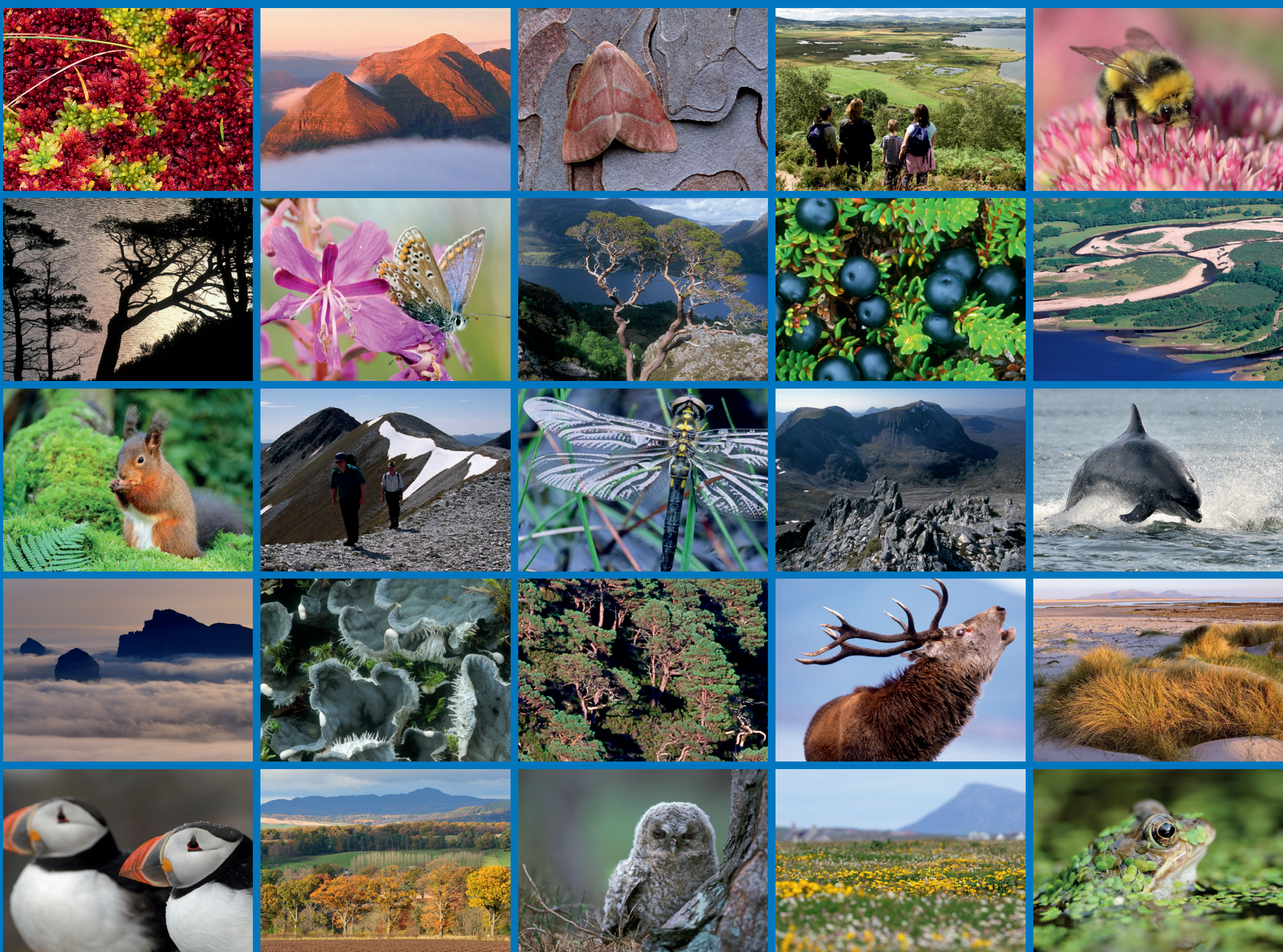
Scottish Natural Heritage
Research Report No. 1160

Scottish Natural Heritage Earth Science Site Condition Monitoring methodology 1999-2019



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RESEARCH REPORT

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RESEARCH REPORT
Summary

Scottish Natural Heritage Earth Science Site Condition Monitoring methodology 1999-2019

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Keywords

geosites; monitoring; geoheritage; geoconservation; geodiversity, Sites of Special Scientific Interest

Background

The assessed condition of Scotland's protected nature sites is publically available through the Protected Nature Sites pages of Scotland's Environment website (https://www.environment.gov.scot/data/data-analysis/protected-nature-sites/). The data for this is provided by Scottish Natural Heritage's Site Condition Monitoring Programme. This report covers the methodology used to obtain the Site Condition Monitoring data on Earth Science features, which was developed following UK-wide guidelines for common standards monitoring (JNCC 1998). The report also discusses results obtained using this methodology over the past 20 years.

Main findings

- Using a structured walk around the site, notified Earth Science features in SSSIs were assessed by comparing their condition against either a photographic Favourable Condition baseline, or the feature description in the legal documentation (citation). A condition assessment was assigned depending on the reversibility and severity of any damage, and any requirements for site management review were noted. Using the extensive feature data obtained during SCM since 1999, a quicker more focused site visit structure (Site Check) was developed in 2012 and, though less robust, also provides acceptable assessments of feature condition.

- A total of 1243 Earth Science SCM assessments have been completed since 1999 and all of the current 666 Earth Science features in Scotland have been monitored at least once. At the end of Cycle 3 (2019) a total of 98% of Earth Science features were assessed as either Favourable (94%) or Recovering (4%). The most common pressures on Earth Science features are obscuring by vegetation, or dumped material, and removal of geological specimens including fossils and rock core samples. Since 1999, 3% of Earth Science features have suffered some form of irreversible damage, and 10% have required remedial action to return them to Favourable condition. This indicates that the number of Earth Science features in Favourable condition would decline over time in the absence of monitoring and remedial action.

- Overall, Site Condition Monitoring in Scotland has produced important and useful data on the condition of protected Earth Science features in Scotland. The approach taken has proved practical, allowing non-specialists to undertake many assessments, and providing spatially specific data that can be related to individual management units if remedial actions are required.

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1. INTRODUCTION

One of the key responsibilities of the statutory nature conservation agencies in the UK is the identification and protection of a series of sites intended to conserve important wildlife and Earth Science features. Such sites may be designated under National legislation (Sites of Special Scientific Interest (SSSIs) in Britain and Areas of Special Scientific Interest (ASSIs) in Northern Ireland), European Directives (Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)), or an International Convention (Ramsar sites).

Once sites have been designated, the country agencies work with owners, occupiers and other stakeholders to protect and enhance the special features of the sites, for example by agreeing management plans and advising on development proposals. Site-based conservation is a corner-stone of biodiversity and Earth Science conservation in the UK, and a substantial proportion of the agencies' resources have been devoted to the selection, management and protection of statutory sites. Clearly, mechanisms are needed to assess how successful these activities have been in achieving nature conservation objectives, both on individual sites and across the site series as a whole.

The Environmental Protection Act 1990 (section 133, 2d) defined one of the special functions of the Joint Nature Conservation Committee (JNCC) as 'the establishment of common standards throughout Great Britain for the monitoring of nature conservation'. Monitoring is, in the sense used here, making an observation to establish whether a standard is being met. This can be established in a single visit or observation and does not require information collected over time.

In the context of protected sites, the development of common standards for monitoring provides two major benefits. Firstly it provides a reliable method with which to assess the conservation status of key interest features on protected nature sites. This enables assessments made by different people at different times to be compared with some confidence and enables staff to identify changes taking place on sites. Secondly, assessments from different sites can be aggregated to produce summary reports at a range of geographical scales. This can identify priorities for action at the local and national level. Such aggregation has been essential for the UK to report on the condition of designated sites across the UK, for example to meet the reporting requirements of EU Directives.

The establishment of common standards does not mean that monitoring has to be undertaken using prescriptive and rigidly-applied procedures. The approach needs to be sufficiently flexible to take into account natural geographical variation across the UK and to accommodate the varying requirements and operational practices of the country agencies (JNCC 2003, Ellis 2004). The detailed operational development of the JNCC Common Standards Monitoring for protected nature conservation features was the responsibility of each of the UK country agencies: Scottish Natural Heritage (SNH) in Scotland, Natural England (NE) in England (formerly English Nature), Natural Resources Wales (NRW) in Wales (formerly Countryside Council for Wales), and Environment and Heritage Services in Northern Ireland. Therefore, during the first 6-year monitoring cycle, each country agency developed locally tailored guidance, based on the JNCC CSM guidance, for monitoring natural heritage features within its remit. This paper details the SNH guidance for monitoring Earth Science features in Scotland first drafted in 1999, and revised and finalised by the author in 2005.

In 1998, JNCC released ‘A Statement on Common Standards Monitoring (CSM)’ (JNCC 1998) to set up common standards for monitoring protected biological and Earth Science features in the UK. Initial guidance for Earth Science features was also produced by JNCC (Ellis 1998, Ellis 1999, Ellis 2000 Appendix 1). This JNCC guidance was used to produce a first draft of Earth Science SCM guidance for Scotland in 1999 (Scottish Natural Heritage

1999 Appendix 2). Further guidance was released by JNCC in 2003-2004 (JNCC 2003, Ellis 2004). These documents now form the basis for monitoring Earth Science sites (geoheritage sites) in the UK and were used to revise and update the Earth Science SCM guidance for Scotland. Revised Earth Science SCM guidance for Scotland, developed by the author, was initially released in 2004 with minor revisions up to October2005. It was revised and updated to its current form in November 2016 (Wignall 2016a, Appendix 3).

Following a pilot year in 1998, implementation of Common Standards Monitoring (CSM) commenced in April 1999 with the intention that monitoring would occur in six-year cycles. Experience from the early part of this initial monitoring cycle was input to the Common Standards Monitoring Guidance released in 2003-2004 and to SNH guidance released in 2004-2005.

