Assessing and Monitoring Biodiversity at Smallcombe Cemetery, Bath

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Introduction

Following a request to Bath Natural History Society from Alastair Cowan of Friends of St Mary's Cemeteries, Dr Alan Rayner agreed to provide baseline information regarding the biodiversity currently to be found in Smallcombe Cemetery. The aims of this were to assist management decisions and to enable any resulting changes in biodiversity to be monitored.

Three recording visits to the site have been made so far. The first was a 3 h long perambulation on 5th June 2013 by Alan Rayner in which a note was made of all the plant, animal and fungal species he came across. The second was a visit of 15 members of Bath NHS, including Alan Feest, Andrew Daw, Alan and Marion Rayner and Alastair Cowan on 7th December 2013. This took the form of an initial perambulation noting plant, animal and fungal species additional to those found in June, including 16 species of snails identified by Andrew Daw, followed by a short structural sampling of bryophytes in a sequence of five 50 m^2 circular localities separated from each other by approximately 20 m. The third visit was made by Alan Feest, Marion and Alan Rayner and Alastair Cowan on 7th February 2014 as a continuation of the bryophyte survey, increasing the number of samples to a total of 20. The accent on bryophytes was to use these sensitive organisms to indicate the overall biodiversity and the detailed survey was used to provide a set of biodiversity indices that could be used for a retrospective comparison post improvement.

Results and Discussion

A list of all species identified during the three site-visits made so far is provided in appendix 1, and the full data set arising from the structured sampling of bryophytes is shown in appendix 2. Although more work, at different times of year is needed, and some kinds of organisms, e.g. insects and birds, are very under-recorded, it is clear that this is a remarkably

species-rich site, given its relatively small area and proximity to the city of Bath. Effort should therefore be made to manage the site in such a way that its biodiversity is conserved and if possible enhanced.

Several factors may contribute to this biodiversity:-

1. The site has not been subject to intensive cultivation and enrichment with fertilizers.

2. The site originates from and partially includes an area of ancient woodland, which supports some uncommon plants including coral-root and solomon's seal.

3. The use of the site as a cemetery has produced a rich variety of macro-habitats and micro-habitats, i.e. ancient woodland and calcareous grassland punctuated by basic and acidic stonework, sandy deposits and moist flushes, all subject to varied light and shade intensity. The habit diversity represented within its small area is hence equivalent to that of many much larger areas of countryside. This is of both scientific and educational interest, the latter being related to the opportunity to introduce members of the public, students and schoolchildren to natural variety that they may be unaware of and pass by without noticing.

The use of both general perambulation and intensive structured sampling illustrated the complementary benefits and disadvantages of each – and hence the value of including both in assessments of biodiversity at a specific site. General perambulation typically provides a large list of the most conspicuous species present, along with an awareness of macro-habitat variety and quality, but is subject to observer-bias and is of limited value in providing quantitative data that can be compared on successive occasions and hence detect changes in species presence and abundance. Intensive sampling cannot cover the full site and may omit some species outside the sampled localities, but is less subject to observer bias, readily reveals less conspicuous species and micro-habitat variety, and provides quantitative data sets that enable changes in species presence and abundance on successive occasions to be detected.

A total of 46 bryophyte species were recorded from the 3 survey exercises, the structured surveying adding 17 species to the list made by perambulation and only 1 species, Frullania dilatata, encountered on the perambulation was missed in the structural survey.

Bryophytes (mosses, liverworts and hornworts) are relatively inconspicuous plants that are often overlooked in general perambulations. Not only did the intensive sampling reveal how many more of these organisms were actually present than 'immediately met the eye', but it also highlighted the potential utility of these plants as indicators of macro-habitat and micro-habitat variety – and hence general biodiversity – in a locality. Many species of bryophytes are known to have quite exacting requirements for particular

habitat conditions of light intensity, moisture availability and the chemistry of the soil, stone and tree-bark surfaces on which they grow.

