and Isle of Man.

Scottish sites are ordered from north to south, the others are arranged numerically as to number of terricolous lichens recorded. The list includes only lichens found on the ground, and **does not include** those found only on shingle, shell fragments, shrubs, driftwood or man-made structures.

UK locations	**County**	**No. of terricolous lichens**
Scotland:		
Dunnet Links SSSI	Caithness	23
Loch Fleet SSSI (Ferry + Coul)	East Sutherland	101
Ferry Links		87
Coul Links		71
Cuthill Links	East Sutherland	71
Morrich More	East Ross	26
Whiteness Head	Easterness	43
Culbin Sands, Culbin Forest and Findhorn Bay SSSI	Moray	73
Findhorn Dunes	Moray	64
Sands of Forvie	Aberdeenshire	41
Menie Links & Pettens Links (pre-golf course data)	Aberdeenshire	34
Kinnaber Links	Angus	50
Barry Links	Angus	51
Tentsmuir	Fife	48
Aberlady Bay	East Lothian	41
Sandy Knowes & West Links	East Lothian	30
Yellow Craig & East Links	East Lothian	21
Tyninghame (N of Bathan's Strand)	East Lothian	16
Belhaven Bay	East Lothian	24
Barns Ness	East Lothian	12
Torrs Warren	Wigtownshire	45
England, Wales & Isle of Man:		
Braunton Burrows	Devon	48
Blakeney Point	Norfolk	46
Ainsdale/Freshfield	Lancashire	44
Penhale Sands	Cornwall	40
Winterton – Horsey Dunes	Norfolk	38
Studland	Dorset	33
Newborough Warren	Anglesey	32
Nicholaston Burrows	Glamorgan	24
Point of Ayre	Is of Man	21
Morfa Harlech	Merioneth	16
Scolt Head	Norfolk	14
Kenfig Burrows	Glamorgan	8
Ynyslas Dunes	Ceredigion	6

Annex 3

Table 2. **Notable terricolous lichen species recorded from Loch Fleet SSSI**

	Conservation status/rarity	**Coul Links**	**Ferry Links**
Lichens			
Agonimia gelatinosa	NS	+	+
Bacidia egenula	NS		+
Bacidia viridescens	NS		
Bryobilimbia sanguineoatra	NS	+	
Cladonia cariosa	NS		+
Cladonia carneola	NS		+
Cladonia mitis	**NT, NR, Sc**	**+**	**+**
Cladonia phyllophora	**NT, NS**		**+**
Cladonia uncialis s1ubsp. uncialis	**NT, NS**	**+**	**+**
Cladonia zopfii	NS	+	+
Collema bachmanianum	**NT, NS**		**+**
Cryptodiscus gloeocapsa	NS	+	
Hypogymnia vittata	**VU, NR, P, Sc**		**+**
Lecania subfuscula	NS	+	
Lecanora zosterae	NS	+	
Lepraria elobata	NS	+	+
Leptogium palmatum	**NT, NS**	**+**	
Moelleropsis nebulosa	NS	+	
Peltigera malacea	**EN, NR, P, Sc**	**+**	**+**
Peltigera neckeri	NS	+	+
Psoroma hypnorum	NS	+	+
Polychidium muscicola	NS	+	
Sarcosagium campestre	NS		+
Stereocaulon condensatum	NS	+	+
Toninia sedifolia	P		+
Thelocarpon impressellum	NS		+
Vezdaea acicularis	NS		+
Lichenicolous fungi			
Dacampia rufescentis	NR, Sc		
Polycoccum trypethelioides	**NT, NR**	**+**	

Conservation Evaluation etc. (Woods & Coppins 2012): VU = Vulnerable; EN = Endangered; NT = Near Threatened; NR = Nationally Rare; NS = Nationally Scarce; P = UK BAP priority species; Sc = on Scottish Biodiversity List [Sect.2(4)]. Red-listed species in **bold** type.

Annex 4

Table 3. Tabulation of number of terricolous lichens and HMCHI* scores for lichen-rich dune systems in Scotland.

The sites are ordered from north to south. The list includes only lichens found on the ground, and **does not include** those found only on shingle, shell fragments, shrubs, driftwood or man-made structures.

