Research Report

Soft Capping in Scotland

The context and potential of using plants to protect masonry

Volume 1

Tom Morton

with

Jenny Andersson, Harriet Lindsay, Rebecca Little, Jane Mackintosh and Elizabeth Parker

ISBN 978 1 84917 075 8

Historic Scotland

Edinburgh 2011

Commissioned by Historic Scotland

HISTORIC SCOTLAND
ALBA AOSMHOR

ACKNOWLEDGEMENTS

The author would like to acknowledge the generous support of the many people who have assisted in this research project, including:

Susan Bain, *National Trust for Scotland*, Lars Båkman, *Statens Fastighetsverk (The National Property Board of Sweden)*, Lawrence Begg, *Historic Scotland*, Karin Blent, *curator Skansen open air museum, Stockholm, Sweden*, Graham Brown, *Mason*, Michael Burgoyne, *Historic Scotland*, Alan Cathersides, *English Heritage*, Jan Cassel, *AIX Arkitekter AB, Sweden*, Steve Cowsill, *Historic Scotland*, Roger Curtis, *Historic Scotland*, Sam Dennis, *National Trust for Scotland*, Torsten Eklund, *Mason at Gotland, Sweden*, Richard Fawcett, *Historic Scotland*, John Fell, *Historic Scotland*, Martin Gregory, Janusz Grenberger, *Grenbergers Byggnadsrestaureringskontor, Sweden*, Martin Hadlington, *Architect*, Sharon Haire, *Historic Scotland*, Leslie F Hunter, *Architect*, Bob Heath, *Architect*, Haraldur Helgason, *National Museum, Reykjavik, Iceland*, Darren Helmsley, *Scottish Natural Heritage*, Ulf Hofstedt, *Riksantikvarieämbetet (The National Heritage Board of Sweden)*, Isse Israelsson, *curator, Ajtte Sami Museum, Sweden*, Karna Jönsson, *Riksantikvarieämbetet (The National Heritage Board of Sweden)*, Kenneth von Kartaschew, *Statens Fastighetsverk (The National Property Board of Sweden)*, Robin Kent, *Robin Kent Architecture & Conservation*, Noel Kingsbury, Prof. Dr. Klaus Kreuziger, Henrik Lindblad, *Riksantikvarieämbetet (The National Heritage Board of Sweden)*, Rebecca Little, *Rebecca Little Construction*, Thomas Löfberg, *Lund & Valentin arkitekter i Göteborg AB, Sweden*, Chris McGregor, *Historic Scotland*, Jane MacKintosh, *Scottish Natural Heritage*, Iain McNair, *Longannet Power*, Michael Nädele, *GAJD Arkitekter, Sweden*, William Napier, *National Trust for Scotland*, Jordan Peden, Mike Penderey, *Historic Scotland*, John Pollitt, *Scottish Borders Council*, K. Pytasz, *Waterman HDC*, John Renshaw, *Architect*, Gordon Rutherford, *Historic Scotland*, Jörgen Renström, *The County Museum of Gotland, Sweden*, John Sanders, *Simpson & Brown Architects*, Douglas Speirs, *Fife Council Archaeology Service*, Adrian Stanger, *Historic Scotland*, Duncan Strachan, *Mason*, Eiwe Svanberg, *Kommendant, Carlsten Fortress, Sweden*, Alun Tarr, *Blackdown Horticultural Consultants*, Marie-andrée Thiffault, *Historic Scotland intern*, Rachel Tilling, *Perth Kinross Heritage Trust*, Ben Tindall, *Ben Tindall Architects*, Heather Viles, *Oxford Brookes University*, Kolbjörn Waern, *Landscape Architect, Sweden*, Steven Watt, *Historic Scotland*, Stina Wedman, *Wedman Arkitektatelјé, Sweden*, Robbie Wilson, *Historic Scotland*, Stuart Witten, Chris Wood, *English Heritage*.

Some photographs included in this digital report may not be clear when printed but have been included for illustrative purposes due to their relevance.

CONTENTS

LIST OF ILLUSTRATIONS

All illustrations are copyright of Arc unless otherwise noted.

