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Interim report to Forestry Commission and Nature Conservancy Council

NATURE CONSERVATION IN UPLAND CONIFER FORESTS

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CONTENTS

SUMMARY

The first year's botanical fieldwork at Kielder Forest has been completed with fifty four kilometre squares sampled. In addition a special study of the Bryophytes has been completed by Dr Hill, the report on which is included in this document

Analysis of the field data is in hand using software developed for the National Vegetation Classification (NVC) but, chiefly due to unavailable delays resulting from major computer hardware modifications at Bangor, will not be completed until February 1988.

This delay precludes submission here of detailed proposals for next field season. However, we believe that because of the sophisticated stratification used at Kielder, general coverage of the major vegetation types has been adequate. Any botanical studies there next year should concentrate on the more complex and diverse types (e.g. base-rich streamsides, former pastures) and less common habitats (e.g. broadleaved woodland, scrub, thinned stands). Linear sampling of vegetation along the courses of selected rivers and streams is likely to yield particularly interesting results.

We propose that the testing of the vegetation classification developed for Kielder in several other upland forests be delayed until 1989 when the results of the additional studies at Kielder will be to hand. However, it would be useful at this stage to discuss appropriate forests for the verification exercise.

We intend that the main thrust of the fieldwork in 1988 will be a study of selected major invertebrate groups (macro-lepidoptera, coleoptera, arachnida, and possibly diptera) associated with the main vegetation types at Kielder. The possibilities for using FC/NCC staff to help in the collection of samples and servicing of equipment are discussed but contingency plans have been made to deal with these aspects in case such help is not available. These plans would involve some sub-contracting and the views of FC/NCC on this are sought.

There is a possibility of doing some ornithological fieldwork at Kielder in 1988 and/or 1989. It is important that any such work should complement other studies and contribute new information rather than simply confirming earlier results on associations between bird species diversity and abundance and stage of forest succession.

Proposals for further research work are presented.

1. INTRODUCTION

The study was commenced in October 1986 with the following objectives:

1.1 To determine if and how plantation design and patterns of felling and restocking can be modified to improve plantations for selected groups of species.

1.2 To determine if and how management during the forest rotation can be modified to improve forests as wildlife habitats.

To achieve these primary objectives the study has the following contributory objectives:

1.3 To describe the habitats actually and potentially available in terms of successional stages and vegetation types.

1.4 To relate the habitat requirements of bryophytes, lepidoptera and coleoptera, and birds to these categories.

After discussions between ITE/NCC/FC nominated officers to consider the project generally, and a subsequent meeting with Dr Malloch and Dr Rodwell of the University of Lancaster to discuss vegetation sampling procedures in relation to the intended use of the National Vegetation Classification in the project, a proposed outline programme of work for the first field season at Kielder Forest was presented to a meeting of nominated officers in London at the end of January 1987. This procedure, including a complex stratification procedure for the selection of sample 1km squares, was agreed and, with slight modifications, has been implemented. The purpose of this report is to inform those concerned about progress to date; to put forward proposals for a programme of work for the remainder of the project period; and to make suggestions for further research work.

2. PROGRESS TO DATE

It was agreed at the January 1987 meeting of nominated officers that the area of Kielder Forest made it impossible to do vegetation sampling from more than a small proportion of it. This necessitated the use of a sophisticated stratification system to optimise the likelihood of all vegetation types occurring there being sampled. The scheme approved at that meeting has, with minor modifications made as a result of field experience at Kielder, been implemented. Details of the methodology and of the sample coverage are given in Appendix 1.

The revised scheme resulted in 54 kilometre squares being sampled (11% of those available) - one square from each selected strata and one additional square from those strata with >9 squares. Because of the scarcity of limestone outcrops and base-rich soils in Kielder and the presumption that they would carry a particularly species-rich flora and associated fauna, it was originally intended that limestone squares in each strata be sampled in addition to those not containing limestone, which would have resulted in 75 squares being sampled in total. However, early in the fieldwork it was realised that the effects of limestone outcrops on the flora were usually very localised and sometimes apparently non-existent so it was decided that where there were squares containing limestone in a strata these would merely be selected in preference to non-limestone squares rather than in addition to them.

Groups recorded in each sample quadrat included all vascular plants and bryophytes. Because of the relative importance of the latter group in moist upland habitats, of which there are many in Kielder, and the expertise required for their accurate identification, an additional supplementary study of bryophytes was done by Dr M.O. Hill at the end of the field season, visiting a representative range of habitat types. His report is included here (see Appendix 2).

The input, handling and analysis of the field data at Bangor involve the use of the VESPAN suite of programmes developed for the NVC, which have been adapted to run on the VAX computer. Delays caused by computer hardware problems at Bangor during the autumn have hindered the process and it has not been possible to complete the analysis. This being so we cannot make fully informed comments either on the past season's fieldwork nor on the plans for next year. This will be possible when the full analysis and interpretation are to hand - probably in late February. However, it is possible on the basis of experience in Kielder to present a general picture of what has been achieved so far and what should be done next year which is unlikely to be substantially affected by the results of the vegetation analysis.

It is clear, for example, that the stratification was in the event more complex in some regards than necessary and that it will be possible to aggregate some strata thus, in effect, increasing sample replication. Bearing this in mind there is little doubt that the coverage of the main range of vegetation types will be seen to be more than adequate, especially for the forest blocks and rides. It may be less satisfactory for the most complex (and hence for nature conservation, most interesting) sites, such as base-rich streamsides and former pastures, and for less common habitat types which are probably underrepresented (e.g. broadleaved woodland, scrub, thinned stands). It is planned to do further sampling in these categories as outlined in section 3 below, the extent to be determined by the analysis of the existing data.

3. PLANS FOR THE 1988 AND 1989 FIELD SEASONS

Assuming that the main vegetation types in Kielder have been satisfactorily characterised four major categories of fieldwork remain to be done:

3.1 To supplement the information for the more complex sites in Kielder and those which occur less commonly there. In particular it is felt that a more detailed study of broadleaved woodland, scrub, thinned conifer stands and especially riparian habitats would be worthwhile. In the case of the rivers and streams it is apparent that there is usually considerable variation in their character and associated flora and fauna along their courses and it is proposed that a number of streams be sampled at intervals from their source to where they join major rivers or enter Kielder Water. It is envisaged that this additional survey work will be done in 1988 and will require three weeks of fieldwork for two people.

3.2 To test the vegetation classification system developed at Kielder in other upland forests and to adapt and extend it as necessary to produce a system of general use to the forest manager concerned with identification, enhancement and diversification of sites of nature conservation value. The amount of time required for the fieldwork to do this depends on the extent and intensity of sampling. It would be sensible to leave this until 1989 when the full range of vegetation types at Kielder have been fully described.

3.3 To survey the invertebrate fauna of Kielder, relating it as far as possible to the vegetation classification. It is intended that in addition to the lepidoptera and coleoptera, which were specified for attention in the contract document, other major groups (definitely the arachnida and possibly the Diptera) likely to be of importance in the forested upland context shall be studied. This work will be done in 1988. Staffing and other problems are discussed in 4 below.

3.4 To do such studies as shall be agreed on the birds of Kielder (mammals are excluded from consideration in this contract). These should be planned so as to complement other ornithological work which is in hand and should not simply repeat earlier studies relating bird species diversity and abundance to forest successional stages. Dr Moss would be available for a limited input in 1988 or 1989.

4. ARRANGEMENTS FOR THE 1988 FIELDWORK

Work itemised under 3.1, and 3.4 can be completed using full-time ITE staff from Bangor. The methodology used for the vegetation sampling will be the same as that used in the 1987 fieldwork. That for the bird work will depend on what is to be done.

Extensive discussions have been held within ITE concerning the methodology to be used for the invertebrate survey and the means of carrying out the work. It is felt that it is not possible in this project, given the funds available, to survey canopy-dwelling insects as the approved methods are very labour intensive in the field and are in any case not well developed. It is suggested that such a study might form the basis for further research (see 5 below).

It is proposed that the work be limited to pitfall trapping, turf and litter extraction (which complements the former by collecting less mobile species) and light trapping, all methods which enable remote collection of a wide range of insects at much reduced cost compared with on-the-spot sampling. The placement of the traps and the sampling points for turf and litter extraction having been carefully determined by ITE invertebrate ecologists on the basis of the vegetation analysis, it would be possible for the routine collection of the samples and servicing of the equipment to be done by reliable non-expert staff. Some of this could be done by ITE support staff based in Bangor, but it would be much more cost-effective to use more locally based labour for the bulk of the work. It would be perfectly possible for suitably motivated FC or NCC staff to do this and if they wished to, and were competent, they could become more intimately involved, perhaps through doing some initial sorting of the catches. There is also the possibility of a keen person actually supplementing the main sampling by doing routine butterfly counts on a regular basis along pre-determined sample 'walks'. Similar butterfly counts have been done efficiently in the past in other areas by NCC wardens.

Considering it necessary to assume for the sake of planning that no such FC/NCC help may be available I have made alternative outline arrangements for a local involvement, but with no commitment whatsoever at this stage. This would involve sub-contracting the sample collection, equipment servicing and preliminary sorting of catches, as well as the extraction of the soil and litter samples to the Zoology Department at the University of Durham under Dr Coulson's supervision. If it were possible to find some extra funds to go some way towards meeting his costs (actual costs for a Durham involvement have **not** been discussed at this stage), Dr Coulson would also be prepared to look at the diptera from the catches. Additionally Dr Judy Butterfield there would be prepared to do identification of the coleoptera excluding the staphylids, but again this would have to be paid for, at least in part. I have agreed to let Dr Coulson know whether we wish to take matters further after our December meeting.

These arrangements would fit in well with our available ITE in-house expertise. Colin Welch at ITE Monks Wood is an expert on the staphylid beetles and would be available to do them, while Nick Gratorex-Davies (also at Monks Wood) would be interested in identifying lepidoptera and Peter Merrett at ITE Furzebrook would do the spiders.

Another possible alternative to the use of the people at Durham is for ITE to have a more-or-less continuous presence at Kielder in 1988 as in 1987, in the form of a specially employed casual member of staff with some training in invertebrate ecology (perhaps a recent graduate). We need to consider in this case (a) the likelihood of getting a suitable member of staff (b) the amount and range of work that he could be expected to complete and (c) the relative cost of this approach, bearing in mind that unless furnished accommodation could be provided full travel and subsistence would have to be paid on top of salary. If we were to decide on this option steps would need to be taken very quickly to try and find a suitable person.

5. PROPOSALS FOR FURTHER RESEARCH WORK

Although thoughts in this area are to some extent limited by lack of knowledge until the results of the vegetation analysis are available, it is possible now to propose a range of possible studies.

5.1 Base-rich streamsides have been identified as a particularly rich habitat type for flowering plants in Kielder. The rocks and crags in the gorges associated with them are, in addition, particularly good bryophyte habitat (see Appendix 2). To what extent do the following factors contribute to or reduce their interest in terms of structural and species diversity:

5.1.1 Cutting back of the crop trees from stream edges

How quickly does any effect take place and is the recovery of the streamside flora eventually complete? Is the length of any recovery period directly proportional to the time period during which the vegetation was shaded or is there a more complex relationship? How are shading effects related to the heights of the remaining trees - how far back must crops of different heights be cut to allow development of 'normal' streamside vegetation? Comparison of streamsides which have never been planted up with similar ones which have been planted for various time periods and which are subsequently cleared is required.

5.1.2 Grazing, particularly by Roe deer

Roe deer are present throughout the forest and clearly have a considerable effect on broadleaved tree and shrub survival and regeneration. However, they are at very low densities compared with those of sheep on the unafforested moorlands and probably have relatively little effect on the ground flora. It would be worth finding out just how selective they are and how much they influence ground flora in comparison with sheep. Stretches of streamside could be fenced to exclude deer while leaving similar stretches unfenced and yet others with deer excluded but sheep enclosed. The whole question of the potential for positive use of deer and sheep as management 'tools' for maintaining and enhancing the conservation value of these streamsides, as well as other high conservation value sites such as former pastures which are no longer commercially grazed, should be studied.

5.1.3 Planting broadleaves

There is considerable planting of broadleaves along watercourses at Kielder. This is often done at fairly uniform spacing and without clear gaps. It may be that as the trees grow up they will shade out much of the interesting ground flora. Trials are needed comparing planting in groups with linear planting and including different species alone and in combination planted at a range of spacings. As well as looking at the effects of the trees on the ground flora and its associated fauna, the contribution of the trees themselves to floral (bryophytes, algae, fungi and lichens) and faunal diversity and abundance should be investigated. Some streamsides and river banks in Kielder contain remnant broadleaved woodland, often dominated by birch and alder. It would be interesting to compare the wildlife value of these trees with the planted broadleaves as the latter develop. Also, how important is the proximity of existing mature trees to the establishment of the full range of epiphytic flora and invertebrates on newly planted trees of the same or different species?