The first 6-year cycle ended at the end of March 2005 and JNCC published a summary report in 2006 (Williams 2006). During the period of the first monitoring cycle, 57% of all features in the UK, designated for their nature conservation value, were monitored. The monitoring cycle in Scotland was then extended to 7 years, with SCM Cycle 2 being completed in March 2012 and SCM Cycle 3 in March 2019. In Cycle 1 the aim of the overall SCM programme in Scotland was to monitor all biological and geological features; however, in Cycle 2 this was reduced to a random selection of 50% of all biological and geological features, and in Cycle 3 this was reduced further to a weighted selection of 33% of features based on perceived robustness of feature types. A less rigorous or 'lighter touch' Site Check assessment was also introduced to be undertaken for all features not undergoing full SCM.

In Scotland all Earth Science features have been monitored one or more times during SNH's Site Condition Monitoring (SCM) programme using the assessment methods developed by the author and summarised in this paper. The results of SNH's SCM programme are publically available through the Protected Nature Sites pages of Scotland's Environment website (https://www.environment.gov.scot/data/data-analysis/protected-nature-sites/).

2. EARTH SCIENCE SITE CONDITION MONITORING METHODOLOGY

The purpose of site monitoring is essentially to determine whether the desired condition of the feature(s) of interest for which the site was designated is being achieved. This can enable judgements to be made about whether the management of the site is appropriate, or whether changes are necessary. Monitoring is also essential to enable managers and policy makers to determine whether the site series as a whole is achieving the required condition, and the degree to which current legal, administrative and incentive measures are proving effective.

The basis of the common standards for site monitoring is that those special features for which the site was designated are assessed to determine whether they are in a satisfactory condition. The nature conservation component which is assessed is therefore not the site itself, but the feature (e.g. habitat, species, or Earth Science feature) for which it was designated. Sites may have one, two, or several interest features on them. Key attributes of the feature (e.g. extent, quality, supporting processes) are identified and targets set for each. Each attribute is then measured and compared against the target value set. If all the targets are met, the feature is in favourable condition. Human activities and other factors which are likely to be affecting the site adversely, and the conservation measures taken to maintain or restore the site, are also recorded.

2.1 Earth Science features to be monitored

The features to be monitored are known as the interest features for which the site has been notified or designated. They include individual habitat types, species and Earth Science features, and also complex features such as habitat mosaics and species assemblages. Each interest feature must be identified, monitored, assessed and reported on separately. For national sites, the interest feature is the feature which has been notified by the country agency in accordance with the SSSI/ASSSI selection guidelines for biological features, or which is the interest feature specified in the Geological Conservation Review (GCR)/Earth Science Conservation Review for Earth Science features.

Table 1: Earth Science SSSI feature names used in Scotland, listed under the sub-categories of their relevant Site Condition Monitoring (SCM) Reporting Categories. All names, except those in italics are the same as the relevant GCR block.

SNH Earth Science SSSI feature names with Reporting Categories as sub-headings			
Stratigraphy			
	Cenomanian-Maastrichtian	Hettengian, Sinemurian, Pleinsbachian	Caradoc-Ashgill
	Oxfordian	Permian-Triassic (red Beds)	Llandeilo
	Kimmeridgian	*Upper Carboniferous [Namurian (part) -Westphalian]*[1]	Arenig-Llanvirn
	Bathonian	*Lower Carboniferous [Dinantian – Namurian (part)]*[1]	Tremadoc-Arenig
	Callovian	Non-Marine Devonian	Tremadoc
	Aalenian-Bajorcian	Wenlock	Cambrian
	Toarcian	Llandovery	Cambrian-Tremadoc
Structural and Metamorphic Geology			
	Moine	Torridonian	Lewisian
	Dalradian	Caledonian Structures of the Southern Uplands	*Caledonian Structures of Shetland*[2]
Igneous Petrology			
	Tertiary Igneous	Old Red Sandstone Igneous	Caledonian Igneous
	Carboniferous-Permian Igneous	Ordovician Igneous	
Mineralogy			
	Mineralogy of Scotland		
Palaeontology			
	Jurassic-Cretaceous Reptilia	Pleistocene Vertebrata	Permian/Carboniferous Fish/Amphibia
	Permian-Triassic Reptilia	Palaeoentomology	Tertiary Palaeobotany
	Tertiary Mammalia	Arthropoda (excluding insects, ostracods, trilobites and Quaternary arthropods)	Mesozoic Palaeobotany
	Mesozoic Mammalia	Silurian-Devonian Chordata	Palaeozoic Palaeobotany
Quaternary Geology and Geomorphology			
	Quaternary of Scotland	Tufa *[sites incorporated into relevant regional Quaternary]*	
Geomorphology			
	Caves	Coastal Geomorphology of Scotland	Fluvial Geomorphology of Scotland
	Karst	Saltmarsh morphology *[sites incorporated into regional coastal geomorphology]*	Mass Movement

[1] Names with ‘Namurian’ in were chosen in preference to the GCR block names ‘Westphalian’ and ‘Dinantian of Scotland’ to ensure that the importance of Namurian rocks on these sites is recognised.
[2] ‘Caledonian Structures of Shetland’ was only introduced as a GCR block in 2016 (http://jncc.defra.gov.uk/page-4171) so is not listed in Ellis et al. 1996

The location and area of an Earth Science feature in a SSSI is defined by the boundary of the relevant GCR site. Any areas within the SSSI but outside the relevant GCR site need not be monitored as they do not contain the interest feature. Two or more separate GCR sites with the same Earth Science interest (e.g. Caledonian Igneous), or separate areas of the same GCR site, may make up a single interest feature in one SSSI. A single GCR site may also span several SSSIs. Areas of a GCR site outside a particular SSSI are also not considered when monitoring the condition of the feature within that SSSI. Therefore, where a GCR site spans several SSSIs, the condition of the portion of the GCR site in each individual SSSI is monitored separately.

Earth Science SSSI feature names used in Scotland are listed in Table 1. These follow the names of the Geological Conservation Review site categories, also known as 'GCR blocks' (Ellis et al 1996), with a few exceptions (see table 1 and its footnotes). The features are divided into broad 'Reporting Categories' following the similar division of GCR blocks into Block-types or 'networks'.

Features which have not been notified and listed on the legal documentation for the site (known as the 'citation') are not reported on under common standards monitoring.

Descriptions of how geological and geomorphological interests fit into the different Reporting Category are given in Ellis 2004. How the features may manifest themselves within a site is also discussed in Ellis 2004. This will clearly vary from site to site; but in general, Earth Science features will be one or more or a combination of: actively forming rock, sediment or landform features; relict landforms; and exposed or buried rock or sediment that may or may not contain important fossils or rare minerals (Figure 1a-h).

Figure 1: Some examples of different types of Earth Science features in Scotland

a) Moine features in Aird Torrisdale SSSI. A typical inland and coastal outcrop site. ©Rachel Wignall/SNH

b) Folding in soft sediment forms part of the Quaternary of Scotland feature in Ardersier Glacial Deposits SSSI near Inverness. ©Rachel Wignall/SNH

c) River outcrop at the classic Forest Lodge locality in Glen Tilt forms part of the Caledonian Igneous feature in Beinn a' Ghlo SSSI. ©Rachel Wignall/SNH

d) The Quaternary of Scotland feature at Black Loch (Abdie) SSSI is the pollen record contained in the sediments of the lochan and surrounding marshes. ©Rachel Wignall/SNH

e) Intertidal outcrop of the Helmsdale Boulder Beds, which form part of the Kimmeridgian feature in Helmsdale SSSI. ©Rachel Wignall/SNH

f) Dune system that forms part of the Coastal Geomorphology of Scotland feature in Dunnet Links SSSI. ©Rachel Wignall/SNH

g) Fluvial Geomorphology of Scotland feature, River Clyde Meanders SSSI. ©Rachel Wignall/SNH

h) Fossil-bearing Caithness flagstones in the working quarry at Spittal Quarry SSSI. ©Rachel Wignall/SNH

2.2 Conservation objectives

The desired condition of the feature is termed Favourable condition. Conservation objectives, also referred to as 'condition objectives', define what constitutes favourable condition for each feature. They describe targets or target ranges that should be met if the feature is to be judged in favourable condition. Each interest feature has one or more measurable characteristics, termed 'attributes' for which targets are set to define favourable condition. These attributes either describe an aspect of the interest feature directly or are good indicators of its condition. The choice of target range for each attribute, in relation to favourable condition, is critical, and must take into account any fluctuations in the attribute that are normal and are not a cause for concern.

In some instances, conflicting conservation objectives for different features on the same site may occur. These cases can only be dealt with on an individual basis but are likely to require careful consideration of target wording.

2.3 Attributes for Earth Science features in Scotland

Attributes selected for monitoring any feature must be measurable, so that targets can be set as part of the conservation objective for the feature. Attributes should also describe the condition of the feature and not the factors which influence it (for example management activities are in general not suitable attributes) (JNCC 1998). However, in geological monitoring, it was clear from an early stage that attributes, considered to be highly important by experts, included subjectively assessable quality of geological features, such as the 'visibility' or 'intactness of exposure' of geological features or 'naturalness of geomorphological processes' (Ellis 2004).

The Common Standards Monitoring guidance states that 'attributes for Earth Science features include the Geological Conservation Review selection criteria and accessibility for education and research purposes' (JNCC 1998). Early JNCC Earth Science SCM guidance (Ellis 1998) listed lengthily worded 'targets' for different types of Earth Science feature including for aspects of the feature (attributes) such as 'physical composition, morphology and internal structure', 'quality of key Earth Science elements', 'physical condition of the site', 'context and relationships of the key Earth Science elements', 'visibility of key Earth Science elements', 'key Earth Science elements remain exposed/unobscured', 'access for the purposes of education and research', 'safe access to the site', 'natural processes', 'evolving naturally' and ''geomorphological processes'. In the early SNH guidance (Scottish Natural Heritage 1999, Appendix 2) this was distilled down into 5 attributes for the majority of Earth Science feature and 6 attributes for active Geomorphology features:

- Process Dynamics (active geomorphology features only)
- Physical Attributes
- Visibility
- Access
- Safety
- Negative Indicators (any changes that might affect one of the other Attributes in future)

For a short while, Physical Attributes was divided into 'Extent', 'Composition', 'Structure' and 'Morphology' (where relevant) but it was found that in the majority of cases these elements overlapped. There was, therefore, a lot of duplication of effort and some confusion in reporting on all of them separately. So the overarching 'Physical Attributes' was used, initially often with the qualifier: 'Physical Attributes: extent, composition, structure and morphology'.