LIST OF ILLUSTRATIONS CONT.

LIST OF ILLUSTRATIONS CONT.

LIST OF ILLUSTRATIONS CONT.

LIST OF TABLES

Fig. 1.1: Soft capping work in progress, Skipness Castle, Argyll. November 2004.

FOREWORD

This Research Report summarises a wide range of experience and practice carried out in Scotland and in other parts of Europe. It has been a collaborative project involving stakeholders and practitioners at different levels

from very diverse sites, all of which have particular challenges. This report does not seek to provide definitive guidance, but is intended to outline principles and give examples of what has worked successfully and what has not. General considerations and a discussion on recent practice are covered in Volume 1, while the second volume looks in more detail at specific examples, covering a range of conditions, materials and flora and how they were handled and treated.

Doubtless other examples will have been missed – this is not a reflection on other projects, rather an illustration that this particular study, like any other, has to have limits.

The benefits of soft capping in the situations described in this report are clear. At a time when reductions in financial expenditure have to be balanced against issues such as increasing rainfall levels in Scotland from climate change, the management and application of natural process to give long term low maintenance solutions to monument conservation must be for the good.

Ewan Hyslop
Head of Sustainability and Science
Historic Scotland Conservation Group

August 2011

Fig. 1.2: Soft capping work in progress, Kilmory Chapel, Argyll.

SUMMARY

Soft capping is a technique that involves using living plants and soil as a thermal and moisture-buffering layer, thereby impeding the decay of masonry structures. It has proved effective in reducing and controlling the effects of a number of decay mechanisms, including:

- Surface erosion
- Leaching of soluble mortar binders
- Differential thermal expansion
- Freeze/thaw cycles

Soft cappings can also have wider environmental and aesthetic benefits.

The north-west Atlantic fringe of Europe is one of only a few areas in the world where suitable geo-botanical conditions coincide with a substantial ruined masonry heritage. Scotland enjoys some of the most favourable climatic conditions for the successful use of soft cappings in conservation, though the technique is used in countries across this region, notably in Sweden and England.

Soft cappings have been used for over a hundred years, with significant regional variations indicating links to vernacular construction. Early written guidance from the Society for the Protection of Ancient Buildings was brief, but notable in a field where there has been little systematic research or development.

A revival of interest since the mid 1980s has resulted in a geo-climatic, typological and technical range of examples. These have been assessed, along with relevant examples of masonry structures that have been naturally colonised by plants and historic structures that used plants as part of their original construction. 39 case studies are presented, with key issues identified and discussed.

A site's climatic exposure is the most important factor in a soft capping's performance, with technique, materials, season of application and botanical context usually having a secondary influence.

Successful soft cappings usually require a very low level of maintenance and are fully reversible. The associated financial, conservation and environmental benefits are key attractions of the technique.

The aesthetic and philosophical context of soft capping work can have significant complexity. This highlights the need for an individually tailored approach to soft cappings, avoiding prescriptive solutions. While soft cappings can be beneficial and appropriate in a broad range of circumstances, they are not suitable in all situations.

An increasingly diverse technical approach to soft capping is developing among practitioners, along with more sophisticated design solutions, in the context of increasing plurality in the presentation of monuments and a heightened sensitivity to environmental issues.

Basic recommendations on good practice are given towards the end of this volume, but this report should be considered as an evaluation of experience to date rather than a comprehensive guide to best practice.

Fig. 1.3: Naturally established cappings, the Nunnery, Iona, Argyll.

1. INTRODUCTION

The term 'soft cappings' describes a range of techniques where living vegetation, sometimes combined with soil and other materials, forms a buffering outer layer to masonry structures. This can reduce the ingress of moisture and have a thermal blanketing effect, thereby inhibiting decay of the masonry through the mechanisms of surface erosion, leaching of soluble binding materials and freeze/thaw cycles.