5.2 Former pastures form one of the most important habitats for the more interesting plant communities in Kielder Forest. Many of them are unimproved, never having been ploughed or re-seeded. While some of them are still grazed others are not and it is apparent that, as would be expected, removal of grazing leads to a decrease in species diversity with coarse grasses tending to dominate. A survey of the former farmland areas is suggested to determine which are of most interest and why. this should be linked to experiments comparing different methods for managing them. Mowing at fairly infrequent intervals might be an economically acceptable alternative to grazing where the latter is, for one reason or another, no longer possible.

5.3 Excepting Kielder Water, areas of open water are very scarce in Kielder Forest, although they would be very easy to produce with the aid of modern heavy plant. There are some flooded quarries and these seem to have a particularly rich and varied flora and fauna, especially compared with dry quarries, which are far more numerous. We need to know more about the effects of providing open water habitats in the forest and these existing areas give a good opportunity for the necessary studies. How quickly does plant colonisation take place and what are the patterns of succession of flora and fauna? How important is the pH and nutrient content of the water body to these processes? How important is proximity of existing water bodies? How important is the size of a water body within the forest in determining its attractiveness to visiting birds?

It was noted early in the 1987 survey period that frogs, toads and palmate newts were using the fire fighting ponds as spawning sites. How important are these ponds and how might their usefulness to amphibians be maximised?

5.4 Bench felling, which results in wide alternate bands of brash covered and and brash-free ground in restocks, as compared with the much more even brash cover with more traditional felling techniques, is now widely used in Kielder. How do the two techniques compare from a wildlife conservation point of view? It appears from casual observation that the bare areas in bench felling re-vegetate more quickly. if this is so other consequences would follow. For example, the plants thus established would perhaps have a better chance of fully replenishing depleted soil seed banks between felling and canopy closure than would plants establishing later in less open ground conditions. Perhaps the differential brash cover associated with bench felling affects the habitat available for invertebrates and the food and cover available to small mammals. If so how does this affect predatory species such as raptors?

5.5 Small areas of windthrow are often left until adjacent larger areas of forest are due for felling or themselves succumb before being cleared. We know nothing about the value of these small areas, which have a very different structure to standing forest, clearfelled areas, or restocks, for wildlife. Casual observation suggests that they result in a greater diversity of vegetation (probably due partly to the greater range of light intensity, partly to their apparent relative unattractiveness to deer and partly to alterations in ground level in relation to water table) and also a richer fauna, particularly of passerine birds (which find nest sites in the thickets of intercrossing branches). These areas are very difficult to study because of access problems but nevertheless they should be looked at.

5.6 Forest roads and their verges provide some of the richest assemblages of plant species in Kielder. This is partly because of the open-ground situations that they provide, allowing ruderal species to colonize, and partly because they are constructed from crushed rock (mostly sandstone, occasionally with whinstone or hard limestone), which has a relatively high base status compared to most of the ground through which they are constructed. It is these roadside communities which produce the most colourful floral effects in what is characteristically drab vegetation. Accepting that these communities are completely artificial it may be felt that they are of value in the forest, particularly in areas frequented by visitors. If this is so it would be nice to know more about the rates and patterns of road colonization. Is the spread of species along roadways mainly linear by natural processes or is it, as seems more likely, greatly assisted by seed brought in with loads of stone from the quarries or carried along on vehicle wheels and the like? Experiments could be established to monitor colonization of stretches of road, including studies of the later stages of colonization on existing stretches of known age.

Roadside verges generally become less interesting after they have reached a certain stage of development. In many cases this does not matter because forest roads are generally regularly re-surfaced, thus repeating the process of colonization. Some of the most important road verges as regards their access and visibility to the public are, however, those alongside more permanent roads through the forest, some of which have a tarmac surface. The floral interest and diversity of these verges could probably be maintained by mowing and/or grazing and it might be worth establishing experiments to test the effectiveness of different management regimes.

5.7 It was suggested in section **4** above that a study of canopy-dwelling insects might form a separate investigation to complement the studies proposed therein. Although the light trapping programme will attract insects from within the canopy there are many invertebrate groups, including all the canopy-dwelling arachnids, as well as the larval stages of others, which will not be sampled in this way. We need to know not only what invertebrates are present in the canopy at the particular periods of sampling, although that would be a great advance on present knowledge, but also their movements and feeding habits. Some insects, such as hoverflies, may feed in the larval stage on other invertebrates in the canopy but require open areas with nectar-bearing flowers to support them as imagines. Again, the conifer canopy may provide cover and shelter for many insects for which it does not provide food. A programme of work is required using such techniques as insecticidal fogging, interception traps and actual collection of branch samples, combined with light trapping.

5.8 We have so far considered only the terrestrial vegetation and the fauna that it supports but the aquatic flora and fauna of the streams and rivers should also be of concern. In the light of existing knowledge on the effects of conifer afforestation on streamwater quality, what are the effects on the flora and fauna of Kielder streams and rivers? How do the palliative measures being adopted, such as clearance of trees from streamsides, planting of broadleaves along streamsides, stopping of drainage ditches and plough lines short of watercourses affect aquatic invertebrates and fish? To answer all these questions would require a major research programme.

REFERENCES

Good, J.E.G., Craigie, I., Last, F.T. and Munro, R.C. 1978. Conservation of amenity trees in the Lothian Region of Scotland. Biological Conservation, **13**, 247-272.

APPENDIX 1

METHODOLOGY FOR THE VEGETATION SURVEY OF KIELDER FOREST

1. Sampling scheme

1.1 Background

The 1km national grid square was selected as the unit for sampling in preference to compartments because the squares are relocatable in the future, regardless of changes in forest practice.

The forest covers 509km^2 (excluding the grouse moor owned by the Duke of Northumberland and an area of farmland in the south totalling 31km^2 and 1.3km^2 respectively).

To avoid over- or under-representation of boundary squares a structured selection was made prior to any stratification. the method used followed Good <u>et al.</u> (1978) whereby boundary squares were eliminated if one of their corners, selected in a cyclic order (NW, NE, SE, SW), fell outside the forest boundary. This resulted in 491 squares remaining available for selection.

The selection of squares for field survey was based on a stratified random scheme, stratification being based on elevation, geology, geographic drainage, and plantation area criteria.

1.1.1 Elevation

Stratification was based on the 250 and 300m contours, which were used to divide the area into land <250m, 250-300m and >300m. (This conforms with the elevation classes used by the F.C. in their restructuring plan and represents a crude assessment of windthrow hazard). The 1km national grid was overlain on the contour map and for each of the 491 squares the % of land (to the nearest 10%) within each elevation class was noted. In addition squares which contained land in all three elevation classes were noted as 'steep'.

A map showing elevation zones was also produced, and the area in each zone calculated:

Land <250m covered 124km^2 (approx. 25% of forest area)
" 250-300m covered 129km^2 (approx. 25% of forest area)
" >300m covered 247km^2 (approx. 50% of forest area)

1.1.2 Geology

A similar method was used to that for elevation. using 1" or 1:50000 drift geology maps the representation of each geological class within each 1km^2 was recorded.

The basic geological features are peat, boulder clay and outcrops of the lower carboniferous group. The solid geology comprises four main types. The cement stones are mainly shales with sandstones and occasional 0.5m thick bands of limestone becoming more marine towards the SW (generally forming featureless ground in the upper reaches). Fell sandstone lies on the cement stone, up to 300m thick in the North, and is almost devoid of interbedded shales or limestone bands (tending to form high hills). The Scremerston coal group is similar to the fell sandstones, but has interbedded thick successions of shale, limestone and coal seams. In the south and east of the forest these outcrops are replaced by the Upper Border group - equivalent to the Scremerston coal group, with significant limestone and sandstone outcrops.

There are also areas of alluvial deposition along some of the more major river valleys, with river terraces.

The initial drift geological classes used were peat, boulder clay and alluvial. For the solid geology the Upper Border group was lumped with the cement stone and Scremerston of the lower carboniferous group, with the fell sandstone being recorded separately. Subsequently the boulder clay and alluvial were lumped to give a 'mineral' group and the fell sandstone and other solid geology types were lumped to give 'rock'.

The presence or absence of cement stone outcrops was always noted.

1.1.3 Geographical drainage

The area was divided into three geographic units of approximately equal size based on major drainage patterns. The northern division was land to the north of the reservoir where drainage was essentially in a southerly direction towards Kielder Water. It also included the Redesdale Forest area.

The southern division was land to the south of the reservoir with an essentially northerly drainage pattern towards Kielder Water.

The third division, which was essentially easterly draining, includes the area to the NE and SE of the eastern limit of Kielder Water, where drainage is away from the reservoir in the south, and easterly in the north, together with an area in the south where a watershed separates the northerly drainage of the 'southern' division from a south or south-easterly drainage in the eastern unit.

Each of the 491 kilometre squares was assigned to a geographical drainage division.

1.1.4 Additional information

The proportions of each square (a) under plantation, and (b) outside the FC boundary were also recorded.

The data for elevation, geology, geographic drainage, plantation and boundary for all 491 squares was input to a computer file for stratification and selection of random samples.

1.2 Stratification

The computer generated produced tables of the number of squares within each assigned strata, together with a listing of grid references for each strata.

The tables are based on the following levels:

<u>Geology</u>

Columns 1-3 — Squares having >75% specified geology.

Columns 4-6 — Squares having two classes of geology each with >25% cover.

Column 7 — Squares with three geological classes having >25% cover.

<u>Elevation</u>

Classes 1-3 — (i.e. <250m, 250-300m, >300m) - squares having >50% of the specified class selected.

Class 4 — (Steep). Squares having all three classes represented.

P = Planted (>50% of the square planted [includes restocking])

U = Unplanted (<50% of the square planted)

Table 1

(a) The number of 1km squares in each geological class by elevation and afforestation status disregarding geographical drainage classes (squares containing limestone omitted).

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	25	2	11	1	18	2	1
	P	38	19	4	33	31	13	5
250-200m	U	1	1	0	2	0	0	0
	P	5	33	1	17	0	5	0
<250m	U	2	29	2	6	0	3	0
	P	0	39	1	6	0	16	0
Steep	U	0	1	0	0	0	4	0
	P	0	12	2	3	0	11	1

P = Peat, M = Mineral, R = Rocky, U = Unplanted, P = Planted

(b) The number of 1km squares in each geological class by elevation and afforestation status disregarding geographical drainage classes (all squares contain limestone).

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	0	0	1	0	8	0	1
	P	1	0	4	2	11	10	0
250-300m	U	0	1	2	0	0	2	0
	P	1	4	0	4	1	6	1
<250m	U	0	1	0	0	0	3	0
	P	0	4	0	0	0	6	0
Steep	U	0	1	0	0	0	0	0
	P	0	1	0	0	2	7	1

Table 2

The number of 1km squares in each geographical drainage class classified by geology, elevation and afforestation status (squares containing limestone omitted).

(a) Northern (draining southerly)

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	13	2	11	1	14	2	1
	P	1	6	4	3	14	8	0
250-300m	U	0	1	0	0	0	0	0
	P	0	1	0	0	0	3	0
<250m	U	0	3	0	0	0	3	0
	P	0	6	1	0	0	11	0
Steep	U	0	1	0	0	0	3	0
	P	0	5	1	0	0	9	1

P = Peat, M = Mineral, R = Rocky, U = Unplanted, P = Planted

(b) Southern (draining northerly)

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	12	0	0	0	3	0	0
	P	30	5	0	15	10	2	5
250-300m	U	0	0	0	0	0	0	0
	P	1	7	1	3	0	0	0
<250m	U	0	11	2	1	0	0	0
	P	0	8	0	0	0	3	0
Steep	U	0	0	0	0	0	0	0
	P	0	4	1	3	0	1	0

(c) Eastern (draining easterly)

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	0	0	0	0	1	0	0
	P	7	6	0	16	7	3	0
250-300m	U	1	0	0	2	0	0	0
	P	4	25	0	14	0	2	0
<250m	U	2	15	0	5	0	0	0
	P	0	25	0	6	0	2	0
Steep	U	0	0	0	0	0	1	0
	P	0	3	0	0	0	1	0

Table 3

The number of 1km squares in each geographical drainage class classified by geology, elevation and afforestation status (all squares contain limestone).