Practical experience of using these Attributes in SCM Cycle 1 showed that there was considerable overlap, and consequent confusion, between elements of the Visibility, Access and Safety Attributes. These was also some confusion as to whether Access meant that general public access had to be in place, or a generic access permission granted for research. Therefore, for Cycle 2, the Access and Safety attributes were merged into the Visibility attribute, giving 3 attributes that must be monitored for the majority of features and 4 attributes that must be monitored for active geomorphology features:

- Physical Attributes
- Visibility
- Process Dynamics (active geomorphological features only)
- Negative Indicators (any changes that might affect one of the other Attributes in future)

This tied in well with the revised JNCC CSM Earth Science guidance (Ellis 2004) which stated that the attributes of geological features to be monitored should include:

- quality of appearance or lack of disturbance to the internal structure of entities – the physical condition of rock/sediment/landform/spoil heap/etc. e.g. lack of disruption of sediments in a landform (that are not yet visible); lack of fragmentation of exposure, no physical damage to important parts of rock 'faces'/sediment stacks/landforms etc.; quality and visibility are intimately linked attributes;
- extent of features (e.g. quantity of important geological material such as volume of important spoil material in a mine dump, or area of rock face in an exposure site where it is advantageous to have a greater amount of rock exposure to study);
- 'visibility'– factors to be monitored will be lack of concealment from vegetation/soil/ talus build ups/ engineering constructions;

- Process dynamics: freedom of geomorphological processes to evolve naturally and unimpeded.'

A further modification for SCM Cycle 2 was that only the first 3 attributes, namely Physical attributes, Visibility and Process Dynamic were used as Condition Assessment attributes, meaning that assessment of these would input to the assessment of feature condition. The last attribute, Negative Indicators, was changed to be a Management Review attribute. This must be monitored for all Earth Science features; but will not have any effect on determining the feature condition. Instead, factors recorded under the 'Negative Indicators' management review attribute will be used to recommend review of site management.

Table 2: Descriptions of the Attributes used for Earth Science Site Condition Monitoring in Scotland.

Attribute	Description
Physical Attributes	Physical Attributes includes the extent, composition, and structure of the feature and also its morphology where this is important, as for example features including glacial, fluvial or coastal landforms. For active process sites Physical Attributes also includes 'active process indicators'. These are landforms and other physical characteristics which have been formed under contemporary environmental conditions and so are still changing or have the capacity to change.
Visibility	Visibility covers lack of concealment of the features for example from vegetation, soil or engineering constructions. Monitoring this attribute involves assessing whether 'appropriate views' of the feature are available. 'Appropriate views' usually include close-up views (e.g. close enough to touch a rock outcrop or sediment section) and more distant views (e.g. showing overall structure of folds in a rock face) (Figure 2). Also included under this attribute are any factors, including safety, that affect the ability of monitoring personnel to physically access the relevant points to obtain the appropriate views.
Process Dynamics	Process Dynamics is monitored for active process geomorphology features only. This attribute is designed to ensure the freedom of geomorphological processes to evolve naturally and unimpeded. In practice this involves checking that no artificial constraints have been imposed, such as coastal or river defences. Extraction of, for example sand and gravel, may also disrupt natural processes and be relevant to this attribute as well as to Physical Attributes. Factors outside the site may also affect the Process Dynamics within the site.
Negative Indicators	*The Management Review Attribute, Negative Indicators, is designed to ensure that any factors which might adversely affect the site in the future are recorded. This could be anything from dumping of waste, or growth of self-seeded trees to planned quarry expansion or likely requirement for future coastal defences. This attribute was used to determine where site management review was required, and also to help assign a trend to the condition assessment (see section 2.6).*

Figure 2: Some aspects of a feature may be best viewed from a distance such as this large scale fold that forms part of the Moine features in Ben More Assynt SSSI. ©Rachel Wignall/SNH

In summary, the Attributes used for Earth Science SCM in Scotland from Cycle 2 onwards are:

Condition Assessment attributes
- Physical Attributes
- Visibility
- Process Dynamics (for active geomorphological features only)

Management Review attributes
- Negative Indicators

Aspects of the feature included in each Attribute are given in more detail in Table 2.

2.4 Targets for Earth Science features in Scotland

For each interest feature, targets are set for the relevant attributes to define favourable condition. CSM guidance recommends that in general, favourable condition will reflect the state of an interest feature at the time of its selection but with the proviso that processes supporting the feature should be such as to enable it to maintain its condition over time. However, the guidance also notes that in practice, the site condition at the time of selection may not be known, or be inappropriate. If this is the case, targets should be set to ensure that the feature is maintained in a condition which is likely to be sustained over the foreseeable future, in line with the principles of favourable conservation status. Targets should not, however, be set at levels which seek to achieve substantial improvements to a site beyond that needed to maintain its notified interest features.

For geological sites, CSM guidance states that a target of no reduction in quality or quantity of the features of interest is generally applicable. However, in order to monitor if no reduction has occurred, a suitable baseline is required. As noted above, this should in theory be the state of the feature at time of notifications. In most cases, however, the only record of feature state at time of notification is the wording of the legal citation that describes the feature. Therefore, favourable condition can best be defined as: any condition where the relevant attributes of the feature (i.e. Physical Attributes, Visibility, and Process Dynamics if applicable) are sufficient to support the legal citation.

Attribute targets, therefore may be written as follows:

Attribute	Target
Physical Attributes	The essential physical manifestations of the feature, on which the citation is based, continue to be present and intact
Visibility	The essential physical manifestations of the feature on which the citation is based are still visible in close and distant views as appropriate (including views appropriate for research and study access).
Process Dynamics	The essential natural processes on which the citation is based, and/or the natural processes forming the essential active process indicators on which the citation is based continue to operate without constraint.
Negative Indicators	*All of the above targets are met and there are no activities or changes in the vicinity of the site that might in the future affect one or more of the above attributes. (Management should be reviewed if current management will not protect the site from the perceived threats.)*

These Attribute targets are useable provided that the person undertaking the monitoring has sufficient expertise to identify the ‘physical manifestation of the features on which the citation is base’ and the ‘essential process dynamics/natural processes forming the essential active process indicators on which the citation is based’. Details of the manifestation of the interest feature on the site (e.g. ‘a 12 m stretch of 4 metre high cliff with ledges supporting patches of grassy vegetation’) are not usually present in the wording of the legal citation, which details the scientific importance of the features. Therefore, relevant scientific expertise is required to determine if the targets, as given above, are met.

CSM guidance, however, is clear that in general, condition assessments should be capable of being undertaken by operational staff within the agencies, and that only for some interest features, is it expected that it will be necessary to have specialist input. Therefore, targets needed to be set that would enable most monitoring to be undertaken by agency staff who were not Earth Science specialists. For this to be done, the baseline against which the current site condition is to be compared needs to be presented in a way that is understandable by non-specialists.

The solution adopted was to use a photographic baseline, with the monitoring conducted via a structured walk around the site checking for changes since the baseline. In many cases this will simply involve looking at the outcrops or landforms and checking for hammer marks, rock saw marks, rock core drill holes, signs of excavations, erosion, constructions, encroaching vegetation, tipping, tree planting etc. However, for Palaeontology (fossil) sites and Mineralogy (mineral) sites, where the fossils or minerals of interest are found in loose material, it is also important to check that the relevant fossils or minerals) are still found by conducting a search for specimens and making a rough count (e.g. few/sparse/moderate/abundant) of numbers of specimens found. This is because disturbance and removal of specimens in loose material can occur without any obvious signs (e.g. hammer marks) being left to record it by, and changes in volumes of loose material may be hard to determine through comparison of photographs.

Using a photographic baseline enables easy comparison of the present condition of a feature with that at the time of the baseline. However, for most features there is no photographic record of their condition at the time of their notification. Therefore, the only practical solution is to use the earliest baseline condition for which there is a photographic record, and which an expert has confirmed to be a record of 'favourable condition' for the feature using the Attribute targets listed above. This is the method adopted by SNH for Earth Science SCM.

The majority of Earth Science features in Scotland were photographically recorded between 1991 and the start of the Site Condition Monitoring programme as part of a project, known as the Site Documentation project, that aimed to provide plain English descriptions of all internationally and nationally important geological and geomorphological features in the country. Therefore, for many features, these 'Site Documentation Reports' could be used as a Favourable Condition baseline for Site Condition Monitoring. There were some issues arising from the fact that the reports were written to describe the geological interest not to provide a baseline for monitoring, however. For example, in some cases, particularly for larger sites, the photographic record could be relatively sparse for the purposes of site condition monitoring. In these cases, the Site Documentation Report photo record was supplemented by photographs from the first SCM visit (Figure 3). This gave a more complete baseline for future monitoring visits. Where no Site Documentation Report had yet been produced, or the Site Documentation Report did not record a Favourable Condition baseline, the targets given above were used for SCM assessments until a Favourable Condition baseline could be photographically recorded. In these cases expert input was needed for monitoring, and the site condition as recorded photographically in Cycle 1, Cycle 2 or even Cycle 3 became the Favourable Condition baseline.

Figure 3: Typical photos used to establish or supplement photographic baseline:

a) Discreet areas of good exposure photographed in their entirety (Dirlot Gorge SSSI). ©Rachel Wignall/SNH

b) Key aspects of the feature such as this classic exposure of the Glencoul Thrust above Loch Glencoul in the Loch Glencoul SSSI. ©Rachel Wignall/SNH

c) General views showing level of outcrop (Ben Hutig SSSI). ©Rachel Wignall/SNH

d) General views showing lack of outcrop (Lennel, Charley's Brae SSSI). ©Rachel Wignall/SNH

Where there is a photographic Favourable Condition baseline, targets are set so that any decline in site condition below this baseline results in a condition assessment target failing, and the site being recorded as not being in Favourable condition.