*HMCHI - Heathland, Moorland and Coastal Heath Index (Sanderson et al. 2018)

Location	**County**	**No. terricolous**	**HMCHI**
Dunnet Links SSSI	Caithness	23	5
Loch Fleet SSSI (Ferry + Coul)	East Sutherland	101	46
Ferry Links		87	43
Coul Links		71	37
Cuthill Links	East Sutherland	71	43
Morrich More	East Ross	26	11
Whiteness Head	Easterness	43	21
Culbin Sands, Culbin Forest and Findhorn Bay SSSI	Moray	73	49
Findhorn Dunes	Moray	64	35
Sands of Forvie	Aberdeenshire	41	30
Menie Links & Pettens Links (pre-golf course data)	Aberdeenshire	34	19
Kinnaber Links	Angus	50	34
Barry Links	Angus	51	34
Tentsmuir	Fife	48	34
Aberlady Bay	East Lothian	41	13
Sandy Knowes & West Links	East Lothian	30	11
Yellow Craig & East Links	East Lothian	21	6
Tyninghame (N of Bathan's Strand)	East Lothian	16	4
Belhaven Bay	East Lothian	24	6
Barns Ness	East Lothian	12	2
Torrs Warren	Wigtownshire	45	29

All of the above sites, except for Findhorn Dunes, fall within a SSSI boundary

Annex 5

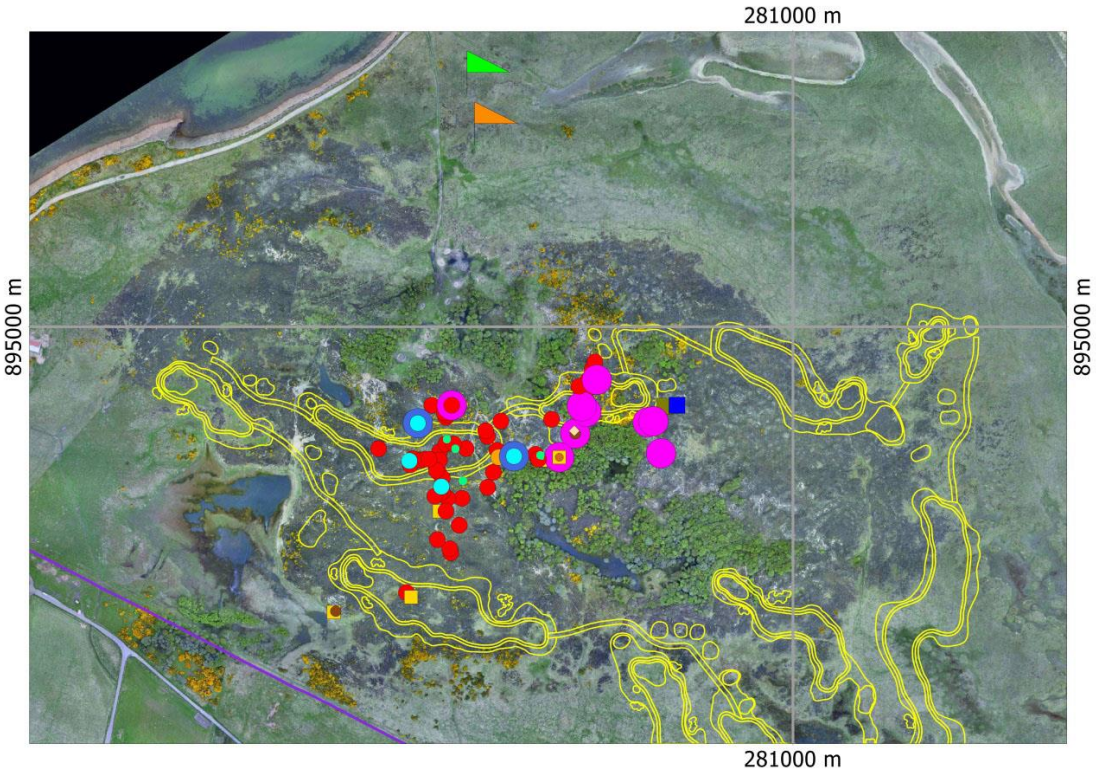


Fig. 1. See caption for Fig. 2. The arrows in the upper (northern part) of the map show locations for *Peltigera leucophlebia* (orange) and *P. leucophlebia* with *P. neckeri* (green).