(a) Northern

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	0	0	1	0	7	0	1
	P	0	0	4	0	5	6	0
250-300m	U	0	0	0	0	0	1	0
	P	0	0	0	0	0	2	0
<250m	U	0	0	0	0	0	0	0
	P	0	1	0	0	0	3	0
Steep	U	0	0	0	0	0	0	0
	P	0	1	0	0	1	5	0

P = Peat, M = Mineral, R = Rocky, U = Unplanted, P = Planted

(b) Southern

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	0	0	0	0	0	0	0
	P	0	0	0	0	2	1	0
250-300m	U	0	0	0	0	0	0	0
	P	0	0	0	0	0	1	0
<250m	U	0	0	0	0	0	0	0
	P	0	0	0	0	0	1	0
Steep	U	0	1	0	0	0	0	0
	P	0	0	0	0	1	1	1

(c) Eastern

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	0	0	0	0	1	0	0
	P	1	0	0	2	4	3	0
250-300m	U	0	1	2	0	0	1	0
	P	1	4	0	4	1	3	1
<250m	U	0	1	0	0	0	3	0
	P	0	3	0	0	0	2	0
Steep	U	0	0	0	0	0	0	0
	P	0	0	0	0	0	1	0

1.3 Selection of samples

Initially selection was restricted (for non-limestone squares) to strata which contained 5 or more squares within a geographic drainage unit (i.e. >1% of the total 491 squares available). For this purpose planted and unplanted squares were considered as separate strata.

The number of squares from each strata which were selected was then weighted according to the following guidelines:

Strata with 5-9 squares - 1 selected

Strata with >10 squares - 2 selected

Random number tables were used to select the sample squares.

Following selection and mapping of sampled squares a few apparent shortcomings were noted and a number of supplementary squares were selected subjectively. Where combining planted and unplanted squares within a geology/elevation strata resulted in the aggregate number of squares exceeding the guidelines above, one square was selected at random from the new grouping. This resulted in the addition of two extra samples immediately north of Kielder Water, one a Mineral+Rock/>300m and the other a Mineral+Rock/Steep.

Similarly, where combining strata within either an elevation class or a geological class of previously unsampled strata resulted in 5 or more squares, samples were selected from the pooled strata. In the north this resulted in the selection of an unplanted mineral sample in the <250m elevation class. In the south it produced a steep sample on mineral soil and a <250m sample on Mineral+Rock. In the east it produced a 250-300m sample on peat.

It was considered at the start of the survey that it was desirable to visit as many limestone outcrops as possible, but in such a way that their influence on the vegetation could be considered in relation to the whole. As a result, in addition to the limestone squares selected by the initial random process, any group within a geographic drainage unit which contained 3 or more squares containing limestone had one selected randomly from it. If necessary unplanted and planted squares in a group were pooled to produce the three. This resulted in 19 limestone squares being selected for full survey. In practice, because early limestone squares indicated very little effect of the limestone on the flora, fewer limestone squares (12) were surveyed.

Table 4

Sampled kilometre squares (denoted by their 4-figure grid references) in each of the geographical drainage divisions classified by geology, elevation and afforestation status (only underscored squares may contain limestone).

(a) Northern

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	6701	-	7705	-	7091	-	-
	P	-	6597	-	-	7449 7698	6593	-
<250	U	-	6590	-	-	-	-	-
	P	-	6392	-	-	-	6788	-
Steep	P	-	7702	-	-	-	7802	-

P = Peat, M = Mineral, R = Rocky, U = Unplanted, P = Planted

(b) Southern

		P	M	R	P+M	P+R	M+R	Complex
>300m	P	5891 5987	6487	-	6191 6782	6683 6983	-	6883
250-300m	U	6381	-	-	-	-	-	-
	P	-	6585	-	-	-	-	-
<250m	U	-	6887 6786	-	-	-	-	-
	P	-	7184	-	-	-	7284	-
Steep	P	-	7084	-	-	-	-	-

(c) Eastern

		P	M	R	P+M	P+R	M+R	Complex
>300m	P	6380	-	-	6780 6779	6379	-	-
250-300m	P	-	7180 7273	-	6677 7372	-	-	-
<250m	U	6669	7375	-	7072	-	-	-
	P	-	7881 7381	-	7781	-	7383	-

NB Some potential afforestation classes contained no available squares and hence are not represented. Underscored represents replicate samples with limestone and non-limestone squares pooled.

Table 5

Sampled kilometre squares (denoted by their 4-figure grid references) in each of the geographical drainage divisions classified by geology, elevation and afforestation status (all squares contain limestone)

(a) Northern

		P	M	R	P+M	P+R	M+R	Complex
>300m	U	-	-	6695	-	6397	7896 6791	-
	P	-	-	-	-	6398	-	-
<250m		-	-	-	-	-	7189	-

(c) Southern

	P	M	R	P+M	P+R	M+R	Complex
>300m	-	-	-	-	6089	-	-
<250m	-	-	-	-	-	6885	-
Steep	-	-	-	-	-	6388	-

(b) Eastern

	P	M	R	P+M	P+R	M+R	Complex
>300m	-	-	-	-	7772 7571	-	-
250-300m	-	-	-	-	-	-	-
<250m	-	7691	-	-	-	-	-

NB Some potential afforestation classes contained no available squares and hence are not represented.

Table 6

Efficiency of sampling as represented by proportion of available squares sampled in relation to proportion of each category in Kielder Forest as a whole.

(a) **Elevation**

	Squares available	Proportion of total (%)	Squares selected	Proportion of sample (%)
>300m	241	49	28	52
250-300	86	18	5	9
<250m	118	24	16	30
Steep	46	9	5	9
TOTAL	491		54	

(b) **Geographical drainage**

	Squares available	Proportion of total (%)	Squares selected	Proportion of sample (%)
Northern	170	35	19	35
Southern	137	28	17	31
Eastern	194	39	18	33
TOTAL	491		54	

(c) **Geology**

	Squares available	Proportion of total (%)	Squares selected	Proportion of sample (%)
Peat	73	15	6	11
Boulder clay	148	30	16	30
Rock	28	6	2	4
Peat + BC	74	15	8	15
Peat + Rock	71	14	10	19
BC + Rock	88	18	11	20
Complex	10	2	1	1
TOTAL	491		54	

Table 7

Summary of occurrence of crop tree species other than Sitka spruce in each of the geology classes in the sampled kilometre squares.

	Species			
	NS	JL	SP(+SS)	LP(+SS)
Geology				
Peat	–	–	–	–
Boulder clay	15	4	4	-
Rock	4	-	1	-
Peat + BC	-	-	1	4
Peat + Rock	-	-	2	7
BC + Rock	2	6	1	-
TOTAL	21	10	9	13

Table 8

Summary of occurrence of different age classes of Sitka spruce in the sample kilometre squares, sub-divided by geology.

	Age classes				
	0-15	16-20	20+	Total	Restock
Geology					
Peat	1	-	7	8	-
Boulder clay	4	6	20	30	12
Rock	-	2	5	7	-
Peat + BC	5	4	13	22	1
Peat + Rock	2	12	19	33	5
BC + Rock	3	4	29	36	10
TOTAL	15	28	93	136	28

1.4 Preparation of selected sample squares

The outline of each of the selected squares was drawn onto the appropriate 1:15000 monochrome air photograph. Individual wallets containing air photograph, 1:10000 FC stock maps and reduced 1:15000 stock maps (same scale as photograph) were prepared.

Air photo interpretation was then done to identify major patterns of variation within the kilometre squares:

1. Division into planted/unplanted.

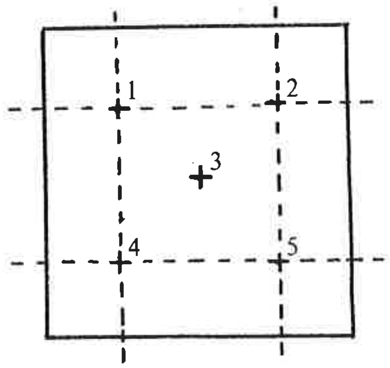
2. Within planted areas species, age-class and yield class.

3. Within planted areas, vegetation patterns.

4. Rivers, streams, rock outcrops, quarries, other features.

A structured selection procedure was then used to determine the locations of some of the sample stations in each square.

A grid was placed over the square on the map (see Figure 1) and a red cross marked on the nearest road or ride in a position where it came nearest to the grid intersection point. This gave a total of 5 road and/or ride sample positions for each square. Rivers or streams were similarly located but were marked in blue.

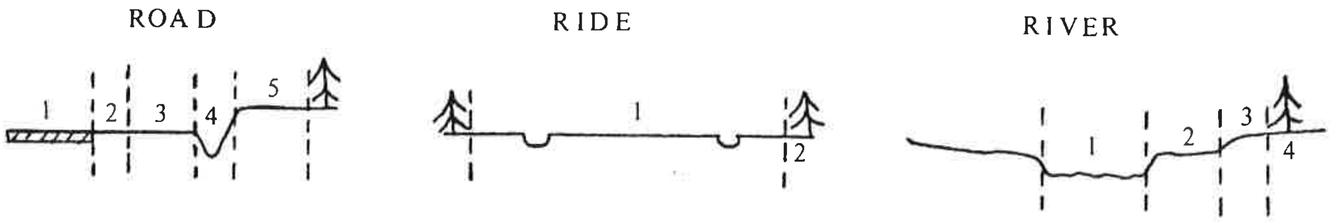


1.5 Field survey procedure

As stations were surveyed their positions were accurately marked onto photocopies of the 1:10000 stock maps for later determination of elevation and grid reference. Positions and directions of photographs taken were similarly recorded in addition to being recorded in a notebook. Distinct vegetation types were also marked onto the air photographs to aid later extrapolations.

1.5.1 Linear features

The location of sample stations was determined as accurately as possible by pacing from known ground positions. A 10m long strip was measured along the road/ride/river, parallel with the forest boundary where present. Lateral zones were then identified and their widths measured (see Figure 2).



Where there was distinct vegetation within any ditch this was recorded separately and where the canopy had a significant effect on the vegetation along the edge of a road/ride this was also.

Zones were identified up to the tree base and each was recorded separately. Where the linear feature was in an unplanted area the influence of the road/river was recorded as lateral zones along a 10m length the adjacent vegetation was treated as an unplanted zone.

1.5.2 Forest block samples

For each road or ride there was a paired forest station: river stations were not paired with forest samples.

Where the forest sample was >15 years old- or reaching the thicket stage, vegetation was recorded as a line transect of 5 (2x2m) quadrats fifteen metres into the block and parallel with its edge. Where the plantation was <15 years old, or a restock, the vegetation was recorded by means of 5 spaced 2x2m quadrats, centred on a single quadrat and forming a square approximately 30x30m.

1.5.3 Unplanted areas

In extensive unplanted areas the vegetation was initially recorded by recognizing distinct vegetation types and placing 5 quadrats (2x2m) within each type by means of a random walk. In small areas and previously recorded types vegetation was recorded by means of a single 2x2m quadrat, plus an extended species list for the whole unit. Distinct vegetation types were marked on both the air photograph and the stock map.

1.6 Recording samples

1.6.1 Linear samples

A cross-section and plan were drawn for each linear sampling station, together with zone widths. Altitude, slope and aspect were also recorded.

The vegetation was recorded separately for each zone using the **Domin** scale:

1	=	1 individual (rare)
2	=	a few individuals (scarce)
3	=	many individuals but <5% cover
4	=	5-10% cover
5	=	11-25% cover
6	=	26-33% cover
7	=	34-50% cover
8	=	51-75% cover
9	=	76-90% cover
10	=	91-100% cover
11	=	seen within the sample unit but not in the quadrat

Species present were crossed off a check list and once the whole zone had been thoroughly searched each species was assigned a score. Bare ground and brash were also recorded. For sparsely vegetated road surfaces and river beds species lists only were recorded, with no Domin scores.

1.6.2 Non-linear samples

A species list was written for the first quadrat and Domin scores assigned to each species. Additional species from subsequent quadrats were then added to the list, Domin scores being given for each quadrat separately. Species seen within a 30x30 m area but not seen in any of the 5 quadrats were recorded and scored '11'. In the case of sampling unplanted areas where the random walk technique was used species were added from the whole area of the particular vegetation type being assigned Domin '11'.

1.7 Soil sampling

For linear features soil was recorded in the dominant zone - the middle of a ride or river bank, away from the disturbed zone in the case of a road. Within forest blocks the sample was taken in the third of the 5 linear quadrats, while in restocks or young plantations it was taken from the centre quadrat. In the case of unplanted areas with 5 quadrats it was taken in the third one while in the case of single quadrat samples it was taken adjacent.

The soil profile was described by taking a narrow 80cm deep screw auger sample. Changes in colour and texture were noted in relation to depth. Five basic colours and 5 basic textures were used, but combined categories sometimes gave the best descriptions.