This can be illustrated by some examples of species encountered that are typical for the habitats present at Smallcombe Cemetery

Frullania dilatata, Cryphaea heteromalla, Metzgeria furcata are all typically found on tree bark, whereas Rhytidiadelphus squarrosus and Pseudoscleropodium purum are common calcareous grassland species. Other species are typical of walls and stonework: Tortula muralis, Grimmia pulvinata and Syntrichia intermedia. With the presence of ancient woodland bordering the site it is not surprising that some species associated with ancient woodland were represented: Rhytidiadelphus triquetrus, Atrichum undulatum, Thuidium tamariscinum, Eurhynchium striatum. There was also a good representation of small 'acrocarpous' (upright growing) mosses colonizing soil and stonework- these include Bryum capillare, Barbula unguiculata, Bryum dichotomum, Didymodon fallax and D. insulanus. None of these species are unexpected given the range of habitats, but the structured survey did produce one surprise- Pogonatum aloides which is typically of acidic soils but was found on the top of a wall possibly where sand had washed down from tree roots in the bank above.

One of the survey plots proved to be particularly rich in bryophyte species achieving a count of 22, perhaps reflecting the range of habitats within the plot which included level grassy pathways, sloping grassy bank, understory of shrubs and trees as well as vertical and horizontal stonework of grave plots.

The structured survey produced the following biodiversity indices (see Appendix 2):

Species richness:	45
Simpson Index	24.32
Density:	278
Species conservation Index:	3.16+/-1.33
Chao 1 expected SR:	55+/-7
Chao 2 expected SR:	55+/- 7
Boostrap expected SR:	53+/-7
Jacknife expected SR:	55+/-11
Nitrogen Index:	5.14

These indices indicate a species rich site (nearby newly planted woods have only a quarter of the species) reflecting the numerous differences in habitat at the bryological scale which in turn indicates the possible numerous ecological niches for other organisms. The Simpson Index of 24 is high and represents the evenness of distribution of the number of species. The lowest number of species per sample plot is 9 and the greatest 22. Density is a record of the total number of species registrations in all sample plots and produces an average of nearly 14 per plot. Only a few species were recorded that were not either common or abundant so the Species

Conservation Value Index (SCVI) of 3.16 (Standard Deviation 1.33) is low. The expected SR ranges from 53 to 55 and indicates that the sampling recorded over 80% of the species expected to be found on the site. Given the restricted surveying area in our methodology this 80% indicates high efficiency of sampling. The final index (Nitrogen Index) is especially interesting in that the figure of 5.14 is high and accords with the known pollution problem of Bath city and its environs. Bryophytes are known to be good indicators of pollution.

This set of indices will be of particular value in retrospective evaluation post-restoration since they can be used to directly compare the biodiversity quality of the site despite a possible turn-over of species.

Further visits at different times of year and to focus on different groups of organisms would greatly extend the list of species recorded so far. The site is likely to be rich in birds and insects, the latter including bees, beetles, moths and butterflies.

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APPENDIX 1

SMALLCOMBE CEMETERY SPECIES LIST

NB All species labelled '1' were identified during a single 3 h perambulation by Alan Rayner on 5th June 2013. All other species were added on subsequent occasions. Species listed in italics were added during structured survey of bryophytes.

TREES AND SHRUBS

	Common Name	Latin Name
1	Birch	Betula pendula
1	Box	Buxus sempervirens
1	Traveller's Joy	Clematis vitalba
1	Hazel	Corylus avellana
1	Hawthorn	Crataegus monogyna
1	Japanese Knotweed	Fallopia japonica
1	Ash	Fraxinus excelsior
1	Ivy	Hedera helix
1	Hydrangea	Hydrangea macrophylla
1	Holly	Ilex aquifolium
1	Cherry laurel	Prunus laurocerasus
1	Evergreen oak	Quercus ilex
1	Oak	Quercus robur
1	Bramble	Rubus fruticosus agg
1	Grey Willow	Salix cinerea
1	Elder	Sambucus nigra
1	Snowberry	Symphoricarpos albus
1	Yew	Taxus baccata
1	various planted conifers	