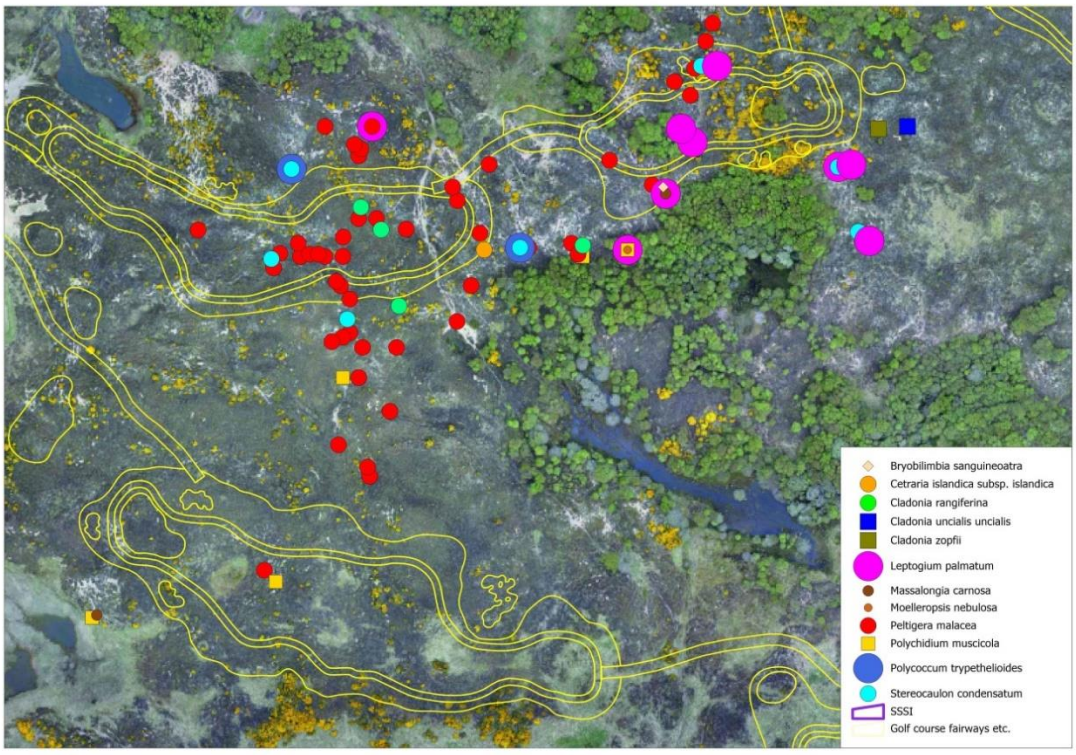


Fig. 2. Locations for some notable lichens at Coul Links. Records made on 03/05/2018, with some additional records from David Genney and Stewart Taylor made in late 2017. Prepared by Andy Acton. The yellow lines outline proposed fairways and greens.

Fig. 3. A typical site for *Peltigera malacea* around a rabbit hole. NH80623 94821. Photo. Brian Coppins.

Fig. 4. A location for *Leptogium palmatum*, *Massalongia carnosa* and *Moelleropsis nebulosa* alongside narrow eroded channel/path at NH80769 94887. Photo: Brian Coppins.

Fig. 5. *Peltigera malacea* in dry state at location in Fig. 3. NH80623 94821. Photo. Brian Coppins.

Fig. 6. *Peltigera malacea* in a wet state showing its distinctive green coloration. Culbin Forest. Photo. Sandy Coppins.

Fig. 7. *Stereocaulon condensatum* forming a 'biological soil crust' at NH80593 94858. Photo. Brian Coppins.

Fig. 8. Close-up of *Leptogium palmatum* in rabbit scrape at NH80639 94918. Photo. Andy Acton.

Fig. 9. *Cladonia mitis* at Findhorn Dunes. Photo, Sandy Coppins.

Fig. 10. *Peltigera malacea* in dry state at Findhorn Dunes, showing clear evidence of rabbit activity. Photo. Sandy Coppins.

Annex 6

Lichens - some FAQs

What is a lichen? A lichen is not a single organism; it is a stable symbiotic association between a fungus and algae and/or cyanobacteria. Like all fungi, lichen fungi require carbon as a food source; this is provided by their symbiotic algae and/or cyanobacteria, which are photosynthetic. The lichen symbiosis is thought to be a mutualism, since both the fungi and the photosynthetic partners, called photobionts, benefit. It allows the two (sometimes three) partners, in the form of lichens, to exploit nutrient poor habitats or niches unfavourable to higher plants, such as exposed rock and barren ground.

The name of a lichen refers to the fungal partner; the algae have separate names.

How many species of lichen are there? About 20,000 world-wide have been described (named), but a conservative estimate is probably 30,000. There are about 2000 in the British Isles (about 2X the no. of native vascular plants, and of bryophytes).

What are lichenicolous fungi? These are fungi which parasitize lichens. Most of them are obligately parasitic on lichen – i.e. they grow only on lichens, and very many of them are specific to a single host species or host genus. There are over 500 species recorded from the British Isles.