Colour	**Texture**
1. Dark brown/black - peat	1. Very stony
2. Dark brown - mineral	2. Peaty
3. Orange - iron pan	3. Sandy
4. Strong brown	4. Clayey
5. Grey gleyed	5. Other

In all cases peat depth and depth to bedrock if within 80cm of the surface were recorded.

A soil sample was taken from the top 10cm using a 3cm corer for subsequent pH and loss on ignition analysis.

Along some roads an additional soil sample was taken on the disturbed verge where there appeared to be a strong influence of the imported road material on the vegetation.

A key has been developed (see Table 9) for classifying the soils so that they may be entered into the vegetation data analysis. It is based only on physical characters:

Table 9

Soil classification key

1. Thickness of peat (if present)	>45cm - Deep peat 0-45cm - go to 2
2. Depth to bedrock	<35cm - go to 3 >35cm - go to 4
3. Skeletal soils - are there >5cm of peat	Y - Peaty skeletal N - Mineral skeletal
4. Is mineral soil dominantly sandy?	Y - Sandy soil N - go to 5
5. Are there between 5 and 45 cm of peat?	Y - go to 6 N - go to 7
6. Does the profile have an iron pan and/or thin peat over grey mineral, over strong brown mineral?	Y - Stagnopodzol N - Peaty gley
7. Soils with no peat, colour predominantly grey	- Non-peaty gley
Soils with no peat, colour predominantly strong brown	- Brown podzolic
Soils with no peat, colour predominantly dark brown	- Brown earth

Kielder soil classification

1. Deep peat
2. Peaty skeletal soil
3. Mineral skeletal soil
4. Sandy soil
5. Stagnopodzol
6. Peaty gley
7. Non-peaty gley
8. Brown podzolic soil
9. Brown earth

APPEND

BRYOPHYTES OF K

W. Perrect

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C O N T E N T S

SUMMARY

Bryophytes of Kielder Forest were surveyed in September 1987. Both 'typical' 1-km squares and sites thought likely to be of special interest were examined.

Much of the forest is on boulder clay and peat, with peaty streams and a general lack of rock outcrops and steep topography. It is diversified by forest roads and quarries, and very locally by deep-peat bogs, steeper stream gullies and calcareous grassland.

The bryophyte flora was, for an upland area, not rich. In total, 198 species were recorded. A few uncommon species such as *Barbula ferruginascens*, *Bryum algovicum*, *Pohlia filum* and *Polytrichum longisetum*, were found only in artificial habitats created by forestry. They have clearly increased as a result of the existence of the forest.

The semi-natural habitats that are most likely to have suffered from forestry are marshes and bogs. However, a marsh by Akenshaw Burn had retained a fairly rich flora. Unplanted bogs seemed to be suffering from insufficient disturbance, and were a rather poor bryophyte habitat.

Also poor were the smaller rocky crags on hillsides. Many of these had been planted over, but they were clearly never a good bryophyte habitat.

The richest natural habitats were the rocky streamsides of Bells Burn, Akenshaw Burn and Lewis Burn, and an area of rocky broadleaved woodland on Bullcrag Edge. The interesting bryophytes of these sites would be diminished and probably eliminated if spruce trees were planted over the rocks.

It is concluded that the main priority in conservation of bryophytes should be to preserve these special habitats. The larger rocky bluffs and steeper banks by streams should be left unplanted or have trees cleared from them if good rocks are now being overshadowed. The relict broadleaved woodland on Bullcrag Edge should be managed as a conservation site.

1 INTRODUCTION

When an upland area is planted with conifers, its vegetation undergoes large changes. Most of these result from cessation of grazing, from effects of shading by the trees, or from construction of roads.

Bryophytes, just as much as higher plants, can be expected to respond to these influences. They do, however, differ from higher plants in one important respect, namely that they are small, and rarely dominate the vegetation in which they are found. Indeed, many species are confined to rock and open-ground habitats, where competition from higher plants is reduced.

This means that some apparently adverse influences, such as shading of the ground by trees, result in more habitat being available for bryophytes; precisely because much of the ground vegetation is suppressed.

The purposes of surveying the Kielder bryophyte flora were:-

1 To establish the general character of the bryoflora;
2 To find out which features are of special interest;
3 To assess likely changes that may result from forest management; and
4 To suggest what may usefully be done to maintain or enhance the value of the bryophytes.

It was not considered feasible to attempt a detailed comparison between the forest and nearby areas that remained unplanted. Nor did I examine high ground above the planting level.

2 METHODS

Two basic methods of search were adopted. For the first, particular 1-km squares were selected on an OS map, and were searched for bryophytes for about 3 hours. Squares that were searched thus were 35/76-91-, on boulder clay along the Tarset Burn; 35/67-92-, near Wainhope, also on clay, but with outcropping gritstone rocks along a stream, and with an area still unplanted; 35/77-72-, including part of a large bog called Bellcrag Flow, also a quarry and a hill top; and 35/67-79-, to the NW of Muckle Samuel's Crags, also mainly on peat, but with a stream. (Details of the habitats within these squares, and of the other sites visited, are given in the Sub-Appendix 1).

The other method was to go to localities that seemed likely to have interesting bryophytes. Habitats included clearcuts, quarries, roadsides, bogs, streamsides, rock outcrops, relict broadleaved woodland, and steep-sided valleys. At these sites, a search was made, recording the more interesting species with care, but sometimes perhaps being less thorough in listing the very common ones.

On 16 and 17 September, sites for special search were selected by H L Wallace. On 18 September, sites were chosen from suggestions made by Mr S J Petty, of the Forestry Commission.

Nomenclature follows Corley & Hill (1981), with a few small deviations. The most notable is Sphagnum angustifolium for S. recurvum var. tenue. Also, Racomitrium elongatum and R. ericoides are newly recognized segregates of R. canescens.

3 RESULTS

3.1 Terrain

The general character of the terrain, with gentle slopes and much boulder clay, is not conducive to a rich bryophyte flora. In total, only 198 species were seen (Sub-Appendix 2), a low value for an upland area. Grass grows vigorously, gravelly ground and rock outcrops are few. Furthermore, there is very little broadleaved woodland. The broadleaved trees were mostly alder, birch and oak. These species are noted for having acid bark, and are poor as hosts for epiphytic bryophytes. (Ash, sycamore and elder have less acid bark, but were very scarce.)

The gently sloping terrain has resulted in development of several deep-peat bogs on hill tops. These are well known as an interesting natural feature of the area, and were examined briefly.

Near to Kielder Water, the valleys of Bells Burn, Akenshaw Burn and Lewis Burn are locally more steep-sided. Some of the rocks are highly calcareous, and very locally give rise to calcareous grassland. In these steep-sided valleys, grit and shale rocks by streams vary between acid and calcareous within a small space.

3.2 Commonest bryophytes

The commonest bryophyte in our survey was Polytrichum commune (Sub-Appendix 3). This is an abundant species of damp grassland, but also grows in planted blocks and in clearcuts. It is almost completely eliminated during the thicket stage by dense Sitka spruce, but rapidly recolonizes when light is readmitted.

Most of the other very common species are typical components of damp or dry grassland, for example Calliergon cuspidatum, Dicranum scoparium, Hylocomium splendens, Hypnum jutlandicum, Pleurozium schreberi, Pseudoscleropodium purum, Rhytidiadelphus squarrosus, Sphagnum palustre, S. recurvum, and Lophocolea cuspidata. The small liverwort Diplophyllum albicans was also very common, but, although occurring in grassland, it is more typically a species of rock outcrops, steep banks and gravelly paths.

Considering that many searches were made along roadsides and in rides, it is not surprising that grassland species were found to be predominant. Planted blocks are generally a poor bryophyte habitat, and were therefore not searched systematically. Although this has resulted in a bias against a few very common species such as Campylopus flexuosus, Dicranella heteromalla and Plagiothecium undulatum, I am confident that I have not missed out on much that is of interest.

3.3 Habitats

3.3.1 Grassland

Grassland is generally a poor bryophyte habitat unless it is either very boggy, with resulting open ground, or steep and rocky. Grassland on rides and by roads was no exception. Where it was damp and lightly shaded, Sphagnum fimbriatum, S. girgensohnii and S. russowii were fairly frequent. These sphagna are frequent along roads and rides in many upland forests, and may even have increased slightly as a result of afforestation.

Steep calcareous grassland with much Briza media occurred in the valleys of Akenshaw Burn and Lewis Burn. This supported Ctenidium molluscum, Ditrichum flexicaule and Campylium protensum in good quantity, but was not otherwise bryologically notable.

On a grassy roadside on Paddaburn Moor grew a fine tuft of Tetraplodon mnioides. This was presumably growing on well rotted fox's dung, as there was no sign of a corpse underneath it.

3.3.2 Planted blocks

Bryophytes of planted blocks, like those of grassland, were mostly of little note. However, the boreal moss Ptilium crista-castrensis was found in one place under trees during the main ITE vegetation survey.

3.3.3 Clearcuts

Except where grass growth is very rapid, clearcuts can produce quite a large amount of moss. This colonizes the site rapidly after the trees are cut down, and mostly originates from scraps that had survived under the trees. Immigrating spores are also significant. Campylopus introflexus, C. pyriformis and Ceratodon purpureus are perhaps often genuine immigrants, and were well distributed in clearcuts in Kielder Forest.

On one restocked site on deep peat near Bellcrag Flow, the attractive Polytrichum longisetum was noted, fruiting in some abundance. This species was also found on peat ridges of a newly afforested bog, a habitat from which it has been noted in Galloway (Hill 1978a).

It follows that clearcuts, although quite mossy, are of no particular value as bryophyte habitats. Bryophytes growing there are either surviving species of the forest, or (except P. longisetum) common immigrants with a high spore output.

3.3.4 Road surfaces

Roads are one of the most notable plant habitats in forests. Where, as in much of Kielder, the roadstone is calcareous, some interesting species are able to colonize. The effect was particularly striking near Bellcrag Flow, where a large area for stacking produce had been made up with hard core. The underlying soil was deep peat. The roadstone was highly calcareous grit, which allowed bryophytes such as Barbula ferruginascens, Bryum algovicum, B. intermedium, Leiocolea badensis and Lophozia excisa to exist in what would otherwise be a bog.

On less strongly calcareous roads, Pohlia drummondii, Pohlia filum and Blasia pusilla were found in several places. Pogonatum urnigerum is a common moss that is particularly characteristic of forest roads in Kielder, as elsewhere. Dicranella subulata was found in 2 places in open communities on roadsides.

3.3.5 Quarries

Quarries are needed for roadstone, and are an essential component of a working forest. Disused quarries were examined in several places, notably on Paddaburn Moor. Rocks surrounding them had been colonized by a number of rupestral species, including some strong calcicoles such as Orthotrichum anomalum, Schistidium apocarpum and Tortula muralis. Other quarry rocks were more acid, but they were almost all composed of rather soft gritstone, which is unlikely ever to constitute a good habitat for epilithic mosses. Racomitrium aciculare occurred on dry rocks in several quarries, an unusual habitat, because its normal habitat is semi-aquatic.

Quarry floors were sometimes flooded, and were similar in character to damp roadsides. Archidium alternifolium and Lophozia bicrenata were found only quarry floors. Andreaea rupestris was seen only on quarry rocks.

3.3.6 Bogs

Although bogs on deep peat had abundant Sphagnum magellanicum, S. papillosum and Odontoschisma sphagni, they appeared to be a rather poor bryophyte habitat. In particular, areas with dying moss and bare peat, on which liverworts could thrive, were few or absent. A small amount of Mylia anomala was present, together with Cephalozia connivens and Kurzia pauciflora on Bellcrag Flow (admittedly not searched for long). Cephalozia macrostachya was present on bare peat on a forest ride near Muckle Samuel's Crags. This was a boggy area with a good depth of peat; the liverwort had clearly benefited from disturbance baring the surface.

According to S B Chapman (lecture to British Ecological Society, December 1986), the flora of Coomb Rigg Moss has changed markedly in response to cessation of grazing and burning, with an increase of coarse plants to the detriment of smaller, less competitive forms such as liverworts. A similar change has presumably affected the liverworts of the bogs examined by me.

3.3.7 Marshes and flushes

Marshy ground by roads and in old quarries had mostly an undistinguished bryophyte flora.

A small area of open base-rich flush occurred by the Akenshaw Burn, and included several characteristic species, including Campylium stellatum, Ctenidium molluscum, Drepanocladus revolvens, Philonotis calcarea, Plagiomnium elatum, Sphagnum angustifolium, Sphagnum teres, and Leiocolea bantriensis.