These characteristics were utilised in a range of vernacular traditions, including to cap walls, and in more 'architectural' structures, such as icehouses. In recent years there has been increased recognition of the varied benefits of using such techniques in the conservation of masonry:

- They are essentially non-destructive and reversible. The malleable soft materials are applied as a facing layer over harder materials, sometimes with a defining membrane between. Occasionally fixings to the masonry may be required to give initial restraint.
- They are sustainable and environmentally sensitive. The materials used are non-polluting and low in waste and embodied energy. As living plants, they have the potential to make a positive contribution to a local eco-system.
- They are often a cost effective means of protecting exposed masonry. If correctly designed and applied soft cappings can be self-healing and require very little maintenance.
- They are aesthetically attractive in many situations. By mimicking the process of natural colonization of masonry structures by plants, a visual presence integrated with its landscape setting and reflecting its age can be achieved.

Some uses of soft cappings have been informed by recent research and technical developments in the conservation of traditional earth structures, while the use of 'green roofs' in contemporary construction is also relevant.

The increased use of soft topping techniques in Scotland since 1995, supported by heritage organisations, conservation architects and specialist contractors, has produced a variety of results that illustrate a diversity of materials and techniques. Many of these are illustrated in the case studies section.

While often successful, these projects demonstrate that there is a complex range of inter-related issues that determine the performance of cappings on an individual site, as well as a need for clear and well-informed guidance on best practice.

Issues of concern include:

The need for careful selection of plant and soil materials appropriate to the local environment and climate.

The need to consider programming of works in relation to the seasonal growth patterns of plants.

The need for a debate over the aesthetic appropriateness of plants in the presentation of historic structures.

1.1 Objectives of the Research Programme

This research was commissioned to assess the performance of soft capping projects to date and the background of existing knowledge, within the context of increased recognition of the importance of sustainability, greater awareness of the connections between the built and natural heritages, and changing cultural attitudes towards the presentation of monuments.

This report presents the results of desk and field based surveys of recent and precedent practice, and the extent of knowledge and experience to date, both within Scotland and in other European countries. It draws conclusions on the relevant issues and gives basic guidance on best practice.

This research programme recognised the recommendations for further research given in English Heritage's pilot soft toppings research project (Viles, Groves & Wood, 2002), though the detail has been tuned to Scottish conditions. The team also liased with English Heritage's ongoing work in this field.

1.2 Scope of the Report

The research presented in this report considered both the diversity of potential applications for soft cappings and the range of other areas where relevant circumstances or information was found.

It considered the damaging and protective effects of plants and soils on built structures, where these have been applied as part of a conservation intervention, have naturally become established or were part of the original construction. It principally studied the common situations of fragmented masonry remains, both walls and larger elements, such as vaults. It focused on near-horizontal situations, but also considered applications on significant slopes and, in passing, vertical situations.

Also included in the research were examples of the range of materials and construction techniques that are subject to conservation, in structures dating from prehistory to the Second World War, as well as relevant contemporary construction and landscape practices using soil and plant materials.

1.2.1 Exclusions

The research did not consider earth-sheltered masonry structures, for example the large earth works covering fortifications from the 18th and 19th centuries, such as at Fort George, Aberdeenshire. Although these have some relevant aspects, their botanical conditions lack the stresses commonly found in soft cappings.

The research considered turf construction, where there was the intention that the plants remain alive, at least partially. It did not consider earth construction, even as root bound earth blocks, except in conservation situations where such materials formed the substrate onto which cappings were applied.

The research did not consider in detail applications of plants on masonry that could be termed ‘gardening’. This is taken as meaning where artificial conditions are created, for example, where a trough is created to retain soil and plants in conditions of controlled moisture.

This research has generally only considered higher order plants and excluded micro-flora. Algae, lichen and other pioneer species have only been considered in detail where their growth is substantial; the effects of typical growths of algae and lichen on sandstone masonry having been the subject of previous published research.

1.3 Sources and Methodology

1.3.1 Desk-based Research

Desk-based research rapidly established that there has been very little written directly on the subject of soft cappings, though there is a wide variety of sources of indirect relevance. As a conservation technique, no substantive generic guidance was found between 1903 (SPAB, 1903) and 2007 (Ashurst, ed, 2007). There was also a lack of any systematic assessment of performance, though there have been a number of very useful commentaries on individual projects.