Attribute targets for features where there is a suitable photographic Favourable Condition baseline are:

Attribute	Target
Physical Attributes	No part of the feature has been damaged, moved or removed (except by natural processes on a temporary basis, through acceptable consented activities, or as part of the natural evolution of active process indicators) since the time of an appropriate baseline.
Visibility	No part of the feature has been partially or wholly covered or otherwise been made inaccessible for viewing (except by natural processes on a temporary basis, or through acceptable consented activities) since the time of an appropriate baseline.
Process Dynamics	The essential natural processes on which the citation is based, and/or the natural processes forming the essential active process indicators on which the citation is based are not further constrained (except through acceptable consented activities) than they were at the time of an appropriate baseline.
Negative Indicators	*All of the above targets are met and there are no activities or changes in the vicinity of the site that might in the future affect one or more of the above attributes. (Management should be reviewed if current management will not protect the site from the perceived threats.)*

The targets for use with and without a baseline(Table 2) are one of the key things that someone monitoring the feature needs to know, so were included in a brief easy-reference summary document (Wignall 2016b, Appendix 3).

Table 2: Attribute targets for features when there is, and when there is not, a photographic Favourable Condition baseline available

Attribute	Target without photographic baseline	Target with photographic baseline
Physical Attributes	The essential physical manifestations of the feature, on which the citation is based, continue to be present and intact	No part of the feature has been damaged, moved or removed (except by natural processes on a temporary basis, through acceptable consented activities, or as part of the natural evolution of active process indicators) since the time of an appropriate baseline.
Visibility	The essential physical manifestations of the feature on which the citation is based are still visible in close and distant views as appropriate (including views appropriate for research and study access).	No part of the feature has been partially or wholly covered or otherwise been made inaccessible for viewing (except by natural processes on a temporary basis, or through acceptable consented activities) since the time of an appropriate baseline.
Process Dynamics	The essential natural processes on which the citation is based, and/or the natural processes forming the essential active process indicators on which the citation is based continue to operate without constraint.	The essential natural processes on which the citation is based, and/or the natural processes forming the essential active process indicators on which the citation is based are not further constrained (except through acceptable consented activities) than they were at the time of an appropriate baseline.
Negative Indicators	*All of the above targets are met and there are no activities or changes in the vicinity of the site that might in the future affect one or more of the above attributes. (Management should be reviewed if current management will not protect the site from the perceived threats.)*	*All of the above targets are met and there are no activities or changes in the vicinity of the site that might in the future affect one or more of the above attributes. (Management should be reviewed if current management will not protect the site from the perceived threats.)*

2.4.1 Acceptable variations from Favourable Condition baseline

The targets for use with a photographic baseline take into account ecosystem dynamics such as varying levels of sand and seasonal vegetation, through the wording in parentheses (‘except by natural processes…’). These exceptions to retaining the feature exactly in its baseline state were detailed in the monitoring guidance (Wignall 2016a) and are summarised below.

Loss of Physical Attributes or decrease in Visibility, compared to the Favourable Condition baseline, is acceptable in instances where:

1) Obscuring or removal of part of the feature occurs naturally and is known (or reasonably believed) to be temporary or periodic (e.g. seasonal). In such cases, the original baseline state must be considered highly likely to reoccur with no need for management intervention. Some examples include:

   - Natural destruction of active landforms such as river bars during periods of flood, or parts of a dune system during winter storms, if the process dynamics of the site are considered capable of recreating such landforms and the change is part of the natural evolution of the site.
   - Seasonal vegetation (e.g. bracken and giant hogweed), as long as the overall area affected by the vegetation has not increased since the baseline.
   - Periodic flooding of quarries, rivers or other water bodies if the outcrop/landform is not obscured more than ~50% of the time.
   - Weather that temporarily obscures key views of the feature.
   - Tide levels that obscure inter-tidal outcrop.
   - Natural variations in sand volume on a beach/shore. These may be seasonal, or weather dependent (Figure 5).
   - Variations in sea-weed cover on coastal outcrops (Figure 4).

2) Activities that result in loss or modification to Earth Science features but have been consented to in advance by SNH, and fulfil the condition that the ‘no baseline’ targets for the remaining portion of the feature are met (see also 2.6 Feature Condition below).

2.4.2 Targets where there are conflicting conservation objectives

As discussed above, targets set for any particular interest feature may need to take into account the conservation objectives of other features on the site. For Earth Science features, this is most likely to involve a conflict between the target for the Visibility Attribute of the Earth Science feature, which is to retain the feature visibility as per the photographic baseline, and targets for a biological feature that include increased vegetation levels, such as increased tree regeneration. In such cases, reverting to the ‘no baseline’ target (‘The essential physical manifestations of the feature on which the citation is based are still visible in close and distant views as appropriate (including views appropriate for research and study access)’) may allow a site condition to be achieved in which both Earth Science and biological features are considered to be in favourable condition. Where this cannot be achieved, decisions may need to be made on the relative priorities of achieving favourable condition for each feature; however, this is outside the scope of this paper.

2.5 Feature condition

The key decision to be made when monitoring statutory sites in the UK following CSM guidance, is whether a feature is in favourable condition or not. Although the CSM guidance stresses that condition assessment is not a completely scientific exercise and that it relies on making judgements based on the best available evidence, the system of Attributes and targets aims to ensure that consistent assessments are made by numerous individuals over a wide geographic area.

Figure 4: Carboniferous-Permian Igneous feature with outcrop partly covered by sand and seaweed in the North Berwick Coast area of the Firth of Forth SSSI. Variations in sand volume and seaweed cover are acceptable changes in sites with coastal outcrops. ©Rachel Wignall/SNH

Favourable and Unfavourable condition are determined by whether feature Attribute targets are met or not. In Scotland, an Earth Science feature is only in Favourable condition if the targets for all the relevant condition assessment Attributes (Physical Attributes, Visibility, and Process Dynamics where appropriate) are met. If not all the condition assessment Attributes targets are met then the assessment is more complex as a feature that is not in Favourable condition may be Unfavourable, Partially Destroyed or Totally Destroyed. Which assessment applies, depends on whether any or all of the detrimental factors (damage, or any other factor causing targets to fail) are reversible or irreversible. The various condition assessments and when they may apply are summarised in Table 3 below. If all detrimental factors are reversible, then the feature is in Unfavourable condition. If any of the detrimental factors are irreversible, then the feature will be either 'Totally destroyed', or will be in one of two possible 'Partially Destroyed' categories.

Table 3: The relationship between detrimental factors and condition assessment

Detrimental factors	Condition assessment
All reversible	Unfavourable
Some irreversible, some reversible	Totally Destroyed *or* Partially Destroyed/Unfavourable
All irreversible	Totally Destroyed *or* Partially Destroyed/Favourable

To determine whether the condition assessment is Totally Destroyed, Partially Destroyed/Unfavourable or Partially Destroyed/Favourable, the condition of the remaining portion of the feature, discounting the destroyed portion, is assessed. This assessment is made, by a relevant expert, using the 'no baseline' targets to determine if the remaining portion of the feature is sufficient to support the citation. If all condition assessment Attribute targets are met for the remaining portion of the feature then the assessment is 'Partially

Destroyed/Favourable’. If the targets are not met, due only to reversible detrimental impacts, then the assessment is ‘Partially Destroyed/Unfavourable’. If the targets are not met due to irreversible impacts, in other words, the remaining portion of the feature is not sufficient to support the citation, then the assessment is that the feature is ‘Totally Destroyed’. Features assessed as ‘Totally destroyed’ are removed from the list of protected features for that site. Ideally a replacement feature at another location should be sought where possible; but this is outside the scope of this report.

A key feature of the assessment of feature condition is that for consistency all irreversible damage, however small on the scale of the feature as a whole, must be recorded with a Partially Destroyed assessment. This is in order to register all irreversible damage that has occurred, and to ensure that repeated ‘minor’ damage does not accumulate, unregistered, into total destruction of the feature. It is important that small areas of irreversible damage are not dismissed or glossed over as ‘minor’ or ‘insignificant’.

2.5.1 Trends in feature condition

Within each of the ‘Favourable’, ‘Unfavourable’ and ‘Partially Destroyed’ categories described above, sub-categories were included to record judgements on whether the condition of the feature is stable, declining or improving. If the evidence for a trend appears dubious or weak, an assessment of ‘no change’ or ‘maintained’ was made. In total SNH SCM assessment allows a choice of 13 different initial condition assessments. Of these initial condition assessments, ‘favourable – declining’ is the only category not listed in the CSM guidance (JNCC 2003). It was added by SNH to record sites where observations indicate that the feature condition may decline into unfavourable condition in the near future. For Earth Science features, this category is usually assigned if all condition assessment Attribute targets are met but the Negative Indicators (management review Attribute) target is not met.

Once an SCM assessment is made, then that assessment stands until the next full SCM assessment is completed. However, for the final SCM assessment reported by SNH, there is one additional condition assessment that can be made. This is an assessment of ‘Recovering – recovering due to management’. It can be made in place of any Unfavourable condition assessment where remedial work or a change of management regime has been successfully undertaken to turn around the initial Unfavourable SCM assessment. This may involve, for example, altering a grazing regime for a grassland feature, or clearing of invasive vegetation from a geological exposure (see also section 3.6).

In total SNH SCM assessment allows a choice of 14 different final reported condition assessments (Table 4). The reasons for assigning any particular condition assessment and trend are always recorded with the assessment.

Table 4: The 14 possible final reported condition assessments in SNH's SCM programme.

Condition assessment	Explanation
Favourable – maintained	The condition of the feature has remained favourable since the previous assessment.
Favourable – recovered	The condition of the feature has changed from unfavourable to favourable since the last assessment.
Favourable – declining	The condition of the feature is favourable but is moving away from the desired state or likely to do so in the near future.
Unfavourable – recovering	The condition of the feature is unfavourable but is moving towards the desired state.
Unfavourable – declining	The condition of the feature is unfavourable and is moving away from the desired state.
Unfavourable – no-change	The condition of the feature is unfavourable and is neither improving nor declining.
Partially destroyed/ Favourable – maintained	Part of the feature is effectively no longer present. The remaining portion of the feature has remained favourable since the previous assessment.
Partially destroyed/ Favourable – recovered	Part of the feature is effectively no longer present. The remaining portion of the feature has changed from unfavourable to favourable since the last assessment.
Partially destroyed/ Favourable –declining	Part of the feature is effectively no longer present. The remaining portion of the feature is favourable but is moving away from the desired state or likely to do so in the near future.
Partially destroyed/ Unfavourable – recovering	Part of the feature is effectively no longer present. The remaining portion of the feature is unfavourable but is moving towards the desired state.
Partially destroyed/ Unfavourable – declining	Part of the feature is effectively no longer present. The remaining portion of the feature is unfavourable and is moving away from the desired state.
Partially destroyed/ Unfavourable – no-change	Part of the feature is effectively no longer present. The remaining portion of the feature is unfavourable and is neither improving nor declining.
Totally destroyed	The feature is no longer present on the site or the portion of the feature remaining is not sufficient to support the legal citation.
Recovering – recovering due to management	The feature has been assessed as Unfavourable during its most recent SCM assessment. Subsequently work has been successfully undertaken to reverse the pressures causing Unfavourable condition.