3.3.8 Streams

Streams cutting through clay and peat were very poor in bryophytes. The rocks in them were few and poorly vegetated, the water was acid and peaty. On rocks in a few such streams grew the liverwort Jungermannia sphaerocarpa, but this was the only species of note.

The banks of such streams were almost as poor a bryophyte habitat as the channels. Dicranella cerviculata grew by streams in 2 places on bare clay and silt.

The rockier streams, notably Bells Burn, Akenshaw Burn and Lewis Burn, were much richer in bryophytes. Fontinalis antipyretica and its var. gracilis grew on rocks in the water, together with typical upland species such as Brachythecium plumosum and B. rivulare.

Crevices of gritstone cliffs along Bells Burn yielded Aulacomnium androgynum, Fissidens pusillus, Gymnostomum aeruginosum, Gyroweisia tenuis c.fr., Tetrodontium brownianum, Blepharostoma trichophyllum and Leiocolea badensis. Jungermannia atrovirens was present in some quantity on shale rocks along Akenshaw Burn and Bells Burn, where there was calcareous seepage.

3.3.9 Rock outcrops

Outcropping rock, in the form of low gritstone crags on hill tops, was poor in bryophytes. The crags were of insufficient size to have developed a special bryophyte flora. Crevices of crags on the side of the Lewis Burn valley were strongly calcareous; Gyroweisia tenuis c.fr. was noted. Encalypta streptocarpa and Eucladium verticillatum grew on similar rocks in the valley of Akenshaw Burn.

By far the most interesting rock outcrop was a rather large gritstone crag on Bullcrag Edge, near Kielder Water. This was noted for Dicranum scottianum, Bazzania trilobata, Calypogeia integristipula, Lepidozia cupressina and the fern Hymenophyllum tunbrigiense. The rock was in relict broadleaved woodland with a mull soil.

3.3.10 Broadleaved woodland

Broadleaved woodland was a poorly represented habitat. The area of relict woodland on Bullcrag Edge was particularly notable, with Dicranum majus, Eurhynchium striatum, Isothecium myosuroides and I. myurum, which were not seen elsewhere.

Elsewhere, small patches of broadleaved trees occurred chiefly on stream banks. Plagiochila asplenioides (var. major) grew in two such places, and Cirriphyllum piliferum and Ulota drummondii in one. Rhytidiadelphus triquetrus also occurred in this habitat, and more plentifully in calcareous grassland.

4 DISCUSSION AND CONCLUSIONS

As upland areas go, the planted parts of Kielder Forest are of rather low bryological interest. This is a result of gentle slopes, a lack of hard rock and the prevalence of clay and peat. While some bryophytes must undoubtedly have declined as a result of planting, losses are likely to have been few. As noted by Hill (1978b), the main losses are likely to have been small plants of marshes and bogs.

In exchange for these losses, roadsides and quarries have provided new habitats for bryophytes such as Barbula ferruginascens and Pohlia filum.

At the present time, the most worthwhile permanent habitats are provided by rock outcrops near streams and by the relict woodland of Bullcrag Edge.

Recommendations for preserving and enhancing the bryophyte flora are essentially simple. They are as follows.

1. Avoid planting close to streams where these are steep-sided, and especially where there are rock outcrops and crags. The whole gully should be left unplanted, as by Akenshaw Burn and Lewis Burn.

2. Preserve relics of broadleaved woodland, especially where situated on steep or rocky slopes. The site on Bullcrag Edge is particularly worthy of preservation.

3. Increase the amount of disturbance on unplanted bogs.

4. Do not fill disused quarries with rubbish.

5. Continue surfacing forest roads with calcareous roadstone.

5 ACKNOWLEDGEMENTS

I am particularly grateful to Hilary Wallace for accompanying me and planning the itinerary so that I could see a wide range of sites. I am grateful also to Steve Petty for suggesting several good localities.

6 REFERENCES

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Hill, M.O. (1978a). Vegetation changes resulting from afforestation of British uplands and bogs. (Unpublished report to Nature Conservancy Council).

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SUB-APPENDIX 1

LIST OF LOCALITIES

Localities are identified by their 1-km grid square. The code refers to the day, the 1-km square and the locality within the 1-km square. Thus locality 114 denotes the 4th locality visited in square 1/1 (OS grid reference 35/76-91-). Day 1 was 16 September 1987, day 2 was 17 September and day 3 was 18 September.

SQUARE 1/1 35/76-91-

Grid square on low-lying boulder clay, comprising banks of Tarset Burn between Comb and Comb Hill, and rides and roadsides in the area. Also a small quarry with some recent disturbance. Generally clayey, with little rock and few bog plants (a little *Eriophorum vaginatum* on a ride where peat deeper).

111 Small quarry with a few concrete artefacts.

112 Gully of stream running down to Tarset Burn. Some broadleaved trees, mostly birch, alder and oak, had preserved a few species of mull soils; *Ulota drummondii* grew on an oak. Also a few nearby rides.

113 Roadside near where car was parked. Clayey, much higher plant vegetation, and few bryophytes of note.

114 Ride with some more acid ground, leading down to river in S of square.

115 Banks of the burn, a rather poor bryophyte habitat. The burn itself was peaty and not rocky, and was exceedingly poor in bryophytes.

116 Deserted farmland by river, near where remains of a peel is indicated on map. Fine *Lycopodium clavatum*.

SQUARE 1/2 35/67-91-

An area of restock with much *Corydalis claviculata*, below Pithouse Crags, above Kielder Reservoir.

121 Hardstanding where car left, noted for *Pohlia filum*, which was later found in several places by roads.

122 S-facing slope, restocked with SS, with quite a lot of grass and *Chamerion*. Clearly a poor bryophyte habitat.

123 Unplanted land by crags at top of slope. The crags were low acid sandstone blocks, of no bryological note.

SQUARE 1/3 35/67-92-

Grid square near Wainhope, with an area of unplanted land, still grazed by cattle. The whole area is also on boulder clay, with few outcropping grit rocks.

131 Roadside and forest edge near 673,923.

132 Grassy clearcut nearby, smallish, not restocked.

133 Riverside with banks and a nearby ride. Rock outcrops beside the river were bryologically poor.

134 Marshy field, still unplanted.

135 Bridge in unplanted area

SQUARE 1/4 35/69-91-

141 Quarry fairly near to Rabbit Crags, at 699,918.

SQUARE 1/5 35/70-91-

151 Ride and Rabbit Crags, mostly rather boggy.

152 Small raised bog near Rabbit Crags.

SQUARE 2/1 35/77-72-

Grid square surrounding Bellcrag Flow in the south of the forest. Generally rather deep peat, but a quarry and very calcareous roadstone.

211 Road to fire tower by Bell Crags. Rather shady, but made up with calcareous roadstone, resulting in habitat for Gentianella amarella and Leiocolea badensis.

212 Ground near quarry, currently being worked, at 777,729. Acid and peaty; main quarry too disturbed to be worth examining.

213 By road beside Bellcrag Flow 776,727. Another highly calcareous site, because of the calcareous roadstone, which had been run across the peat bog.

214 Bellcrag Flow, a deep peat bog.

215 Large area of hardstanding by road to S of Bellcrag Flow. Another area of highly calcareous roadstone, with Bryum pendulum, B. intermedium.

216 Area of restock close by. Little of note except Polytrichum longisetum.

SQUARE 2/2 35/67-79-

Grid square to the NW of Muckle Samuel's Crags. Generally an area of rather deep peat, with 2 bits of remnant unplanted flow, one of which with little heather.

221 Roadside; roadstone somewhat base rich

222 Area of bog by road, now planted with LP 76 and still open enough to have P. longisetum.

223 Ride leading S to flow and a few species on flow. In fact, main flora limited and similar to that seen on Bellcrag.

224 Stream running along edge of northern flow. Had a steep bank with some sphagna; otherwise unremarkable.

225 Flow over the river (incompletely recorded).

SQUARE 2/3 35/70-77-

231 Quarry with attractive pool at 701,777, N of Great Tongue Rigg. Surrounding rocks distinctly base-rich, with Tortula muralis on some of them.

SQUARE 2/4 35/64-78-

Grid square on Paddaburn Moor, only sampled for quarry and streamside.

241 Quarry and nearby road, fairly acid and gravelly.

242 Beside Padda Burn, here near its headwater, hard by the quarry.

SQUARE 2/5 35/65-78-

251 Roadside and small quarry on Paddaburn Moor, N of Johnny's Crags.

SQUARE 3/1 35/61-94-

311 Banks, rocks and streams along Bells Burn. The unplanted side of the stream was in Scotland. Attractive base-rich rocks, with Tetrodontium brownianum and Gyroweisia tenuis.

SQUARE 3/2 35/60-89-

Upper part of gully by Akenshaw Burn. Steep sides and open valley bottom little planted, but obviously not well landscaped. From a landscape point of view, much could be achieved by rounding off some edges and removing some intrusive trees on steep banks.

321 Streamside with rocks and bank. Some calcareous seepages, but far from uniformly calcareous.

322 Steep calcareous earth scree with much Briza media. Bryophyte flora not especially rich, perhaps because too unstable. A few calcareous rock ledges by this.

323 Calcareous and mesotrophic flush complex between stream and road. Although of small extent, with quite a good complement of typical species.

SQUARE 3/3 35/62-89-

331 Akenshaw Burn, about 500 m above its confluence with Lewis Burn. Alders and other broadleaved species, with mull humus on banks.

332 Roadside at the same place

SQUARE 3/4 35/63-88-

Valley of Lewis Burn just above The Forks, where it merges with Akenshaw Burn. Rather similar in character to the Akenshaw Burn valley, with a similar patch of calcareous earth scree, some base-rich sandstone rocks, and some shales interspersed with coal. Some of the shales quite acid, and therefore rather a complex mixture of acid and calcareous ground and water.

341 Riverside near The Forks.

342 Rocks on hillside above right bank of the burn; mostly calcareous grit, with some overhangs.

343 Gully running up the same steep hillside, 633,884. The water in the gully was acid, but the grassland beside it was highly calcareous with much Briza.

344 Riverside about 600 m up from The Forks, with rocks and calcareous seepages.

SQUARE 3/5 35/66-86-

Bullcrag Edge, beside Kielder Water, consisting of forest, paths and roads near the water, and of a bluff with gritstone rocks in relict broadleaved woodland.

351 Road running through forest, and path near lake.

352 Under conifer trees.

353 Old woodland with mull soil and rocks on steep slope at 668,863. Interesting rocks with Hymenophyllum tunbrigiense, Dicranum scottianum, Bazzania trilobata, Calypogeia integristipula and Lepidozia cupressina. Clearly a special site. It seemed to have benefited from being near to but not in a conifer plantation. Recent felling had led to some death of Bazzania.

SUB-APPENDIX 2

LIST OF BRYOPHYTE SPECIES IN LOCALITIES VISITED

No. times found	Name	Locality code (see Sub-Appendix 1 for details)								
		11111 11111 12345	11111 12223 61231	11111 33334 23451	11222 55111 12123	22222 11122 45612	22222 22234 34511	22333 45122 21112	33333 23344 31212	33333 44555 34123
1	Ambl serp	*....	.....	.....	.....	.....	.....	.....	.....	.....
1	Andr rupe	.....	.....	.....	.....	.....	.....	.*...	.....	.....
1	Arch alte	*....	.....	.....	.....	.....	.....	.....	.....	.....
11	Atri undu	.*..*	.....	.*...	..*.*	.*.*.	.....	.....	.*.*.	.*..*
1	Aula andr	.....	.....	.....	.....	.....	.....	..*..	.....	.....
8	Aula palu	...*.	.....	.....	.*...	*..**	...**	.....	*....	.....
2	Barb conv	*....	.....	.....	.....	.*...	.....	.....	.....	.....
2	Barb cyli	*....	.....	.....	.....	.....	.....	..*..	.....	.....
7	Barb fall	.....	.....	.....	..*.*	.*.*.	.....	..*..	.....	**...
5	Barb ferr	.....	....*	.....	.....	.*...	....*	.*...	..*..	.....
3	Barb rigi	*....	.....	.....	.....	.....	...*.	.....	....*	.....
1	Barb toph	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Barb ungu	.....	.....	.....	.....	.*...	.....	.....	.....	.....
1	Brac albi	.....	.....	...*.	.....	.....	.....	.....	.....	.....
5	Brac plum	....*	.....	.....	.....	.....	.....	..**.	.*.*.	.....
3	Brac rivu	.....	.....	.....	.....	.....	.....	.***.	.....	.....
10	Brac ruta	*....	..*..	*..*.	..*..	.*...	...*.	.**..	.....	...*.
2	Bryu algo	.....	.....	.....	.....	.*.*.	.....	.....	.....	.....
1	Bryu arge	..*..	.....	.....	.....	.....	.....	.....	.....	.....
1	Bryu bico	.....	.....	.....	.....	.....	...*.	.....	.....	.....
5	Bryu capi	*.*..	.....	.....	.....	.....	...**	..*..	.....	.....
1	Bryu inte	.....	.....	.....	.....	.*...	.....	.....	.....	.....
1	Bryu micr	.....	.*...	.....	.....	.....	.....	.....	.....	.....
8	Bryu pall	.....	....*	.....	..*..	.*.*.	...*.	..**.	.....	*....
7	Bryu pseu	.....	....*	.....	....*	.*.*.	.....	.*...	*....	.*...
17	Call cusp	*....	....*	..*..	..***	.*.*.	...**	.**.*	*..*.	**...
4	Call stra	....*	*....	.....	.....	.....	.*...	.....	*....	.....
2	Camp prot	.....	.....	.....	.....	.....	.....	....*	.....	*....
1	Camp stel	.....	.....	.....	.....	.....	.....	.....	*....	.....
9	Camp flex	...*.	..*..	*....	*..*.	..***	.....	.....	.....	..*..
7	Camp intr	.....	..*..	*....	....*	..***	...*.	.....	.....	.....
7	Camp pyri	...*.	..*..	*....	*..*.	..**.	.....	.....	.....	.....
10	Cera purp	..*..	.**.*	*..*.	...*.	.*...	...**	.....	.....	.....
2	Cirr pili	.....	.....	.....	.....	.....	.....	.....	.*...	*....
3	Clim dend	*....	.....	..*..	.....	.....	....*	.....	.....	.....