There are two substantive published works on mural vegetation by ecologists (Segal, 1969, and Darlington, 1981) and, while these are written from a botanical perspective with limited consideration of the host structure, they remain relevant and valuable sources. Rather more specific and recent is Rooted in Stone (English Nature, 1996), although the information presented is less detailed and much of the climatic and species information is not directly transferable to Scotland.

Fig. 1.4: Fort George, Inverness-shire, earthworks and embrasures.

Fig. 1.5: Alvastra Monastery, Sweden. The vegetation grows in lead containers on the wallhead.

While the expertise of mainstream turf producers is of limited relevance, there are a small number of specialist horticulturalists with relevant skills. There is ongoing work, both practical and research based, on the restoration of natural grasslands where skills and knowledge are relevant to the issues of stress conditions and species control found in soft cappings.

The use of modern ‘green roof’ techniques developed in Germany in the 1980s, following studies of the increased durability and thermal insulation associated with naturally seeded vegetation on gravelled flat roof surfaces. Though much of the leading work in this field is written in German, there is an increasing number of useful English sources, particularly relating to rainwater attenuation and thermal insulation.

1.3.2 Field Assessments

The extent of practice in the field was established through targeted inquiry with private practice architects and craftspeople, Historic Scotland’s architects, who advise on work to private property and property in state care, and Historic Scotland’s local works managers and masons. Although interesting examples continue to come to light, the cases considered are believed to have achieved a reasonably comprehensive and representative range of examples.

Assessments of the extent and relevance of work in other countries was less comprehensive, though a reasonable overview was achieved through contact with a variety of state heritage organisations and individuals. Northern islands, such as Iceland and the Faroes, as well as northern Scandinavia produced examples of vernacular construction relevant to some Scottish bio-regional traditions. Southern Scandinavia, Germany and England produced information and diverse practice of soft cappings in conservation. The recent soft capping test programme undertaken by English Heritage is of particular relevance.

Fifty-four Scottish sites were assessed in the field and one site assessed from available information sources. Twenty-three botanical surveys were carried out on site and sixteen from photographs. Fourteen sites were visited in Sweden, with botanical assessments from photographs, and six sites were visited in England, without botanical assessments. Detailed information was obtained on one German site.

1.4 Limitations

Background information was drawn from written sources primarily written in other contexts, where circumstances can be different.

Many of the case studies involved works carried out without detailed specifications and accessible records of the works were sometimes limited. Where archive information was available, this sometimes conflicted with oral accounts, suggesting that memories of projects can sometimes be inaccurate, or that paper records do not always reflect changes made on site.

Most of the field assessments were based on a single site visit, which allowed for limited assessment of the overall condition of capping vegetation, especially where these were carried out before plants had flowered or after they had seeded.

Similarly, the botanical surveys should be regarded as an overview, rather than comprehensive, both as a whole and in individual case studies. In a few cases, a thorough assessment was possible, but generally assessments were made on limited information. Assessments made from photographic records are necessarily less definitive than those made on site, while assessments of foreign sites were based on less detailed species knowledge.

Nonetheless, while individual case studies may have limited depth, as a broad assessment the report is believed to have accurately recorded the diversity of circumstances and patterns.

Fig. 2.1: Arbroath Abbey, Angus. The modern visitor centre in the foreground has a sedum roof. This complements the historic masonry ruin, which has been colonised by algae.

2. CONTEXT FOR USE

Scotland is one of a relatively small number of countries where suitable conditions exist for the successful use of soft cappings in building conservation. Although soft cappings have been used for over a hundred years, the last fifteen years has seen a significant increase in interest in them in several countries where they are viable.

These recent developments have been driven by perceived multiple benefits of soft cappings over common current practice in some common masonry conservation situations. This chapter describes the context within which these developments have occurred and examines the range, benefits and limitations of soft cappings.

2.1 The Environmental Context

2.1.1 Geo-botanical Context

The north-west Atlantic fringe of Europe is one of the few global locations where suitable climatic, and botanical conditions coincide with an architectural masonry heritage, allowing vegetation to be considered as a viable conservation tool.