2.6 Resetting the monitoring baseline

There are certain circumstances in which it may be necessary to re-set the favourable condition photographic baseline used for monitoring a feature. These include

- When a feature is Partially Destroyed. A revised baseline should be used for the next SCM assessment to avoid a repeated assessment of Partially Destroyed for the same damage.
- In cases where a geological site has just been cleared, either for scientific research or as part of actions to improve site condition. In such cases it may be that the level of visibility of the feature directly after clearance is not reasonably maintainable. If these situations, a suitable length of time should be allowed to elapse, for natural slope stabilisation and an acceptable level of vegetation growth to occur, before a 'favourable baseline' condition is recorded. Expert judgement may be required to assess when a baseline should be recorded.

Re-setting the Site Condition Monitoring Favourable Condition baseline needs to be done by an expert who can where appropriate:

- assess the remaining portion of the feature against the 'no baseline' targets to determine whether it is sufficient to support the legal citation, where the feature has been Partially Destroyed, or
- judge the level of vegetation/slope stabilisation that is acceptable and reasonably maintainable where the feature has been enhanced by clearing.

2.7 Recording pressures and management measures

An important part of monitoring is the potential for relating observed changes in the condition of the interest features to the reasons for such changes. As part of the monitoring process, therefore, the following were recorded:

- threats occurring on, or near, the site that may be driving features into unfavourable condition or preventing them from achieving favourable condition; and
- management measures that may result in improvements to the condition of features or maintain features in favourable condition.

The recording of threats was done using a standard list of 'pressures' (e.g. geological core extraction, tree regeneration, dumping/spreading/storage of materials). This enabled an assessment of which pressures most often affect different types of features.

It was not always possible to attribute cause and effect from the information gathered during monitoring, however, where useful conclusions could be made, the information was used to guide management and remedial actions if required.

2.8 Field methodology

Earth Science site condition monitoring assessments in Scotland are almost always conducted via a structured walk around the site checking for changes since the baseline. The route taken may vary between visits or may remain the same, depending on the geography of the site. The key point is that all appropriate localities are visited.

2.8.1 Fixed Point photography

Photographs are taken at Fixed Points during each SCM assessment. However, 'fixed point photography' is used primarily as a means of recording observations on site condition and is not essential for drawing conclusions about site condition. Observations recorded as written comments are the crucial factor, with photographs acting to support and illustrate points. The feature as visible at each Fixed Point should be checked in order to make a condition assessment of the feature; however it is not necessary to re-take all Fixed Point photographs in order to make a condition assessment of the feature (Wignall 2016c). This is due to practicalities such as the direction and intensity of sunlight that may make re-taking some shots difficult. Alternatively it could be that the tide is slightly higher or wet weather has made the rock more slippery than on the previous visit, making it more dangerous or impossible to access the Fixed Point. If it is considered unsafe or impossible to return to a Fixed Point photo location, this could be a temporary situation or it could be an indication that the 'Visibility' target for the feature may not be met.

Photographs, other than those from Fixed Points, are also often taken. In some cases this is to illustrate damage or change, and in other cases simply to add to the data available for the feature. New Fixed Points can be added if considered necessary, for example if damage is recorded in an area not previously noted as a Fixed Point.

2.8.2 Recording methods and the SCM database

Photographs and field notes may be recorded in any way considered appropriate. Over time, for example, photographs have been taken on film-cameras, then digital cameras, then using electronic tablets. GPS devices have also been updated over time with tablets having internal GPS systems. Written notes made in the field (using a protected 'Weather-Writer' clip-board or waterproof notebook) were originally entered into an electronic or paper document and these were processed centrally. Later, during Cycle 2, an SCM database was developed, and SNH staff (and later some staff from partner agencies) could enter SCM assessments directly into this system.

2.8.3 Swift app

During Cycle 3, an app (Swift) on hand-held electronic tablets was trialled and rolled out for both Earth Science SCM and Site Check (see section 2.14 for more information on Site Check). The Swift app can display SSSI boundary maps and current location which was found to be very useful, especially in bad weather. However the app does not yet display the GCR site boundary, which indicates the area of Earth Science interest in the SSSI, and addition of this would be useful. The app allows geo-referenced photos and notes taken on the tablet while in the field to be uploaded directly into the SCM database on return to the office. This was found to considerably reduce the time required to complete assessments once back in the office. However, it often increased the time taken to record data in the field – typing on the small pop-up screen keypad one-handed, often through a thick plastic waterproof cover, was found to be much slower than writing in a clip-board or note-book. There have also been a number of technical issues with the Swift system which have meant that back-up recording (via camera, GPS and note book) has often been required. This has significantly increased the time required for data-recording in the field. As with much new technology, when the Swift system worked it was very useful for both SCM and Site Check, but it will take time and investment for it to become completely reliable and be tailored ideally to the task. A future test for the system will be how easy it is to retrieve data, particularly photographs, recorded on the Swift app on previous site visits, and compare it to what is being observed on a current visit.

2.8.4 Monitoring very large Earth Science features

During the early part of Site Condition Monitoring Cycle 1, it became obvious that many Earth Science features were too large to have a comprehensive photographic baseline. Some sites were also too large to reasonably visit, let alone photograph, every part of the site during a single SCM cycle (Figure 5). So a methodology was developed to cover these sites (Wignall 2016c, Appendix 3). This is outlined below.

The impracticality of comprehensive site visits and photo-recording of larger Earth Science features leads to several problems in monitoring these sites:

- It is unlikely that any baseline will include a comprehensive photographic or written description of every outcrop or landform of interest in the site;
- It is possible that not every area of the site was visited prior to compiling the baseline; so it may be that not all damage present at the time of the baseline was recorded.
- It may be unfeasible to visit every area of the site during a single SCM cycle or to check every outcrop or landform.

For large Earth Science features therefore, photos should be taken from additional points during SCM visits and used to supplement the existing baseline.

Where the site is of a size where it is possible to visit the whole site but not to photograph all areas of outcrop or landform, the following types of area should be photographed where possible:

- Areas where damage has previously been recorded, or areas at risk of damage (e.g. active quarries, disused quarries/pits where tipping may occur, sections of coast or river where defences exist or may be required, adjacent to forestry plantations where trees may self-seed, roads, tracks, paths, human habitation, obvious landmarks such caves and ruined castles that attract visitors).
- Any key geological/geomorphological features (e.g. historic or famous localities, localities popular for teaching or featuring in geological guide books)
- General views of the site including either the main areas of outcrop or landform or representative areas if the outcrop is spread patchily across the whole site.

Where it is not possible to visit the entire site, the following should be considered:

- How is the Earth Science interest distributed within the site?

If there are key areas of Earth Science interest (e.g. important geological contact, notable example of a landform), these should be visited and photographed.

- Where are the most likely places for damage to occur?

Damage is likely to occur in areas where people are most likely to go such as roads, tracks, paths, hill summits, caves, landmarks and around settlements; and areas where vegetation growth and erosion may damage the feature, such as rail/road or other man-made cuttings, disused quarries, adjacent to plantations (self-seeded trees), or areas of rhododendron or gorse. These areas should be visited.

- Where might good vantage points be?

A selection of good vantage point should be identified, and all, or a selection of these, should be visited during each monitoring cycle, to record the general appearance of the Earth Science feature throughout the site (e.g. general distribution of outcrop, and vegetation cover).

- How might the 'rest of the site' be covered?

It is recommended that some other areas of the site are also visited, but that these additional areas are varied each monitoring cycle.

All new, increased or previously unrecorded damage and potentially damaging operations should be recorded comprehensively, preferably photographically with appropriate notes. Any areas considered particularly at risk from potentially damaging operations should also ideally be photographically recorded and notes made as to the perceived risk.

If multiple site visits are required in order to monitor a single feature, these should be carried out preferably within 1 year, or 3 years at a maximum, to try to avoid any likelihood of the feature condition changing during the period of the monitoring visits.

Figure 5: Clach Bun Rudhtair in the Eastern Cairngorms Mountains. This impressive tor forms part of the Quaternary of Scotland feature in the Eastern Cairngorms SSSI, which covers an area of over 16,500 Ha. Monitoring of this feature in 2003 helped develop the Large Earth Science Features guidance (Wignall 2016c, Appendix 3). ©Rachel Wignall/SNH

2.8.5 Questionnaire field forms

The idea of using questionnaire-style 'field forms' for Earth Science site condition monitoring, was introduced through the JNCC guidance in 1999 (Appendix 1). The idea for the field forms was to assist non-specialist carrying out monitoring to know what to look for and record, and to guide them in making an appropriate assessment against feature attribute targets. The field forms as proposed by JNCC included a relatively long list of questions with simple yes/no answers relating to aspects of the feature such as intactness and condition of exposure, but also activities such as tipping, engineering works and agricultural use, and other changes such as in vegetation and water level that might affect the feature.

Some SNH staff trialled the JNCC field forms in the early part of SCM Cycle 1. They reported that, although they were usually able to give an appropriate yes/no answer to the questions, there was no guidance as to which answers meant that a feature target failed or which target should fail. Work was done (by the author) in 2003 to try to address this issue (Appendix 4), changing the field form to show which, if any of the attribute targets should fail if each statement was true (or answer was 'yes'). Further feedback from monitoring staff, however, showed that the number of questions and amount of text requiring to be read and interpreted for a single feature assessment was seen as time-consuming and off-putting rather than helpful. Therefore, the use of questionnaire-style field forms was abandoned in Scotland for the remainder of Cycle 1 and for later SCM cycles. Questionnaire-style field forms were also not included in the revised JNCC Earth Science monitoring guidance (Ellis 2004).