Sub-Appendix 2 (cont'd)

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No.    Name     Locality code (see Sub-Appendix 1 for details)
times
found           11111 11111 11111 11222 22222 22222 22333 33333 33333
                11111 12223 33334 55111 11122 22234 45122 23344 44555
                12345 61231 23451 12123 45612 34511 21112 31212 34123

 3 Crat comm    ..... ..... ..... ..... ..... ..... ...*. ....* .*...
 8 Crat fili    *.... ..... ..... ..*.* .*.*. ...*. ..*.. ..... .*...
 9 Cten moll    ..... ..... ..... ..*.. ...*. ....* ....* **.** *....
11 Dich pell    .*... ....* ..... ..... .*.*. ....* .***. .*... **...
 2 Dicr cerv    .*... *.... ..... ..... ..... ..... ..... ..... .....

13 Dicr hete    *...* .*..* *.... ..**. ...*. .*... ..*.. ..... .*.**
 1 Dicr palu    ..... ....* ..... ..... ..... ..... ..... ..... .....
 2 Dicr rufe    ..... ..... ..... ..... ..... ...*. ..... ..... .*...
 2 Dicr subu    ..... .*..* ..... ..... ..... ..... ..... ..... .....
 7 Dicr vari    ..... ..... ..... ..*.. .*.*. ..... ..... ...** **...

 2 Dicr cirr    ....* ..... ..... ..... ..... ..... ..... ..... ....*
 1 Dicr bonj    ..... ..... ..... ..... ..... ..... ..... *.... .....
 1 Dicr fusc    ..... ..... ..... ..... ..... ..... ..... ..... ....*
 1 Dicr maju    ..... ..... ..... ..... ..... ..... ..... ..... ....*
19 Dicr scop    .*.*. ...** ..*.. .**** ...** ....* .***. .*..* *...*

 1 Dicr scot    ..... ..... ..... ..... ..... ..... ..... ..... ....*
 2 Ditr flex    ..... ..... ..... ..... ..... ..... ....* ..... *....
 1 Ditr hete    ..... .*... ..... ..... ..... ..... ..... ..... .....
 1 Drep flui    ..... ..... ..... ..... ..... ..... .*... ..... .....
 1 Drep revo    ..... ..... ..... ..... ..... ..... ..... *.... .....

 2 Drep unci    ..... ..... ..... ..... ..... ..... ....* .*... .....
 1 Enca stre    ..... ..... ..... ..... ..... ..... ....* ..... .....
 2 Eucl vert    ..... ..... ..... ..... ..... ..... ..*.* ..... .....
 5 Eurh prae    .*... ..*.. .*.*. ..... ..... ..... ..*.. ..... .....
 1 Eurh ripa    ..... ..... ..... ..... ..... ..... ...*. ..... .....

 1 Eurh stri    ..... ..... ..... ..... ..... ..... ..... ..... ....*
 4 Fiss adia    ..... ..... ..... ..... ...*. ....* ..... *...* .....
 1 Fiss bryo    ..... ..... ..... ..*.. ..... ..... ..... ..... .....
 1 Fiss cris    ..... ..... ..... ..... ..... ..... ....* ..... .....
 1 Fiss tenu    ..... ..... ..... ..... ..... ..... ..*.. ..... .....

 4 Fiss taxi    ..... ..... ..... ..... ..... ..... ..*.. .*.** .....
 1 Font anti    ..... ..... ..... ..... ..... ..... ..*.. ..... .....
 2 Font grac    ..... ..... ..... ..... ..... ..... ...*. ..... .*...
 1 Funa hygr    ..... ..... ..... ..... ..... ...*. ..... ..... .....
 3 Grim pulv    ..... ..... ...*. ..... ..... ...** ..... ..... .....

 1 Gymn aeru    ..... ..... ..... ..... ..... ..... ..*.. ..... .....
 2 Gyro tenu    ..... ..... ..... ..... ..... ..... ..*.. ....* .....
 1 Hygr eugy    ..... ..... ..... ..... ..... ..... ..*.. ..... .....
 1 Hygr luri    ..... ..... ..... ..... ..... ..... ..... ...*. .....
 2 Hygr ochr    ..... ..... ..... ..... ..... ..... ..*.. .*... .....
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Sub-Appendix 2 (cont'd)

No. times found	Name	Locality code (see Sub-Appendix 1 for details)								
		11111	11111	11111	11222	22222	22222	22333	33333	33333
		11111	12223	33334	55111	11122	22234	45122	23344	44555
		12345	61231	23451	12123	45612	34511	21112	31212	34123
14	Hylo sple	.**..	...*.	.**..	*.*..	.....	...**	....*	*..*.	**...
3	Hyoc armo	....*	.....	.*...	.....	.....	.....	.....	.....	.*...
3	Hypn cupr	*....	.....	.....	.....	.....	...*.	.....	....*	.....
19	Hypn jutl	..*.*	.****	**..*	**.**	...**	....*	.*...	.*...	....*
5	Hypn mamm	.*.*.	.....	.....	.....	.....	.....	..*..	.*...	....*
2	Isop eleg	.....	.....	.*...	..*..	.....	.....	.....	.....	.....
1	Isot myos	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Isot myur	.....	.....	.....	.....	.....	.....	.....	.....	....*
2	Lept pyri	.....	.....	.....	.....	.....	.....	..*..	.....	..*..
1	Leuc glau	.....	.....	.....	.....	.....	.....	.....	.....	....*
7	Mniu horn	.*..*	.....	.....	..*..	.....	.....	...*.	.*...	...**
3	Olig herc	.....	.....	....*	.....	.....	.*...	.....	.....	..*..
2	Orth anom	.....	.....	...*.	.....	.....	..*..	.....	.....	.....
1	Phil calc	.....	.....	.....	.....	.....	.....	.....	*....	.....
6	Phil font	.....	*...*	.....	.....	...*.	...*.	.*...	.....	.*...
1	Plag elat	.....	.....	.....	.....	.....	.....	.....	*....	.....
1	Plag rost	.....	.....	.....	.....	.....	.....	.....	.*...	.....
5	Pmni undu	.....	.....	.*...	..*..	.....	.....	..*..	*..*.	.....
1	Plag succ	.....	.....	.....	.....	.....	.....	..*..	.....	.....
11	Plag undu	.*...	....*	.*...	***..	.....	*...*	.....	.*...	...**
16	Pleu schr	*.*..	*..**	.**..	****.	...*.	.....	.*...	.....	*..**
3	Pogo aloi	....*	.....	.....	.....	.....	.....	..*..	.....	.*...
13	Pogo urni	.....	.*..*	....*	...*.	..**.	...**	.*.*.	...*.	*.*..
4	Pohl anno	.....	.*...	.....	.....	.....	...**	.....	.....	.*...
2	Pohl carn	.....	.....	.....	.....	.....	.....	.....	...**	.....
3	Pohl drum	.....	....*	....*	.....	.....	.....	.*...	.....	.....
5	Pohl filu	.....	.*..*	....*	.....	.....	...*.	.*...	.....	.....
9	Pohl nuta	..*..	.**..	*...*	.*...	..*..	....*	.*...	.....	.....
6	Pohl wahl	.....	.....	.....	..**.	.*...	.....	.*...	.*...	.*...
4	Poly alpe	.....	..*..	.....	.....	..*.*	.....	.....	*....	.....
22	Poly comm	***.*	..*.*	.**.*	*.***	..**.	.*.**	.*...	.*...	*.*..
9	Poly form	....*	..*..	*...*	...**	.....	...*.	.....	...*.	....*
1	Poly juni	.....	.....	.....	.....	.....	...*.	.....	.....	.....
2	Poly long	.....	.....	.....	.....	..*.*	.....	.....	.....	.....
4	Poly pili	.....	.*...	....*	.....	.....	...*.	.*...	.....	.....
14	Pseu puru	.*.*.	...**	.*.*.	...*.	.*.*.	....*	....*	.*.*.	*....
1	Ptyc poly	.....	.....	.....	.....	.....	...*.	.....	.....	.....
9	Raco acic	..*.*	.....	.....	.....	.....	...**	.***.	.*.*.	.....
1	Raco aqua	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Raco elon	.....	.....	.....	.....	.....	....*	.....	.....	.....

Sub-Appendix 2 (cont'd)

No. times found | Name | Locality code (see Sub-Appendix 1 for details)

No. times found	Name	11111 11111 12345	11111 12223 61231	11111 33334 23451	11222 55111 12123	22222 11122 45612	22222 22234 34511	22333 45122 21112	33333 23344 31212	33333 44555 34123
6	Raco eric	.....	.....	...*.	.....	...*.	...**	....*	.....	*....
3	Raco fasc	.....	.....	.....	.....	.....	...**	.*...	.....	.....
4	Raco hete	.....	.....	.....	..*..	.....	...**	...*.	.....	.....
3	Raco lanu	.....	.....	.....	.....	.....	...**	....*	.....	.....
8	Rhiz punc	.*..*	.....	.....	..*..	.....	.....	..**.	**...	.*...
6	Rhyt lore	.*...	.....	.*..*	**...	.....	.....	.....	.....	....*
18	Rhyt squa	.**..	...**	.**..	..*.*	.*...	.*.**	.**..	.*.*.	*...*
6	Rhyt triq	.*...	.....	.....	.....	.....	.....	..*.*	.*.*.	*....
3	Schi apoc	.....	.....	...*.	.....	.....	...*.	.....	.....	*....
1	Schi rivu	.....	.....	.....	.....	.....	.....	..*..	.....	.....
2	Spha angu	.....	.....	.....	.....	.....	.....	*....	*....	.....
8	Spha auri	.**..	*...*	*....	.....	.....	.....	.*...	..*..	..*..
10	Spha capi	...*.	....*	.*...	**...	*...*	.....	**...	*....	.....
3	Spha cusp	.....	.....	.....	.....	.....	*....	**...	.....	.....
5	Spha fimb	....*	.....	.*...	.....	..*..	.*...	.....	.....	....*
8	Spha girg	.**.*	.....	.*...	.....	....*	.....	.....	*....	.*.*.
4	Spha mage	.....	.....	.....	**..*	....*	.....	.....	.....	.....
16	Spha palu	.****	.....	.**..	*.*..	....*	**...	.....	**.*.	.**..
3	Spha papi	.....	.....	.....	.*..*	.....	.....	*....	.....	.....
2	Spha quin	.....	.....	.....	.....	.....	.....	.....	.....	**...
17	Spha recu	.**..	....*	***..	***.*	..*.*	.*...	.*...	*....	*.*..
5	Spha russ	.....	....*	.*...	.....	.....	.....	.....	*....	*.*..
2	Spha subn	.....	.....	.*...	.....	.....	.....	.....	*....	.....
3	Spha tene	.....	.....	.....	.....	*...*	*....	.....	.....	.....
1	Spha tere	.....	.....	.....	.....	.....	.....	.....	*....	.....
2	Tetr pell	.....	.....	.....	...*.	.....	.....	.....	.....	....*
1	Tetr mnio	.....	.....	.....	.....	.....	....*	.....	.....	.....
1	Tetr brow	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Tham alop	.....	.....	.....	.....	.....	.....	..*..	.....	.....
7	Thui tama	.*...	.....	..*..	.....	.....	.....	..*.*	.*...	*...*
3	Tort mura	.....	.....	...*.	.....	.....	...*.	.....	....*	.....
4	Ulot cris	.*...	.....	.....	.....	.....	.....	..*..	.*...	....*
1	Ulot drum	.*...	.....	.....	.....	.....	.....	.....	.....	.....
6	Aneu ping	.....	....*	.....	..*..	.*.*.	.....	..*..	*....	.....
5	Barb atte	.*...	...*.	.....	*....	.....	.....	.....	.*...	....*
7	Barb floe	.....	.*..*	.*...	*....	.....	...**	.*...	.....	.....
1	Bazz tril	.....	.....	.....	.....	.....	.....	.....	.....	....*
5	Blas pusi	.....	....*	.....	.....	.....	...*.	.*...	..*..	.*...
1	Blep tric	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Caly inte	.....	.....	.....	.....	.....	.....	.....	.....	....*