In places that are distant from the moderating influence of an ocean, climatic conditions are usually inappropriate to sustain mural vegetation. Summer and winter peak temperatures are too severe, relative humidity is too low and periods without rain are too long.

In the southern hemisphere, botanical conditions are often too aggressive to consider encouraging plants to grow on the substantial masonry heritage that exist in countries such as Peru, Cambodia and Zimbabwe. In the northern hemisphere, where there are suitable conditions in parts of North America, vernacular construction generally used biodegradable materials, often for temporary buildings, and there is not a surviving heritage of masonry ruins. A similar materials context exists in Japan.

The coastal fringe of China is the only other geographical area where the correct natural and cultural conditions exist for the use of soft cappings.

There is a variety of historic references reflecting an aesthetic appreciation of vegetation on ruins in Chinese culture, but no examples of their use in contemporary conservation were found by the author. In this poem, a soldier returns to a ruined home in 1st century BC China (Waley, 1923).

That over there is your house,
All covered over with trees and bushes.
Rabbits had run in at a dog-hole,
Pheasants flew down from the beam of the roof.
In the courtyard was growing some wild grain,
And by the wall some wild mallows.
I'll boil the grain and make porridge,
I'll pluck the mallows and make soup.
Soup and porridge are both cooked,
But there is no one to eat them with.
I went out and looked to the east,
While tears fell and wetted my clothes.

North-western Europe has some of the best geo-botanical conditions of benign mural vegetation in the world and Scotland, with its substantial ruined masonry heritage, is a prime location. On the continent, the warm and comparatively dry summers of central and sub-Atlantic Europe tend to restrict significant plant growth on walls to the coastal fringe and inland areas where high relative humidity microclimates are associated with large rivers.

The climatic conditions of the British Isles and Brittany are the most favourable in the region for soft capping, with mild winters, cool summers, damp air and high precipitation. Within the UK, the oceanic climate to the west and north are more benign than the comparatively continental climate of the south and east. The relatively high latitude of Scotland means that orientation is less significant than in more southern latitudes, however this research has found that wind severity begins to be a restrictive factor, particularly in northern areas.

The projections of climate change are that conditions in Scotland will become marginally more benign in terms of moisture, that is rainfall will increase, but that winds may become more severe.