DICOTS

	Common Name	Latin Name
1	Yarrow	Achillea millefolium
1	Bugle	Ajuga reptans
1	Garden Lady's Mantle	Alchemilla mollis
1	Garlic Mustard	Alliaria petiolata
1	Wood Anemone	Anemone nemorosa
1	Great Burdock?	Arctium lappa
1	Daisy	Bellis perennis
1	White Bryony	Bryonia dioica
1	Coralroot	Cardamine bulbifera
1	Wavy Bitter-Cress	Cardamine flexuosa
1	Cuckooflower	Cardamine pratensis
1	Enchanter's Nightshade	Circaea lutetiana
1	Spear Thistle	Cirsium vulgare
1	Cherry Pie	Epilobium hirsutum
1	Broad-leaved Willowherb	Epilobium montanum
1	Wild Strawberry	Fragaria vesca
1	Goosegrass	Galium aparine
1	Hedge Bedstraw	Galium mollugo
1	Hedgerow Crane's-bill	Geranium pyrenaicum
1	Herb Robert	Geranium robertianum
1	Wood Avens	Geum urbanum
1	Shining Crane's-bill	Geranium lucidum
1	Hogweed	Heracleum sphondylium
1	Spanish Bluebell	Hyacinthoides hispanica
1	Meadow vetchling	Lathyrus pratensis
1	Creeping-Jenny	Lysimachia nummularia
1	Early Forget-me-not	Myosotis ramossissima
1	Wood-sorrel	Oxalis acetosella
1	Barren Strawberry	Potentilla sterilis
1	Mouse-ear Hawkweed	Pilosella officinarum

1	Ribwort Plantain	Plantago lanceolata
1	Primrose	Primula vulgaris
1	Meadow Buttercup	Ranunculus acris
1	Lesser Celandine	Ranunculus ficaria
1	Creeping Buttercup	Ranunculus repens
1	Common Sorrel	Rumex acetosa subsp. acetosa
1	Curled Dock	Rumex crispus
1	Broad-leaved Dock	Rumex obtusifolius
1	English Stonecrop	Sedum anglicum
1	Common Ragwort	Senecio jacobea
1	Red Campion	Silene dioica
	Mind-your-own-business	Soleirolia solerolii
1	Dandelion	Taraxacum officinale agg.
1	Lesser Trefoil	Trifolium dubium
1	Common Nettle	Urtica dioica
1	Germander Speedwell	Veronica chamaedrys
1	Slender Speedwell	Veronica filiformis
1	Ivy-leaved Speedwell	Veronica hederifolia
1	Bush Vetch	Vicia sepium
1	Lesser Periwinkle	Vinca minor
1	Early Dog-violet	Viola reichenbachiana
1	Common Dog-violet	Viola riviniana

MONOCOTS- GRASSES,SEDGES, RUSHES, ORCHIDS

	Common name	Latin name
1	Ransoms	Allium ursinum
1	Barren Brome	Anisantha sterilis

1	False oat grass	Arrhenatherum elatius
1	Cuckoo Pint	Arum maculatum
1	Wood False Brome	Brachypodium sylvaticum
1	Upright Brome	Bromopsis erecta
1	Cock's-foot	Dactylis glomerata
1	Red Fescue	Festuca rubra
1	Field Wood-rush	Luzula campestris
1	Smooth Meadow-grass	Poa pratensis
1	Rough Meadow-grass	Poa trivialis
1	Black Bryony	Tamus communis

FERNS ETC

	Common Name	Latin Name
1	Male-fern	Dryopteris filix-mas
1	Field Horsetail	Equisetum arvense
1	Great Horsetail	Equisetum telmateia
1	Hart's-tongue Fern	Phyllitis scolopendrium
	Hard Shield-fern	Polystichum aculeatum
1	Soft Shield-fern	Polystichum setiferum

BRYOPHYTES

	Common name	Latin name
	Creeping Feather-moss	*Amblystegium serpens*
1	Catherine's Moss	Atrichum undulatum
	Lesser Bird's-claw Beard-moss	*Barbula convoluta*