Sub-Appendix 2 (cont'd)

No. times found	Name	Locality code (see Sub-Appendix 1 for details)								
		11111	11111	11111	11222	22222	22222	22333	33333	33333
		11111	12223	33334	55111	11122	22234	45122	23344	44555
		12345	61231	23451	12123	45612	34511	21112	31212	34123
3	Caly muel	....*	....*	.....	.....	.....	.....	.....	.....	...*.
6	Ceph bicu	.*..*	....*	.....	.....	.....	.*...	.....	.....	.*..*
1	Ceph conn	.....	.....	.....	.....	*....	.....	.....	.....	.....
1	Ceph lunu	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Ceph macr	.....	.....	.....	.....	....*	.....	.....	.....	.....
1	Ceph diva	.....	.....	.....	.....	.....	...*.	.....	.....	.....
1	Ceph hamp	.....	.....	.....	.....	.....	.....	.*...	.....	.....
2	Chil poly	.....	.....	.....	.....	.....	.....	..*..	.....	.*...
2	Cono coni	.....	.....	.....	.....	.....	.....	..*..	.*...	.....
14	Dipl albi	.**..	**...	.*..*	..**.	.....	.....	..**.	...*.	.**.*
1	Frul dila	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Frul tama	.....	.....	.....	.....	.....	.....	.....	.....	*....
2	Gymn infl	..*..	.....	.....	.....	.....	.....	.....	.....	*....
3	Jung atro	.....	.....	.....	.....	.....	.....	...*.	.*...	.*...
2	Jung grac	.....	.....	....*	.....	.....	.....	.....	.....	..*..
5	Jung spha	.....	*...*	.*...	.....	.....	.....	.....	.....	**...
1	Kurz pauc	.....	.....	.....	.....	*....	.....	.....	.....	.....
2	Leio bade	.....	.....	.....	..*..	.....	.....	..*..	.....	.....
1	Leio bant	.....	.....	.....	.....	.....	.....	.....	*....	.....
1	Leio turb	.....	.....	.....	.....	.....	.....	.....	.*...	.....
2	Lepi rept	.....	.....	.....	..*..	.....	.....	.....	.....	...*.
1	Lepi cupr	.....	.....	.....	.....	.....	.....	.....	.....	....*
14	Loph cusp	.*...	....*	*.*..	*..**	.*...	...**	.*..*	.*...	...*.
1	Loph bicr	.....	.....	....*	.....	.....	.....	.....	.....	.....
1	Loph exci	.....	.....	.....	.....	.*...	.....	.....	.....	.....
1	Loph inci	.....	.....	.....	.....	.....	.....	.....	.....	.*...
11	Loph vent	.*...	...*.	.....	.*.*.	....*	.*.**	.*.*.	...*.	.....
3	Marc poly	.....	.....	.....	.....	.....	...*.	..**.	.....	.....
3	Myli anom	.....	.....	.....	.....	*....	*.*..	.....	.....	.....
9	Nard scal	..*..	**.**	....*	...*.	.....	....*	.....	.....	..*..
4	Odon spha	.....	.....	.....	.*...	*...*	..*..	.....	.....	.....
9	Pell endi	.....	.....	.....	..*.*	.....	.....	..**.	.*.**	**...
9	Pell epip	.*..*	.....	.*...	.....	.....	.*...	..*..	.*.*.	*...*
1	Pell nees	.....	....*	.....	.....	.....	.....	.....	.....	.....
3	Plag aspl	.*...	.....	.....	.....	.....	.....	.....	.*...	....*
5	Plag pore	....*	.....	.....	.....	.....	.....	..*..	....*	*...*
1	Prei quad	.....	.....	.....	.....	.....	.....	..*..	.....	.....
3	Ptil cili	.....	.....	.....	*....	.....	.....	**...	.....	.....
4	Ricc cham	.....	.....	.....	....*	.*.*.	.....	....*	.....	.....
1	Scap grac	.....	.....	.....	.....	.....	.....	.....	.....	....*

Sub-Appendix 2 (cont'd)

No. times found	Name	Locality code (see Sub-Appendix 1 for details)								
		11111	11111	11111	11222	22222	22222	22333	33333	33333
		11111	12223	33334	55111	11122	22234	45122	23344	44555
		12345	61231	23451	12123	45612	34511	21112	31212	34123
4	Scap irri	*....	....*	.....	.....	.....	...*.	.*...	.....	.....
1	Scap nemo	.....	.....	.....	.....	.....	....*	.....	.....	.....
10	Scap undu	.*..*	....*	.*...	.....	.....	.*...	.*.*.	.*.*.	*....

SUB-APPENDIX 3

BRYOPHYTE SPECIES, LISTED IN DESCENDING ORDER OF FREQUENCY

Locality code (see Sub-Appendix 1 for details)

No. times found	Name	11111 11111 12345	11111 12223 61231	11111 33334 23451	11222 55111 12123	22222 11122 45612	22222 22234 34511	22333 45122 21112	33333 23344 31212	33333 44555 34123
22	Poly comm	***.*	..*.*	.**.*	*.***	..**.	.*.**	.*...	.*...	*.*..
19	Dicr scop	.*.*.	...**	..*..	.****	...**	....*	.***.	.*..*	*...*
19	Hypn jutl	..*.*	.****	**..*	**.**	...**	....*	.*...	.*...	....*
18	Rhyt squa	.**..	...**	.**..	..*.*	.*...	.*.**	.**..	.*.*.	*...*
17	Call cusp	*....	....*	..*..	..***	.*.*.	...**	.**.*	*..*.	**...
17	Spha recu	.**..	....*	***..	***.*	..*.*	.*...	.*...	*....	*.*..
16	Pleu schr	*.*..	*..**	.**..	****.	...*.	.....	.*...	.....	*..**
16	Spha palu	.****	.....	.**..	*.*..	....*	**...	.....	**.*.	.**..
14	Dipl albi	.**..	**...	.*..*	..**.	.....	.....	..**.	...*.	.**.*
14	Hylo sple	.**..	...*.	.**..	*.*..	.....	...**	....*	*..*.	**...
14	Loph cusp	.*...	....*	*.*..	*..**	.*...	...**	.*..*	.*...	...*.
14	Pseu puru	.*.*.	...**	.*.*.	...*.	.*.*.	....*	....*	.*.*.	*....
13	Dicr hete	*...*	.*..*	*....	..**.	...*.	.*...	..*..	.....	.*.**
13	Pogo urni	.....	.*..*	....*	...*.	..**.	...**	.*.*.	...*.	*.*..
11	Atri undu	.*..*	.....	.*...	..*.*	.*.*.	.....	.....	.*.*.	.*..*
11	Dich pell	.*...	....*	.....	.....	.*.*.	....*	.***.	.*...	**...
11	Loph vent	.*...	...*.	.....	.*.*.	....*	.*.**	.*.*.	...*.	.....
11	Plag undu	.*...	....*	.*...	***..	.....	*...*	.....	.*...	...**
10	Brac ruta	*....	..*..	*..*.	..*..	.*...	...*.	.**..	.....	...*.
10	Cera purp	..*..	.**.*	*..*.	...*.	.*...	...**	.....	.....	.....
10	Scap undu	.*..*	....*	.*...	.....	.....	.*...	.*.*.	.*.*.	*....
10	Spha capi	...*.	....*	.*...	**...	*...*	.....	**...	*....	.....
9	Camp flex	...*.	..*..	*....	*..*.	..***	.....	.....	.....	..*..
9	Cten moll	.....	.....	.....	..*..	...*.	....*	....*	**.**	*....
9	Nard scal	..*..	**.**	....*	...*.	.....	....*	.....	.....	..*..
9	Pell endi	.....	.....	.....	..*.*	.....	.....	..**.	.*.**	**...
9	Pell epip	.*..*	.....	.*...	.....	.....	.*...	..*..	.*.*.	*...*
9	Pohl nuta	..*..	.**..	*...*	.*...	..*..	....*	.*...	.....	.....
9	Poly form	....*	..*..	*...*	...**	.....	...*.	.....	...*.	....*
9	Raco acic	..*.*	.....	.....	.....	.....	...**	.***.	.*.*.	.....
8	Aula palu	...*.	.....	.....	.*...	*..**	...**	.....	*....	.....
8	Bryu pall	.....	....*	.....	..*..	.*.*.	...*.	..**.	.....	*....
8	Crat fili	*....	.....	.....	..*.*	.*.*.	...*.	..*..	.....	.*...
8	Rhiz punc	.*..*	.....	.....	..*..	.....	.....	..**.	**...	.*...
8	Spha auri	.**..	*...*	*....	.....	.....	.....	.*...	..*..	..*..

Sub-Appendix 3 (cont'd)

No. times found	Name	Locality code (see Sub-Appendix 1 for details)								
		11111	11111	11111	11222	22222	22222	22333	33333	33333
		11111	12223	33334	55111	11122	22234	45122	23344	44555
		12345	61231	23451	12123	45612	34511	21112	31212	34123
8	Spha girg	.**.*	.....	.*...	.....	....*	.....	.....	*....	.*.*.
7	Barb fall	.....	.....	.....	..*.*	.*.*.	.....	..*..	.....	**...
7	Barb floe	.....	.*..*	.*...	*....	.....	...**	.*...	.....	.....
7	Bryu pseu	.....	....*	.....	....*	.*.*.	.....	.*...	*....	.*...
7	Camp intr	.....	..*..	*....	....*	..***	...*.	.....	.....	.....
7	Camp pyri	...*.	..*..	*....	*..*.	..**.	.....	.....	.....	.....
7	Dicr vari	.....	.....	.....	..*..	.*.*.	.....	.....	...**	**...
7	Mniu horn	.*..*	.....	.....	..*..	.....	.....	...*.	.*...	...**
7	Thui tama	.*...	.....	..*..	.....	.....	.....	..*.*	.*...	*...*
6	Aneu ping	.....	....*	.....	..*..	.*.*.	.....	..*..	*....	.....
6	Ceph bicu	.*..*	....*	.....	.....	.....	.*...	.....	.....	.*..*
6	Phil font	.....	*...*	.....	.....	...*.	...*.	.*...	.....	.*...
6	Pohl wahl	.....	.....	.....	..**.	.*...	.....	.*...	.*...	.*...
6	Raco eric	.....	.....	...*.	.....	...*.	...**	....*	.....	*....
6	Rhyt lore	.*...	.....	.*..*	**...	.....	.....	.....	.....	....*
6	Rhyt triq	.*...	.....	.....	.....	.....	.....	..*.*	.*.*.	*....
5	Barb atte	.*...	...*.	.....	*....	.....	.....	.....	.*...	....*
5	Barb ferr	.....	....*	.....	.....	.*...	....*	.*...	..*..	.....
5	Blas pusi	.....	....*	.....	.....	.....	...*.	.*...	..*..	.*...
5	Brac plum	....*	.....	.....	.....	.....	.....	..**.	.*.*.	.....
5	Bryu capi	*.*..	.....	.....	.....	.....	...**	..*..	.....	.....
5	Eurh prae	.*...	..*..	.*.*.	.....	.....	.....	..*..	.....	.....
5	Hypn mamm	.*.*.	.....	.....	.....	.....	.....	..*..	.*...	....*
5	Jung spha	.....	*...*	.*...	.....	.....	.....	.....	.....	**...
5	Plag pore	....*	.....	.....	.....	.....	.....	..*..	....*	*...*
5	Pmni undu	.....	.....	.*...	..*..	.....	.....	..*..	*..*.	.....
5	Pohl filu	.....	.*..*	....*	.....	.....	...*.	.*...	.....	.....
5	Spha fimb	....*	.....	.*...	.....	..*..	.*...	.....	.....	....*
5	Spha russ	.....	....*	.*...	.....	.....	.....	.....	*....	*.*..
4	Call stra	....*	*....	.....	.....	.....	.*...	.....	*....	.....
4	Fiss adia	.....	.....	.....	.....	...*.	....*	.....	*...*	.....
4	Fiss taxi	.....	.....	.....	.....	.....	.....	..*..	.*.**	.....
4	Odon spha	.....	.....	.....	.*...	*...*	..*..	.....	.....	.....
4	Pohl anno	.....	.*...	.....	.....	.....	...**	.....	.....	.*...
4	Poly alpe	.....	..*..	.....	.....	..*.*	.....	.....	*....	.....
4	Poly pili	.....	.*...	....*	.....	.....	...*.	.*...	.....	.....
4	Raco hete	.....	.....	.....	..*..	.....	...**	...*.	.....	.....
4	Ricc cham	.....	.....	.....	....*	.*.*.	.....	....*	.....	.....
4	Scap irri	*....	....*	.....	.....	.....	...*.	.*...	.....	.....
4	Spha mage	.....	.....	.....	**..*	....*	.....	.....	.....	.....