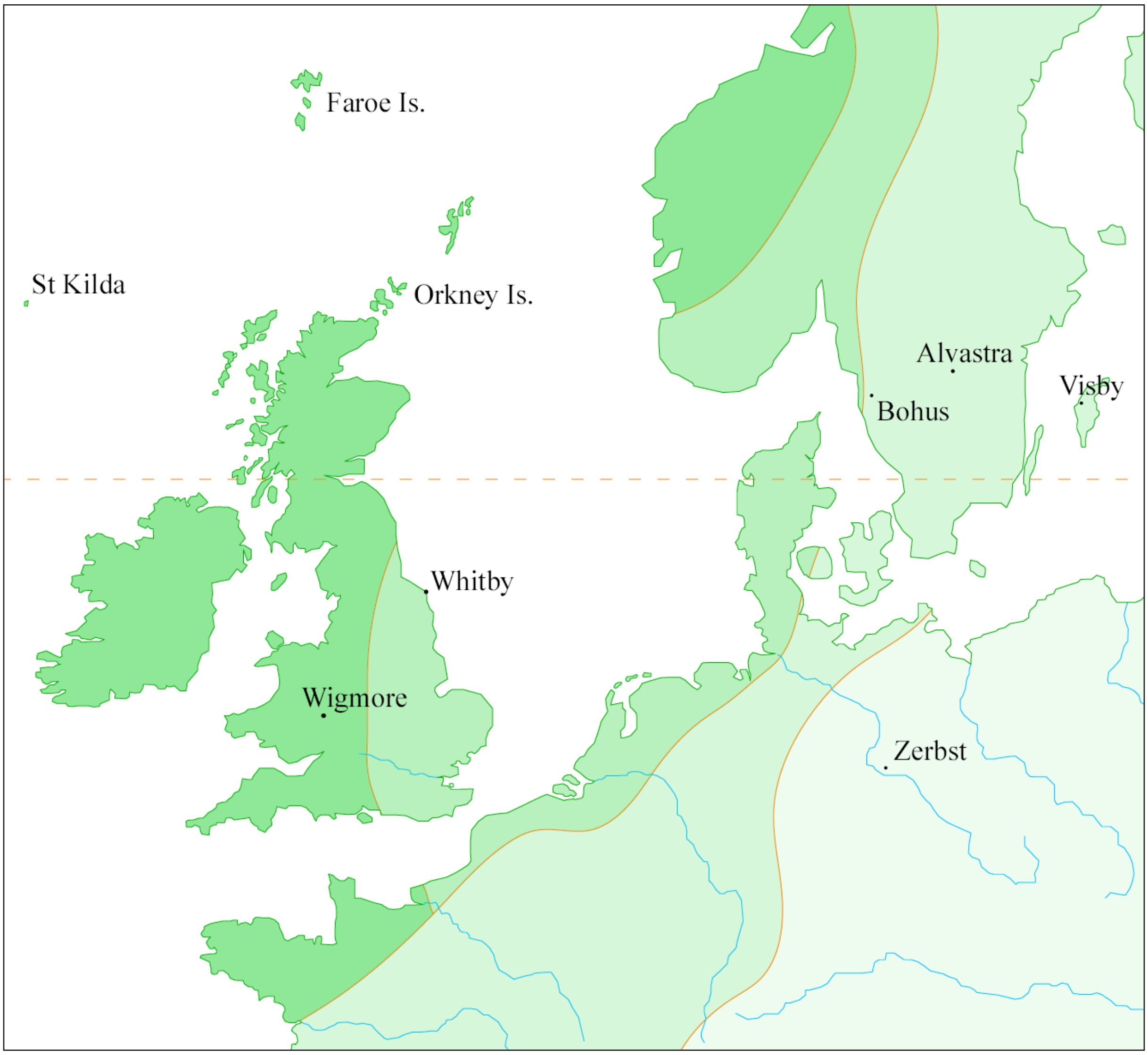

Fig. 2.2: Geographical distribution of conditions for mural vegetation in north-west Europe, with the darker colours representing the most benign conditions. The main southern distribution is after Segal (1969), the northern section a conjectural extension by the author based on the results of this research. The location of notable foreign sites is shown.

2.1.2 The Natural History of Ruins

> *Historic features frequently provide locally important habitats for flora and fauna, the nature of which is often closely related to human activity in the past.*
>
> *Passed to the Future, Historic Scotland's policy for the Sustainable Management of the Historic Environment (2002).*

While the natural growth of plants on ruined masonry in Britain has long been noted and appreciated aesthetically, only comparatively recently has it become widely accepted that such natural growth could be significantly protective of the host structure or that the vegetation could be ecologically or culturally important.

The relationship between the built and natural heritage has been discussed in a variety of contexts, but has rarely been the subject of specific detailed investigation. The importance of designed landscapes and of the settings of listed buildings have been given formal recognition by the building conservation community, while naturalists recognise the unusual habitats in post industrial sites or of listed buildings within nature reserves, but the full complexity of the inter-relation of the natural and built heritages rarely emerges and often merits more sophisticated and structured multi-disciplinary assessment.

The sister disciplines of building and nature conservation share many of the same core principles and have parallels in methodology and working practices. At a deeper level, the imprint of historic building culture on the natural landscape is profound, while the natural context of many buildings gives them much of their meaning; it provided the materials they were built with and was the environment they were made to withstand.

On historic sites, the ground may not have been disturbed since ruination and elements within the vegetation may relate to ancient natural ecologies and retain important contemporary habitat value, as well as being indicators of past land use patterns. Such local ecological communities may also be significant because they retain vestiges of flora whose cultivation directly related to the building, for example, monastic gardens.

Fig. 2.3: The Gatehouse, Wigmore Castle, Herefordshire, England. The ruin stands beside an ancient woodland that has been undisturbed since the castle's ruination in 1643.

A botanical survey of the Coliseum in Rome was published in 1855, cataloguing 420 species, including some so rare in Western Europe that the only explanation is that they had originated in seeds transported on the bodies of animals brought for the gladiatorial games.