2.9 Length of monitoring cycles

SCM Cycle 1 was preceded by a trial year (April 1998 – March 1999) and the monitoring cycle itself, from which results were submitted to JNCC, was 6 years in duration (April 1999 - March 2005). In Scotland, Cycle 2 was extended to 7 years (April 2005 – March 2012). An initial proposal was to undertake 6 years of monitoring and have a further year to collate data and finalise reports. However a new online system for reporting SCM assessment became available part way though Cycle 2 and made calculations of results and statistics automated. It therefore became clear that there was no reason to stop further SCM assessments being carried out in the final year of the cycle. SCM Cycle 3 was also 7 years in duration (March 2012 – April 2019) with assessments being carried out throughout the period.

2.10 Monitoring frequency and the introduction of Site Check

In Cycle 1 (1999-2005) the aim of the overall SCM programme was to monitor all biological and geological features. The JNCC summary of results (Williams 2006) reports that 57% of features were actually monitored across the UK as a whole (including around 67% of all Earth Science features). This suggests that even if the process, now better established, became more efficient in Cycle 2, monitoring all features every cycle was not likely to occur without an impossibly large increase in budget and staff time. Therefore, in Cycle 2 (2005-2012) the target in Scotland was reduced to a random selection of 50% of all biological and geological features. With budget cuts in Cycle 3 (2012-2019) this was reduced further to a weighted selection of 33% of features based on perceived robustness of feature types. It was realised, however, that this reduction in the percentage of features being monitored each cycle increased the risk of damage occurring unnoticed between monitoring visits. It was also possible that some features monitored in 1999, would not be visited again before the end of Cycle 3 (2019). Therefore a ‘lighter touch’ programme of site visits known as Site Check was introduced during Cycle 3.

Site Check is designed to be undertaken, primarily for features not undergoing full SCM, to help ensure that features are visited more regularly. Site Check can be undertaken during a dedicated site visit. Alternatively a Site Check might be recorded if the feature is visited for another reason, such as a visit to discuss site management, review a planning proposal or to monitor another feature on the site. Site Check can also be carried out for features that have undergone full SCM, for example as a means of recording a follow-up visit to full SCM.

Site Check is proposed to provide a simple overview of all, or part of, a site to check whether management and wider influences have changed since the last SCM assessment or Site Check visit. These ‘wider influences’ might include third party damage or natural events such as erosion and vegetation growth.

Current guidance for Earth Science Site Check methodology is given in full in Appendix 5, however a brief summary is given below.

In order to carry out a Site Check of an Earth Science feature, you need to:

- view all key areas (e.g. important geological contact, notable example of a landform) of the feature, and any areas where previous damage has occurred, from a distance where it is possible to
    - identify any damage previously recorded that may be repeated (Figure 6)
    - identify any damage of a type likely to occur to that feature (e.g. specimen collecting on a fossil or mineral site with visual appeal),
    - identify any management changes
- record any damage, and any changes in management or wider influences.

Sufficient of the feature should be viewed from an appropriate distance to determine whether or not likely damage has occurred to the feature, and to identify any change in management regime that might affect the feature. It is accepted that damage outside key areas or of an unusual type may go unrecorded.

Despite its less comprehensive and robust nature, feedback regarding Site Check so far indicates that results are useful and do pick up pertinent site issues. Therefore Site Check reports do appear to record an acceptable assessment of feature condition. An important factor in success of Site Check in reporting an accurate feature condition is the comprehensive photographic and written information on Earth Science features available from both Site Documentation Reports and previous SCM assessments. With this good baseline information it is possible to successfully structure short site visits to provide appropriate information on site condition. The more flexible nature of Site Check, allowing multiple site visits within one SCM cycle to be recorded on the SCM database, is also a useful feature.

Figure 6: Key fossil-bearing outcrops that have previously suffered from collecting damage, such as this easily-accessible outcrop with visually spectacular brachiopod fossils at Petershill Quarry SSSI, should be visited during a Site Check. ©Rachel Wignall/SNH

3. RESULTS AND DISCUSSION

The results of SNH's SCM programme are publically available through the Protected Nature Sites pages of Scotland's Environment website (https://www.environment.gov.scot/data/data-analysis/protected-nature-sites/). Summary results of the first cycle of Site Condition Monitoring for all features across the UK were also published by JNCC (Williams 2006).

Since a pilot year in 1998, Site Condition Monitoring (SCM) has been undertaken in cycles of 6 or 7 years, during which 1243 full Earth Science monitoring assessments have been completed, and all Earth Science features in Scotland monitored at least once. During the period of the SCM programme a number of new Earth Science features were added to SSSI, and some features were also removed. Overall the number of notified Earth Science features in Scotland increased from 608 in Cycle 1, to 657 in Cycle 2, and 666 in Cycle 3.

3.1 Cycle 1

For Cycle 1 (1999-2005) the aim was to monitor all notified features in Scotland. At the end of Cycle 1 in 2005, 595 (98%) Earth Science features in Scotland had been monitored and 90% of these were assessed as in Favourable condition (N.B. the category 'Recovering due to management' was not introduced until Cycle 2). A total of 4 features were assessed as Partially Destroyed.

Key points noted at the end of Cycle 1 (Scottish Natural Heritage 2010), in relation Earth Science features included:

- A higher proportion of Earth Science features were assessed as 'Partially Destroyed' than features in any other Feature Category (e.g. Birds, Fish, Woodlands, Upland Habitat etc.), due to the non-renewable nature of the majority of Earth Science features.
- Encroachment of vegetation was the most common negative pressure on Earth Science features.
- Fly tipping, both historic and current, were negative pressures on Earth Science features particularly near urban centres and in agricultural areas.
- Irresponsible collecting was the single biggest negative pressure on Mineralogy features, and was also a negative pressure on Palaeontology and Stratigraphy features.

See section 3.5 below for further discussion of pressures recorded through SCM.

3.2 Cycle 2

For Cycle 2 (2005-2012) the aim was to monitor a random selection of 50% of all biological and geological features. During Cycle 2 (2005-2012) 419 (64%) Earth Science features were monitored (many for a second time) so that over the two cycles 643 (98%) features had been monitored at least once. At the time of their most recent monitoring visit (Cycle 1 or Cycle 2) 92% of these features were assessed as being in Favourable condition and a further 4% were assessed as 'Recovering due to management'. During Cycle 2, 8 features were assessed as Partially Destroyed. One feature was assessed as Totally Destroyed due to over collecting and was denotifed (removed from the list of notified features).

There is no JNCC or SNH summary report for the end of SCM Cycle. However SNH produced a Condition of Designated Sites report in 2010 (Scottish Natural Heritage 2010) to report against the Scottish Government's Condition Target which was to achieve 95% of natural features in favourable condition by March 2010. As well as a summary of the Cycle 1 findings, the Earth Science section of this report gives an interim figure of 93% of Earth Science feature in favourable condition (as of March 2010). It also first considered features that are 'Unfavourable - recovering 'due to remedial management post-assessment as counting positively towards the favourable condition target. These features were later given the new assessment category of 'Recovering –recovering due to management' to distinguish them from those features found to be Unfavourable-Recovering during SCM assessment. Since 2010, reports of features in favourable condition always include both features assessed as 'Favourable' and features where remedial action has updated the assessment to 'Recovering'.

3.3 Cycle 3 and overall results

In Cycle 3 the aim was to monitor a weighted selection of 33% of all biological and geological features. The selection was based on perceived robustness of feature types. Features were weighted by assigning monitoring frequency, either monitoring once every cycle (7 years) or only every 2, 3 or 4 monitoring cycles (14, 21 or 28 years). Earth Science features, were generally rated as relatively robust and given monitoring frequencies of 3 or 4 cycles (21 or 28 years). This lead initially to selection of relatively few Earth Science features for monitoring in Cycle 3. However, due to constraints with monitoring some biological features, the proportion of Earth Science features monitored increased over the period of the cycle. Overall during Cycle 3, 229 (34%) Earth Science features were monitored, many for a second time and some for a third time. By the conclusion of Cycle 3, all currently notified Earth Science features in Scotland (666) had been monitored at least once. Over the period of Cycle 3, an additional 393 (59%) Earth Science features had at least one Site Check visit. This meant that during Cycle 3, a field visit to monitor or check the site was undertaken for 622 (93%) Earth Science features in Scotland.

During Cycle 3, 2 further features were denotified having been assessed as Totally Destroyed, both due to infilling, and in one case also extraction, that had long-standing planning consent given prior to SSSI notification. Therefore in total 3 features were assessed as Totally Destroyed during the 20 year SCM programme.

Also during Cycle 3, a further 9 features were assessed as Partially Destroyed. Therefore overall during the period of the SCM programme (1999-2019), 21 (3%) features suffered some form of irreversible damage and were assessed as Partially Destroyed. This is a higher proportion than for any other feature type (Williams 2006, https://www.environment.gov.scot/data/data-analysis/protected-nature-sites/), and reflects the non-renewable nature of many Earth Science features that cannot regenerate if part of the feature is damaged or removed.

Including the remaining portions of Partially Destroyed features, at the time of their most recent assessment (Cycle 1, 2 or 3) 98% of Earth Science features in Scotland were found to be in either Favourable (94%) or Recovering (4%) condition. A summary of the results discussed above is given in table 5.

Table 5: Summary of Earth science features monitored in each SCM cycle and assessment results.

	Cycle 1 (1999-2005)	Cycle 2 (2005-2012)	Cycle 3 (2012-2019)
Planned % of all natural heritage features to be monitored in cycle	100%	50%	33%
No. of Earth science features in Scotland	608	657	666
% (no.) of Earth science features assessed in cycle	98% (595)	64% (419)	34% (229)
% (no.) additional Earth science features where at least one Site Check visit made	-	-	59% (393)
% (no.) Earth science features visited in cycle	98% (595)	64% (419)	93% (622)
% (no.) of Earth science features assessed at least once since start of SCM	98% (595)	98% (643)	100% (666)
No. Earth science features assessed as Partially destroyed in cycle	4	8	9
No. Earth science features assessed as Destroyed in cycle	0	1	2
% Earth science feature Favourable at last assessment	90%	92%	94%
% Earth science features Recovering due to management	-	4%	4%

3.4 Robustness of results

Around 20% of Earth Science features reported on in Cycle 1 were monitored by an Earth Science specialist (the author). In Cycles 2 and 3, with the guidance in place, a higher proportion was monitored by non-specialists. Practical on-site training was offered on a group or one-to-one basis. Further specialist advice was available if required, and the majority of features where possible issues were identified, or where a non-favourable assessment was likely, were referred for specialist advice.