	Bird's-claw Beard-moss	Barbula unguiculata
1	Rough-stalked Feather-moss	Brachythecium rutabulum
	Capillary Thread-moss	Bryum capillare
	Bicoloured Bryum	*Bryum dichotomum*
	Crimson-tuber Thread-moss	*Bryum rubens*
1	Pointed Spear-moss	Calliergonella cuspidata
1	Comb-moss	Ctenidium molluscum
	Lateral Cryphaea	*Cryphaea heteromalla*
1	Broom Fork-moss	Dicranum scoparium
	False Beard-moss	*Didymodon fallax*
1	Cylindrical Beard-moss	Didymodon insulanus
	Dusky Beard-moss	*Didymodon luridus*
	Common Striated Feather-moss	Eurhynchium striatum
1	Common Pocket-moss	Fissidens taxifolius
1	Dilated Scalewort	Frullania dilatata
	Thickpoint Grimmia	Grimmia pulvinata
	Yellow Feather-moss	*Homalothecium lutescens*
1	Silky Wall Feather-moss	Homalothecium sericeum
	Mamillate Plait-moss	*Hypnum andoi*
1	Common Plait moss	Hypnum cupressiforme
1	Common Feather-moss	Kindbergia praelonga
	Top Notchwort	*Leiocolea turbinata*
	Bifid Crestwort	Lophocolea bidentata
	Crescent-cup Liverwort	*Lunularia cruciata*
1	Forked Veilwort	Metzgeria furcata
1	Wood Bristle-moss	Orthotrichum affine
1	Anomalous Bristle-moss	Orthotrichum anomalum
	Swartz's Feather-moss	*Oxyrrhynchium hyans*
	Endive Pellia	Pellia endiviifolia
	Greater Featherwort	Plagiochila asplenioides

	Many-fruited Thyme-moss	*Plagiomnium affine*
1	Hart's-tongue Thyme-moss	Plagiomnium undulatum
	Aloe Haircap	*Pogonatum aloides*
	Neat Feather-moss	*Pseudoscleropodium purum*
1	Clustered Feather-moss	Rhynchostegium confertum
	Tender Feather-moss	Rhynchostegiella tenella
1	Springy Turf-moss	Rhytidiadlphus squarrosus
1	Big Shaggy-moss	Rhytidiadelphus triquetrus
1	Thickpoint Grimmia	Schistidium crassipilum
	Intermediate Screw-moss	*Syntrichia intermedia*
1	Fox-tail Feather-moss	Thamnobryum alopercurum
	Common tamarisk-moss	*Thuidium tamariscinum*
1	Wall Screw-moss	Tortula muralis

LICHENS AND ALGAE

Common name		Latin name
	1	Arthonia radiata
	1	Aspicilia calcarea
	1	Caloplaca flavescens
	1	Diploicia canescens
		Graphis scripta
	1	Lecanora albellus
	1	Lecanora chlarotera
	1	Lecanora erisybe
	1	Lecanora gangaleoides
	1	Lecidella elaeochroma

1	Melanelia glabratula
1	Parmelia sulcata
	Peltigera membranacea
1	Physcia adscendens
1	Physcia tenella
1	Porpidia tuberculosa
1	Psilolechia lucida
1	Ramalina farinacea
1	Ramalina fastigiata
1	Trentepohlia abietina
1	Verrucaria baldensis
1	Verrucaria nigrescens
1	Xanthoria parietina

FUNGI

	Common name	Latin name
	Smoky Bracket	Bjerkandera adusta
	Glue Crust	Hymenochaete corrugata
1	Hazel Woodwart	Hypoxylon fuscum
1	Bleeding Broadleaf Crust	Stereum rugosum
	Turkeytail	Trametes versicolor
1	Waxy Crust	Vuillemenia comedens

MAMMALS

Common name	Latin Name
Grey Squirrel	Sciurus carolinensis

BIRDS

	Common Name	Latin name
1	Swift	Apus apus
1	Common Buzzard	Buteo buteo
1	Wood pigeon	Columba palumbus
1	Robin	Erithacus robecula
1	Chaffinch	Fringilla coelebs
1	Jay	Garrulus glandarius
	Great Tit	Parus major
	Magpie	Pica pica
1	Goldcrest	Regulus regulus
1	Wren	Troglodytes troglodytes
1	Blackbird	Turdus merula

LEPIDOPTERA- butterflies and moths

	Common name	Latin Name
1	Orange Tip	Anthocharis cardamines
1	Large White	Pieris brassicae

HYMENOPTERA-bees,wasps,ants,

	Common name	Latin Name
1	Buff tailed bumblebee	Bombus terrestris

MOLLUSCS- slugs and snails

Common name	Latin name
Copse Snail	Arianta arbustorium
Blind Snail	Cecilioides acicula
White-lipped Banded Snail	Cepaea hortensis
Two-toothed Door Snail	Clausilia bidentata
Slippery Snail	Cochlicopa lubrica
Plaited Door Snail	Cochlodina laminata
Garden Snail	Helix aspersa
Girdled Snail	Hygromia cinctella
Kentish Snail	Monacha cantiana
Rayed Glass Snail	Nesovitrea hammonis
Garlic Snail	Oxychilus alliarius
Dusky Snail	Perforatella subrufescens
Round-mouthed Snail	Pomatias elegans
Hairy Snail	Trichia hispida
Strawberry Snail	Trichia striolata
Grass Snail	Vallonia excentrica/pulchella