All plants were removed from the Coliseum in the course of 19th century excavations, which laid the monumental masonry bare. While there is no such dramatic example in Scotland, the lack of systematic evaluation of botanical information in surveys of historic sites means that more subtle natural evidence may be unrecorded or inadvertently destroyed.

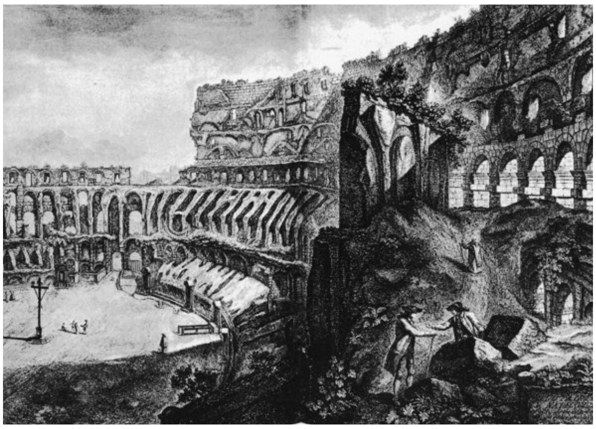

Fig. 2.4: The verdant pre-excavation ruins of the Coliseum being enjoyed by 18th century tourists, engraving by Piranesi.

2.1.3 The Ecology of Soft Cappings

> *The historic and natural aspects of the environment often overlap and can be inter-dependent. Sympathetic management can enhance local biodiversity.*
>
> *Passed to the Future, Historic Scotland's policy for the Sustainable Management of the Historic Environment (2002).*

Ruins may contain important habitats because of their materials and forms. Masonry walls often present cliff conditions in places where such habitats are uncommon. As such they can support locally rare species of flora and fauna. While four of the case study sites were located in Sites of Special Scientific Interest and three were in National Nature Reserves and one was a World Heritage Site for its natural heritage, none of these structures had been the subject of botanical survey.

The botanical surveys of mature cappings[1] carried out as part of this research indicated that the number of locally rare[2] species found ranged between seven and fifteen and related primarily to the microclimate. However, microclimate was the primary determining factor for all species and on such sites an average of 75% of species recorded on the cappings were locally rare (see Table 3).

Assessing whether a site's vegetation is of value for ecological or historical reasons should be good practice for any assessment of a historic site, whether intervention is planned or not. In sites where there has been little previous intervention and especially if removal of existing, or introduction of new, species is being considered, the level of detail of such assessments becomes increasingly important.

Currently, there is commonly some limited recording of whether a site is an SSSI, and of specific legally protected species, such as bats, in quinquennial surveys, but a more methodical approach is merited. This would require access to botanical surveying skills. Fostering cooperation, which already exists between HS and SNH at a local level, would facilitate this process and the benefits should be reciprocal.

The development of such an integrated approach to natural and cultural heritage on historic sites would be supported by established policy.

> *To avoid damage to, and where appropriate enhance, the natural heritage interest of sites and areas of archaeological and historical significance…. HS and SNH will…. establish clear consultative procedures on planning casework of mutual interest.*
>
> *A Statement of Intent Between Historic Scotland and Scottish Natural Heritage, May 1995*

Beyond recording, SNH are well placed to advise on the selection of appropriate species for use as conservation materials in soft cappings on sensitive sites, so that these will survive without damaging the indigenous flora and fauna.

2.1.4 Sustainability

The need to integrate sustainable practices at every level is recognised in the policies of many heritage organisations.

> *Good stewardship of the historic environment can make a contribution towards addressing wider issues like energy conservation (maintaining and using existing resources) and recycling (re-use of buildings and materials). The use of local resources, traditional materials and skills can help reduce the impact of transportation.*
>
> *Passed to the Future, Historic Scotland's policy for the Sustainable Management of the Historic Environment' (2002).*

Soft cappings are an environmentally sound conservation technique and, although savings in the consumption of resources and energy are difficult to quantify, their value from this perspective should be recognised. Hard capping techniques require distantly manufactured, high embodied carbon materials, such as cement and lime. In contrast, soft cappings largely use locally sourced, very low embodied carbon materials. Using soft rather than hard cappings can therefore significantly reduce the emission of carbon dioxide and other greenhouse gasses resulting from repairs where capping is required.