Sub-Appendix 3 (cont'd)

No. times found	Name	Locality code (see Sub-Appendix 1 for details)								
		11111	11111	11111	11222	22222	22222	22333	33333	33333
		11111	12223	33334	55111	11122	22234	45122	23344	44555
		12345	61231	23451	12123	45612	34511	21112	31212	34123
4	Ulot cris	.*...	.....	.....	.....	.....	.....	..*..	.*...	....*
3	Barb rigi	*....	.....	.....	.....	.....	...*.	.....	....*	.....
3	Brac rivu	.....	.....	.....	.....	.....	.....	.***.	.....	.....
3	Caly muel	....*	....*	.....	.....	.....	.....	.....	.....	...*.
3	Clim dend	*....	.....	..*..	.....	.....	....*	.....	.....	.....
3	Crat comm	.....	.....	.....	.....	.....	.....	...*.	....*	.*...
3	Grim pulv	.....	.....	...*.	.....	.....	...**	.....	.....	.....
3	Hyoc armo	....*	.....	.*...	.....	.....	.....	.....	.....	.*...
3	Hypn cupr	*....	.....	.....	.....	.....	...*.	.....	....*	.....
3	Jung atro	.....	.....	.....	.....	.....	.....	...*.	.*...	.*...
3	Marc poly	.....	.....	.....	.....	.....	...*.	..**.	.....	.....
3	Myli anom	.....	.....	.....	.....	*....	*.*..	.....	.....	.....
3	Olig herc	.....	.....	....*	.....	.....	.*...	.....	.....	..*..
3	Plag aspl	.*...	.....	.....	.....	.....	.....	.....	.*...	....*
3	Pogo aloi	....*	.....	.....	.....	.....	.....	..*..	.....	.*...
3	Pohl drum	.....	....*	....*	.....	.....	.....	.*...	.....	.....
3	Ptil cili	.....	.....	.....	*....	.....	.....	**...	.....	.....
3	Raco fasc	.....	.....	.....	.....	.....	...**	.*...	.....	.....
3	Raco lanu	.....	.....	.....	.....	.....	...**	....*	.....	.....
3	Schi apoc	.....	.....	...*.	.....	.....	...*.	.....	.....	*....
3	Spha cusp	.....	.....	.....	.....	.....	*....	**...	.....	.....
3	Spha papi	.....	.....	.....	.*..*	.....	.....	*....	.....	.....
3	Spha tene	.....	.....	.....	.....	*...*	*....	.....	.....	.....
3	Tort mura	.....	.....	...*.	.....	.....	...*.	.....	....*	.....
2	Barb conv	*....	.....	.....	.....	.*...	.....	.....	.....	.....
2	Barb cyli	*....	.....	.....	.....	.....	.....	..*..	.....	.....
2	Bryu algo	.....	.....	.....	.....	.*.*.	.....	.....	.....	.....
2	Camp prot	.....	.....	.....	.....	.....	.....	....*	.....	*....
2	Chil poly	.....	.....	.....	.....	.....	.....	..*..	.....	.*...
2	Cirr pili	.....	.....	.....	.....	.....	.....	.....	.*...	*....
2	Cono coni	.....	.....	.....	.....	.....	.....	..*..	.*...	.....
2	Dicr cerv	.*...	*....	.....	.....	.....	.....	.....	.....	.....
2	Dicr cirr	....*	.....	.....	.....	.....	.....	.....	.....	....*
2	Dicr rufe	.....	.....	.....	.....	.....	...*.	.....	.....	.*...
2	Dicr subu	.....	.*..*	.....	.....	.....	.....	.....	.....	.....
2	Ditr flex	.....	.....	.....	.....	.....	.....	....*	.....	*....
2	Drep unci	.....	.....	.....	.....	.....	.....	....*	.*...	.....
2	Eucl vert	.....	.....	.....	.....	.....	.....	..*.*	.....	.....
2	Font grac	.....	.....	.....	.....	.....	.....	...*.	.....	.*...
2	Gymn infl	..*..	.....	.....	.....	.....	.....	.....	.....	*....

Sub-Appendix 3 (cont'd)

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No.    Name     Locality code (see Sub-Appendix 1 for details)
times
found           11111 11111 11111 11222 22222 22222 22333 33333 33333
                11111 12223 33334 55111 11122 22234 45122 23344 44555
                12345 61231 23451 12123 45612 34511 21112 31212 34123

  2 Gyro tenu   ..... ..... ..... ..... ..... ..... ..*.. ....* .....
  2 Hygr ochr   ..... ..... ..... ..... ..... ..... ..*.. .*... .....
  2 Isop eleg   ..... ..... .*... ..*.. ..... ..... ..... ..... .....
  2 Jung grac   ..... ..... ....* ..... ..... ..... ..... ..... ..*..
  2 Leio bade   ..... ..... ..... ..*.. ..... ..... ..*.. ..... .....

  2 Lepi rept   ..... ..... ..... ..*.. ..... ..... ..... ..... ...*.
  2 Lept pyri   ..... ..... ..... ..... ..... ..... ..*.. ..... ..*..
  2 Orth anom   ..... ..... ...*. ..... ..... ...*. ..... ..... .....
  2 Pohl carn   ..... ..... ..... ..... ..... ..... ..... ...** .....
  2 Poly long   ..... ..... ..... ..... ..*.* ..... ..... ..... .....

  2 Spha angu   ..... ..... ..... ..... ..... ..... *.... *.... .....
  2 Spha quin   ..... ..... ..... ..... ..... ..... ..... ..... **...
  2 Spha subn   ..... ..... .*... ..... ..... ..... ..... *.... .....
  2 Tetr pell   ..... ..... ..... ...*. ..... ..... ..... ..... ....*
  1 Ambl serp   *.... ..... ..... ..... ..... ..... ..... ..... .....

  1 Andr rupe   ..... ..... ..... ..... ..... ..... .*... ..... .....
  1 Arch alte   *.... ..... ..... ..... ..... ..... ..... ..... .....
  1 Aula andr   ..... ..... ..... ..... ..... ..... ..*.. ..... .....
  1 Barb toph   ..... ..... ..... ..... ..... ..... ..*.. ..... .....
  1 Barb ungu   ..... ..... ..... ..... .*... ..... ..... ..... .....

  1 Bazz tril   ..... ..... ..... ..... ..... ..... ..... ..... ....*
  1 Blep tric   ..... ..... ..... ..... ..... ..... ..*.. ..... .....
  1 Brac albi   ..... ..... ...*. ..... ..... ..... ..... ..... .....
  1 Bryu arge   ..*.. ..... ..... ..... ..... ..... ..... ..... .....
  1 Bryu bico   ..... ..... ..... ..... ..... ...*. ..... ..... .....

  1 Bryu inte   ..... ..... ..... ..... .*... ..... ..... ..... .....
  1 Bryu micr   ..... .*... ..... ..... ..... ..... ..... ..... .....
  1 Caly inte   ..... ..... ..... ..... ..... ..... ..... ..... ....*
  1 Camp stel   ..... ..... ..... ..... ..... ..... ..... *.... .....
  1 Ceph conn   ..... ..... ..... ..... *.... ..... ..... ..... .....

  1 Ceph diva   ..... ..... ..... ..... ..... ...*. ..... ..... .....
  1 Ceph hamp   ..... ..... ..... ..... ..... ..... .*... ..... .....
  1 Ceph lunu   ..... ..... ..... ..... ..... ..... ..... ..... ....*
  1 Ceph macr   ..... ..... ..... ..... ....* ..... ..... ..... .....
  1 Dicr bonj   ..... ..... ..... ..... ..... ..... ..... *.... .....

  1 Dicr fusc   ..... ..... ..... ..... ..... ..... ..... ..... ....*
  1 Dicr maju   ..... ..... ..... ..... ..... ..... ..... ..... ....*
  1 Dicr palu   ..... ....* ..... ..... ..... ..... ..... ..... .....
  1 Dicr scot   ..... ..... ..... ..... ..... ..... ..... ..... ....*
  1 Ditr hete   ..... .*... ..... ..... ..... ..... ..... ..... .....
```

Sub-Appendix 3 (cont'd)

No. times found / Name / Locality code (see Sub-Appendix 1 for details)

No. times found	Name	11111 11111 12345	11111 12223 61231	11111 33334 23451	11222 55111 12123	22222 11122 45612	22222 22234 34511	22333 45122 21112	33333 23344 31212	33333 44555 34123
1	Drep flui	.....	.....	.....	.....	.....	.....	.*...	.....	.....
1	Drep revo	.....	.....	.....	.....	.....	.....	.....	*....	.....
1	Enca stre	.....	.....	.....	.....	.....	.....	....*	.....	.....
1	Eurh ripa	.....	.....	.....	.....	.....	.....	...*.	.....	.....
1	Eurh stri	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Fiss bryo	.....	.....	.....	..*..	.....	.....	.....	.....	.....
1	Fiss cris	.....	.....	.....	.....	.....	.....	....*	.....	.....
1	Fiss tenu	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Font anti	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Frul dila	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Frul tama	.....	.....	.....	.....	.....	.....	.....	.....	*....
1	Funa hygr	.....	.....	.....	.....	.....	...*.	.....	.....	.....
1	Gymn aeru	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Hygr eugy	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Hygr luri	.....	.....	.....	.....	.....	.....	.....	...*.	.....
1	Isot myos	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Isot myur	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Kurz pauc	.....	.....	.....	.....	*....	.....	.....	.....	.....
1	Leio bant	.....	.....	.....	.....	.....	.....	.....	*....	.....
1	Leio turb	.....	.....	.....	.....	.....	.....	.....	.*...	.....
1	Lepi cupr	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Leuc glau	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Loph bicr	.....	.....	....*	.....	.....	.....	.....	.....	.....
1	Loph exci	.....	.....	.....	.....	.*...	.....	.....	.....	.....
1	Loph inci	.....	.....	.....	.....	.....	.....	.....	.....	.*...
1	Pell nees	.....	....*	.....	.....	.....	.....	.....	.....	.....
1	Phil calc	.....	.....	.....	.....	.....	.....	.....	*....	.....
1	Plag elat	.....	.....	.....	.....	.....	.....	.....	*....	.....
1	Plag rost	.....	.....	.....	.....	.....	.....	.....	.*...	.....
1	Plag succ	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Poly juni	.....	.....	.....	.....	.....	...*.	.....	.....	.....
1	Prei quad	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Ptyc poly	.....	.....	.....	.....	.....	...*.	.....	.....	.....
1	Raco aqua	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Raco elon	.....	.....	.....	.....	.....	....*	.....	.....	.....
1	Scap grac	.....	.....	.....	.....	.....	.....	.....	.....	....*
1	Scap nemo	.....	.....	.....	.....	.....	....*	.....	.....	.....
1	Schi rivu	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Spha tere	.....	.....	.....	.....	.....	.....	.....	*....	.....
1	Tetr brow	.....	.....	.....	.....	.....	.....	..*..	.....	.....

Sub-Appendix 3 (cont'd)

No. times found	Name	Locality code (see Sub-Appendix 1 for details)								
		11111 11111 12345	11111 12223 61231	11111 33334 23451	11222 55111 12123	22222 11122 45612	22222 22234 34511	22333 45122 21112	33333 23344 31212	33333 44555 34123
1	Tetr mnio	.....	.....	.....	.....	.....	....*	.....	.....	.....
1	Tham alop	.....	.....	.....	.....	.....	.....	..*..	.....	.....
1	Ulot drum	.*...	.....	.....	.....	.....	.....	.....	.....	.....