What is the importance of lichens?

A. Biodiversity & Ecology

Lichens are amongst the first organisms to colonize barren surfaces (e.g. road cuttings, rock outcrops and bare ground) and prepare these areas for later plants by trapping moisture and windblown organic debris and then contributing to the organic deposits when they themselves die and decay.

Lichen colonies provide food and/or shelter for numerous invertebrates, often the very tiny invertebrates, which are then eaten by larger invertebrates which, in turn, are eaten by other creatures (e.g. birds & mammals). Such lichen colonies are thus indirectly important in various food chains.

Lichens are often used as nesting material by birds, and some birds are very choosy as to what species of lichen they use.

Lichens are a source of food for some mammals, especially in 'arctic habitats'. This is not very apparent in the British Isles, but can be so in harsh winters, when lichens are eaten by deer and rabbits.

Lichens act as the sole host to numerous specialist fungi (see Lichenicolous fungi above).

Nitrogen constitutes about 80% of the volume of the earth's atmosphere and is essential for life, yet the majority of organisms cannot make direct use of atmospheric nitrogen. Cyanobacteria are amongst the organisms that are able to make direct use of atmospheric nitrogen and such organisms are said to be able to **fix** atmospheric nitrogen. Hence, lichens with cyanobacterial photobionts fix atmospheric nitrogen. After fixation the nitrogen can become available to plants following the death and decay of the lichen thallus or through herbivore defecation after consumption of such lichens. Some nitrogen may be leached from the lichen and be trapped by other epiphytes (for eventual release through the same processes of death or consumption) or drain into the soil. Various studies have shown that lichens can be a significant source of nitrogen for plants.

Some lichens are very effective sand and soil binders and can help in dune stabilization and erosion control. In arid and sub-arid areas lichens, in association with bryophytes, they can create extensive 'biological soil crusts' on the soil and such crusts help maintain the underlying soil structure and resist erosion.

Lichens are an integral part of the biodiversity of many habitats, both in terms of numbers, and of cover. It is estimated that c. 6% of land surfaces is covered by lichens. This is likely an under-estimate as it does not take full consideration of the (sometimes close to 100%) lichen cover of tree boles, branches and twigs) – hence lichens can be considered important 'holders' of carbon.

B. For Man

Lichens are indicators of the health of our environment and have been widely used as bio-indicators or bio-monitors in studies of air quality, metal and nucleotide contamination and water quality (e.g. in rivers with a rocky river-bed).

Lichens are indicators of the ecological continuity (or not) of woodlands and other habitats. The high number of lichens, including some of restricted distribution (geographical and/or ecological), occurring at Loch Fleet SSSI is indicative of a long ecological continuity – degree of pristineness if you like!

Many crustose lichens that form a crust or skin over rock surfaces are very slow growing (e.g. a radial growth rate of c. 1 mm per year), and have been used to date the retreat of glaciers, age of rock falls, past events affecting ancient buildings. Such studies are termed Lichenometry.

Lichens have had medicinal uses for centuries – some effective, some not! However, lichens produce an array of chemicals not found elsewhere in the natural world, such that they are still much used in pharmacological investigations, especially regarding anti-cancer treatments.

Many people consider lichens to be an important contributor to aesthetic appeal of natural landscape (including dune systems), and also of gravestones and other stonework, roofs, wooden fencing and the like. Such appreciations are widely alluded to in works of literary prose and poetry.

Admittedly, lichens can be a nuisance, e.g. by colonizing the recent habitat, solar panels. However, these can be easily dealt with by regular cleaning. Lichens 'disfiguring lawns' is usually a reflection that the lawn has not been properly cared for by regular feeding with fertilisers (cf. golf greens).

Lichens have been used for hundreds of years for providing a source of natural dyes for textiles and litmus production. Although still used in some craft industries (e.g. production of Harris Tweed), lichen dyes are now mostly substituted by artificial dyes.

Lichens have limited use as a human foodstuff – and have a very much 'niche' market, mainly in the Far East and the Indian subcontinent. For example, the lichen *Thamnolia*, found at Ferry Links, is sold in Chinese markets as 'snow tea'.

Lichens, especially the *Cladonia* 'reindeer lichens' as found at Coul Links, are commonly used in commemorative wreaths and to act as trees in model railways and architect's models.

Lichens, especially *Evernia* and *Pseudevernia*, are still used extensively in the production of ‘quality’ perfume and are gathered in large quantity in the Mediterranean region.