A random sample of features also underwent QA by specialists. Issues were identified early on with the use of local contractors who were not Earth Science specialists. These relatively rare cases occurred, for example, where a habitats or species specialist were contracted to monitor Earth Science features alongside biological features on the same site. While, in theory, Earth Science SCM can be undertaken by non-specialists, it appeared that contractors found it harder to do successfully than SNH staff. This was presumably due to SNH staff being able to access internal training and specialist support. Later SCM assessments were, therefore, undertaken by SNH staff or specialist Earth Science contractors working on national contracts.

The overall results of the QA exercise indicated that an acceptable level of consistency was being achieved across the country and between different Earth Science features even where specialist advice had not been sought by areas staff. This gave confidence that the results of the Site Condition Monitoring programme in Scotland are an accurate representation of the state of Scotland's protected Earth Science features.

3.5 Pressures affecting Earth Science features

As mentioned in section 3.1 above, Site Condition Monitoring not only records a condition assessment for each feature, it also records the reasons for the assessment. This includes any pressures that are believed to be affecting the feature. Pressures may be recorded as 'negative', 'negative but not the cause of unfavourable condition', 'positive and negative', 'neutral' or 'positive'. Pressures can be 'active' or 'inactive'. The latter might apply to a pressure that was recorded as 'active' in Cycle 1 but was no longer in Cycle 2.

Pressures are recorded as a selection from a standardised list of with an explanatory note, and the option of adding Key Words (e.g. the type of an invasive species). This allows data to be gathered about the most common pressures affecting different feature types as well as detailed information about the individual cases. Standard Pressures on the list are grouped into larger 'Pressure Groups'. For example the Pressure Group 'Development' includes 'Beach replenishment', 'Development with planning permission', 'Energy production - at sea (wind & wave turbines)' and 'Energy production - on land (power stations, inc. nuclear)' (see Appendix 6).

While the overview list of Pressure Groups used in SCM assessments (see Figure 1) has remained unchanged, the list of Standard Pressures within Pressure Groups has changed over time.

In particular Standard Pressures have been added where monitoring staff have found a pressure not listed, or wished to be able to distinguish a specific pressure from others in a more generic category. New Pressures were also added to clarify which category a certain pressure should be placed in where it could potentially be placed in two or more categories. For example 'Tree regeneration' was added as a sub-category of 'Natural event' for SCM Cycle 3, to enable the pressure on the Visibility Attribute of Earth Science features from self-seeded trees (usually from adjacent forest plantations) to be distinguished from other types of 'Natural event'. It also ensured that this pressure was always recorded in the same place where previously it might have been recorded under 'Natural event', 'Forestry Operation' or 'Invasive species'. Similarly 'Geological Core Extraction' was added as a sub-category of 'Extraction' to ensure that all cases of core extraction were easily identifiable. Previously core extraction may have been recorded under 'Extraction – Mineral Extraction', 'Recreation/disturbance – Recreation/disturbance' or even 'Recreation/disturbance – Fossil Collection'.

As was also noted from the Cycle 1 results, the combined SCM assessments at the end of Cycle 3 show that the most common pressure on Earth Science features in Scotland is still obscuring of the feature by vegetation (Figure 7). This is recorded either as 'Invasive species' or 'Natural event', particularly the sub-category 'Natural event – tree regeneration'. Obscuring of the feature by dumped material (dumping/storage of material) is also common. The fourth most common pressure noted was Recreation/disturbance which includes fossil collecting (MacFadyen 2015b), graffiti (Bain 2013) and off-road vehicle tracking. Also high on the list is 'Extraction' which will include most incidents of extraction of geological cores (though see previous paragraph). The issue of damage by extraction of geological core samples (Figure 8) has increasingly become apparent, and received considerable attention in the geoconservation community in recent years (Butler 2015, Campbell & Wood 2002, MacFadyen 2006b, 2007b, 2009, 2011a, 2017a, 2017b).

Figure 7: Trees obscuring visibility and making it difficult or impossible to access appropriate views of the Silurian-Devonian Chordata feature at Oxendean Burn SSSI. ©Rachel Wignall/SNH

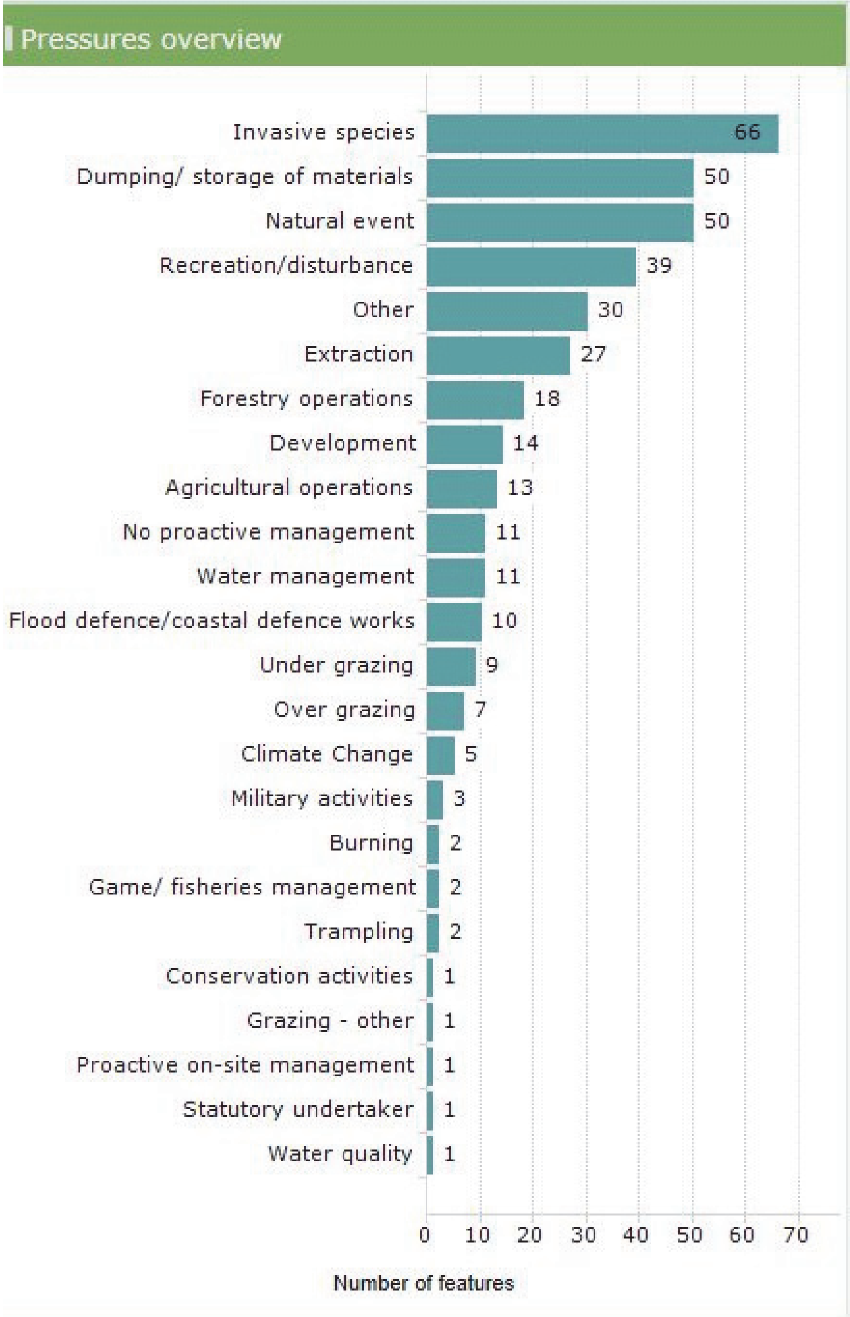
Data, at 'Pressure Group' level, on pressures recorded as 'active' and 'negative' is available through the Protected Nature Sites pages of Scotland's Environment website (https://www.environment.gov.scot/data/data-analysis/protected-nature-sites/) (Figure 9).

Figure 8:

a) Core holes, permanently disfiguring superb outcrops of Devonian sandstone at Tarbat Ness SSSI. The worn edges suggest they are several decades old. ©Rachel Wignall/SNH

b) Core holes, from 1970s research, defacing a text-book example of rhythmites folded around a sandstone wedge in Dalradian metasediment, Garvellach Islands. ©Rachel Wignall/SNH

Figure 9: Summary of pressures affecting Earth Science features (as of March 2019).



3.6 Scottish Natural Heritage's Remedies programme

Overall during the 20 year period of SCM, an average of 1-2 Earth Science features have declined into Unfavourable condition each year, and a similar number have been Partially Destroyed each year. Therefore maintaining and increasing the proportion of Earth Science features in Favourable condition, has required on-going remedial action.

Remedial action can be triggered by an Unfavourable SCM assessment or an assessment where a requirement for management review has been noted. Results from Cycle 1 first indicated where remedial action was required, and between 2005 and 2010 a total of 34 Earth Science features were brought into favourable condition by change in management or other activity on the site (Scottish Natural Heritage 2010). From March 2011, remedial action, triggered by SCM, became part of SNH's 'Remedies' programme. So far this programme has instigated remedial action for 887 natural heritage features including 32 Earth Science features. This means that over the time of the SCM programme, remedial action has been carried out for 66 Earth Science features. This is 10% of Earth Science features over 20 years, suggesting that if remedial action were to cease, around 5% of features would be likely to fall into Unfavourable condition every decade.

Remedial action for Earth Science features has predominantly involved clearance of vegetation (Blair 2017, Figure 10), but also management of slumping and landslip (Edwards 2013), graffiti removal (Bain 2013), coastal management schemes, removal of tipped material and measures to prevent further tipping. Features where remedial action has been taken as part of the remedies programme are the 4% of features assessed as 'Recovering', or more explicitly 'Recovering - Recovering due to management', in the overall SCM results.