Appendix 2
Structured Bryophyte Survey

Smallcombe Cemetery Bryophytes 2014
07/02/14

Samples used = 20

Species name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Sum	SCVI	BI
GP S.rastilling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
GP S.riparium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0: Brachythecium rutabu...	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	0
11: Bryum capillare	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	0
2: Calliergonella cuspidata	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	2	0
3: Ctenidium molluscum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	3	0
4: Didymodon fallax	1	1	1	1				1	1	1	1	1	1	1	1	1	1		1	1	9	5	0
5: Didymodon insularus	1	1	1				1	1	1		1	1	1	1	1		1		1	1	12	4	0
6: Eurynchium strlatum	1	1	1						1		1	1	1	1	1		1		1	1	13	3	0
7: Homalothecium seric...	1	1	1	1	1	1	1		1	1	1					1	1	1	1	1	14	3	0
8: Hypnum andoi	1																				1	4	0
9: Kindbergia praelonga	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	2	0
10: Lophocolea bidentata	1				1	1				1	1		1	1			1				7	2	0
11: Plagiomnium undula...	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	2	0
12: Rhytidiadelphus squ...	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	12	3	0
13: Fissidens taxifolius		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	8	2	0
14: Plagiomnium affine		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	12	4	0
15: Barbula unguiculata					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	6	3	0
16: Hypnum cupressiform...					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2	0
17: Thamnobryum alop...					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	8	3	0
18: Didymodon luridus					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
19: Metzgeria furcata					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	0
20: Orthotrichum affine					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	7	2	0
21: Rhynchostegiella ten...					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	4	0
22: Schistidium cf. crass...					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	3	0
23: Pellia endiviifolia						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	0
24: Atrichum undulatum							1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	0
25: Barbula convoluta							1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	0
26: Bryum rubens							1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	3	0
27: Pogonatum aloides							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
28: Pseudoscleropodium...							1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	0
29: Thuidium tamariscin...							1	1	1	1	1	1	1	1	1	1	1	1	1	1	7	3	0
30: Lunularia cruciata								1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
31: Homalothecium lute...									1	1	1	1	1	1	1	1	1	1	1	1	3	3	0
32: Tortula muralis									1	1	1	1	1	1	1	1	1	1	1	1	7	2	0
33: Bryum dichotomum									1	1	1	1	1	1	1	1	1	1	1	1	3	3	0
34: Grimmia pulvinata										1	1	1	1	1	1	1	1	1	1	1	3	2	0
35: Syntrichia intermedia										1	1	1	1	1	1	1	1	1	1	1	1	5	0
36: Oxyrhynchium hians											1	1	1	1	1	1	1	1	1	1	4	3	0
37: Amblystegium serpens												1	1	1	1	1	1	1	1	1	1	2	0
38: Orthotrichium anom...												1	1	1	1	1	1	1	1	1	1	3	0
39: Plagiochila asplenioi...												1	1	1	1	1	1	1	1	1	3	4	0
40: Rhytidiadelphus trq...												1	1	1	1	1	1	1	1	1	3	3	0
41: Leiocolea turbinata														1	1	1	1	1	1	1	1	10	0
42: Cryphaea heteromalla																	1	1	1	1	1	4	0
43: Rhynchostegium con...																	1	1	1	1	2	2	0
44: Dicranum scoparium																	1	1	1	1	1	2	0
Summary	13	12	14	12	9	16	11	11	16	9	22	18	20	15	12	17	11	11	16	13	278	3.136	

Chao1 (pop.) Richness = 55.0+/-6.7314
Chao2 (pres./abs.) Richness = 55.0+/-6.7314
Bootstrap Richness = 52.763+/-7.4159
Jackknife Richness = 54.5+/-11.5325

Species Richness = 45
Shannon-Wiener Index = 3.422(0.0)
Simpson Index = 24.3184(0.0)
Berger-Parker Dominance Index = 0.07190(0.0)
Density = 0.278 per sq.m.
Species Conservation Value Index = 3.1555+/-1.3325
Biomass Index = 0.0

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