Figure 10: Gorse clearance to re-expose the Lower Carboniferous feature at Bishop Hill SSSI, Fife, in 2016. ©Rachel Wignall/SNH

3.7 Supporting good practice

Preventing further partial or total destruction of Earth Science features may require site-based or broader, non-site based approaches to change people's attitudes and actions.

At some sites in Scotland measures have been put in place to combat irresponsible specimen collecting (Kelly 2016). SNH is also working to develop better recording of specimen collecting carried out under consent at protected sites, to ensure that appropriate conditions are set and that these are adhered to. New standard application forms for consent to collect are being trialled (Appendix 7). These require the applicant to supply considerable detail of sample locations and sampling methods as well as the names and affiliations of individuals who will carry out the work. A requirement to provide SNH with a field report is also being trialled. This is must be submitted within 6 months of the work being carried out, and must including 'before' and 'after' photographs of sampled localities. Draft guidance to be provided alongside the application form is being trialled concurrently (Appendix 7). It is hoped that if sample collecting proposals are considered in greater detail in advance, and applicants are required to record the changes that sampling has had on the site, as well as have only named individuals carrying out sampling, this will encourage:

- specification by SNH of clear and appropriate conditions for collecting consents,
- responsible behaviour by those undertaking consented sample collecting, and
- strict adherence to the conditions of collecting consents.

As well as site-based measures, raising awareness is also important along with clear guidance on legal issues and good practice. Awareness raising and guidance is important for both:

- those with little or no Earth Science knowledge who may be unaware when they are causing damage to an important feature (MacFadyen & Boyes 2007, MacFadyen 2016a, 2016b), and
- those with geological knowledge, but primarily commercial or research interests, who may lack awareness of geological conservation issues (Butler 2015, MacFadyen 2011b, 2017b, Threadgould *et al* 1999, Townley 2002).

During the 20 year period of the SCM programme, SNH has implemented a number of measures to raise awareness of good practice and to promote responsible geological fieldwork and collecting practices. These include:

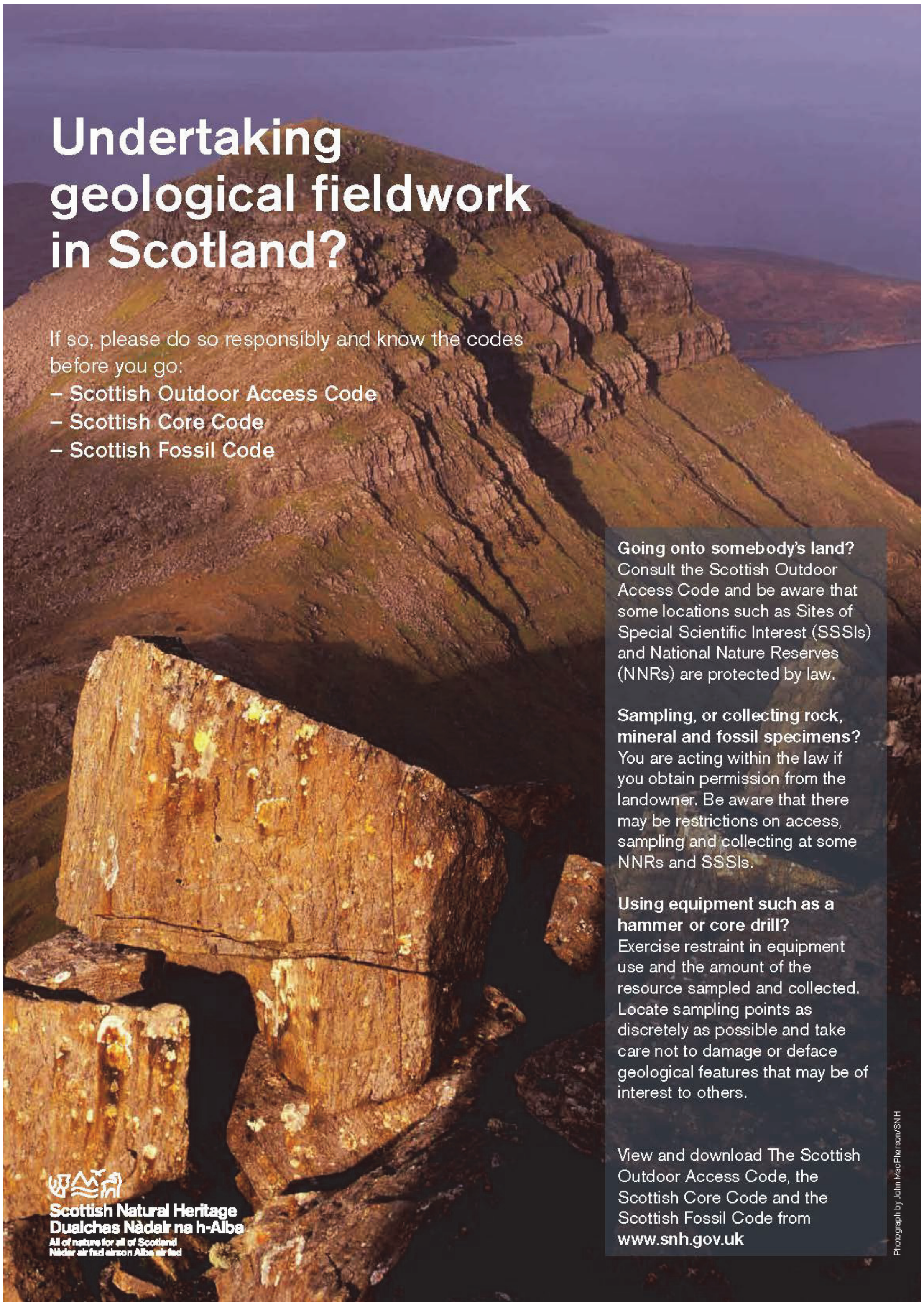
- The Scottish Fossil Code Code (https://www.nature.scot/scottish-fossil-code). The Nature Conservation (Scotland) Act 2004 included provision for Scottish Natural Heritage to prepare the Scottish Fossil Code (MacFadyen 2004). A working group of stakeholders was convened and following extensive consultation (MacFadyen 2005, 2006a, 2007a, Campbell et al 2007) the fossil code was launched in April 2008 (Campbell et al 2008). The Code sets out best practice for collecting, identifying, conserving and storing fossil specimens found in Scotland. Four years after its publication, a first review of the Fossil Code was carried out (MacFadyen 2011b, 2012). This concluded that the content of the Code is good, and indications were that it had resulted in fossil collectors generally behaving more responsibly. However large-scale damage was still occurring at a few sites. Targeted promotion of the Code was recommended amongst those most likely to collect recklessly, and land managers with particularly vulnerable fossil-bearing sites.

- The Scottish Core Code (https://www.nature.scot/landforms-and-geology/protecting-our-geodiversity/codes-researchers-and-collectors/scottish-core-code, MacFadyen 2011a), in 2011 in response to the rising awareness that a significant number of geological features have been damaged by extraction of geological core samples (Butler 2015, Campbell & Wood 2002, MacFadyen 2006b, 2007b, 2009, 2011a, 2017a, 2017b);

- A code of good practice relating to sampling for cosmogneic dating (https://www.nature.scot/landforms-and-geology/protecting-our-geodiversity/codes-researchers-and-collectors/sampling-cosmogenic-dating), following realisation that, like coring, this relatively new technique could result in natural heritage damage;

- Production and distribution of posters aimed at promoting responsible fieldwork practices to researchers (https://www.nature.scot/landforms-and-geology/protecting-our-geodiversity/codes-researchers-and-collectors/responsible-fieldwork, MacFadyen 2015a, Figure 11). These were developed in response to both the recommendations of the Fossil Code review and the rising awareness of the issue of core-hole damage. Copies were sent to Earth Science departments across the country and to hostels and other venues accommodating fieldworkers.

Figure 11: One of the SNH posters promoting responsible geological fieldwork in Scotland. Photograph by John MacPherson/SNH.



3.8 Earth Science Site Condition Monitoring after 2019

With both budget and staff resources likely to decrease further in future, it will also undoubtedly become necessary to further reduce the costs and staff time required for Site Condition Monitoring in response. This is an issue that will need to be looked at and co-ordinated across all areas of Site Condition Monitoring, both biological and geological and is beyond the scope of the current report. However, as discussed in section 2.10 above, the lighter touch Site Check methodology, utilising the extensive feature data accumulated over the last 20 years, has so far produced encouragingly accurate assessments of feature condition. A methodology based on Site Check may therefore offer an appropriate, lower cost and less time consuming, mechanism for Earth Science Site Condition Monitoring in future.

4. CONCLUSIONS

Site Condition Monitoring in Scotland between 1999 and 2019 has produced useful, valuable and meaningful data on the condition of protected Earth Science features in Scotland. The approach developed and refined over the 20 year period has proved practical, allowing non-specialist SNH staff to undertake many assessments. It has also provided informative and spatially specific data that can be related to individual management units if remedial actions are required.

The proportion of Earth Science features monitored has fallen during each cycle (from 98% in Cycle 1, to 64% in Cycle 2, to 34% in Cycle 3). However, the risk of changes to feature going unnoticed due to long periods between site visits has been reduced by the introduction of Site Check assessments in Cycle 3. Despite its less comprehensive nature, so far Site Check has been found to be successful in picking up pertinent site issues, and report an accurate feature condition. An important factor in this is the wealth of feature information available from previous baseline and SCM assessments, which makes it easier to successfully structure short site visits to provide appropriate information on site condition.

Important data has been gathered from the Site Condition Monitoring programme regarding the negative pressures affecting Earth Science features in Scotland, and this has greatly assisted with a number of actions undertaken to address these pressures. Although the percentages of Earth Science features recorded in Favourable condition are consistently high, the SCM results also highlight a steadily increasing number of features that have suffered irreversible damage. Since 1999, 3% of nationally and internationally important Earth Science features in Scotland have been irreversibly damaged. Continual remedial action is also needed to address on-going but reversible decline of Earth Science features into unfavourable condition. Since 1999 10% of Earth Science features have required remedial action to return them to Favourable condition. This indicates that without changes in people's attitudes and actions, at least one Earth Science feature is likely to be irreversibly damaged each year, and without continued monitoring and remedial action, the number of Earth Science features in Favourable condition would decline over time, possibly by around 5% per decade.

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APPENDICES 1 TO 7

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