Use of soft cappings, and the retention of naturally established vegetation, can also significantly reduce the level of intervention on the host structure needed in both the short and long terms, which is desirable from conservation, financial and ecological perspectives.

Soft cappings usually require considerably less frequent and less substantial maintenance than hard cappings. For example, soft cappings may need the occasional removal of a tree sapling from a mobile form of access, such as a ladder or cherrypicker, while hard cappings can require regular pointing repairs from scaffolding. In the context of monuments that are often difficult to access, the use of soft cappings in these situations will result in an ongoing reduction in carbon emissions.

In considering the whole life cycle of these two techniques, including their possible reversal, it is apparent from recent work that has been done to remove concrete cappings from masonry that soft cappings would require far less energy to remove, would not damage the underlying structure in achieving this and the waste created would be simple to dispose of in a benign manner.

Soft cappings are inherently sustainable conservation techniques, with low carbon emissions, low resource depletion, low maintenance requirements, and low waste impacts over a whole life cycle. Life Cycle Costing is included by Historic Scotland among criteria for assessing the impact of interventions in the historic environment (HS, 2002). While any individual case must be considered on its own merits, there will usually be significantly less environmental impact in comparison to hard capping techniques.

A shift towards sustainable landscaping practices generally parallel those in construction. These developments take landscaping away from standardised, simple compositions of, for example, amenity turf with shrub mass beneath emergent trees. Such traditional approaches do not reflect local character and ecology, create a static effect, and can require considerable input of resources for site preparation, plant establishment and long-term maintenance.

In contrast, sustainable landscape planting uses plants that require low energy and resource inputs, are locally appropriate, and contribute to local ecological integrity. Sustainable plantings are often dynamic, that is, they are not managed to preserve the vegetation in a steady state, but rather to encourage natural processes such as self-regeneration and nutrient cycling. They aim to support local biodiversity, but not necessarily through the complete exclusion of locally native plant species (Benson & Roe, 2000).

On the basis of the sites visited for this research, current landscape management of historic sites is broadly sympathetic, but varies widely with location, popularity and character. Remote rural sites, such as Eilean Mor (CS1) interfere very little with the natural environment. More popular sites, such as Skara Brae (CS10), necessarily have higher levels of maintenance, which can suppress local biodiversity. On sensitive sites within SSSI's, such as Eynhallow Monastery (CS18), there is detailed consultation between HS and SNH over maintenance practices.

Selection of soft capping materials has important environmental considerations.

> *The basis of a sustainable approach to landscape planting must always be to choose species that are suitable to the site.*
>
> *Landscape and Sustainability, Benson & Roe, (2000).*

While good practice in soft capping will consider the potential environmental impact of species selection and provenance, the case study botanical surveys demonstrate that the ecology of cappings can be significantly different from that in the surrounding area. It might therefore sometimes be appropriate to introduce new species that would perform well on cap conditions, though any that could colonise and out-compete established local vegetation should be avoided. Equally, consideration should be given to the species and management of the structure's setting, so that the potential for colonisation of cappings by damaging species is minimised and so that the aesthetic effect of the soft capping is in tune with the wider landscape.

Fig. 2.5: West Gable, the Old Mill, Ardkinglass, Argyll, species on the walls are in keeping with, but different from those in the surrounding area.

2.2 The Conservation Context

Soft cappings have the potential to impede decay of climatically exposed masonry, by application as a protective weathering layer over the vulnerable surface. Although 'softer' than hard cappings, correctly designed soil and plant layers are much more suited to, and resilient against, most weather conditions than the host masonry. Natural selection has 'designed' local plants for exactly these conditions, whereas roofless and broken masonry was never intended, or constructed, to be exposed.

Fig. 2.6: Hailes Abbey, Gloucestershire, England. Although they obscure the covered surface, soft cappings protect masonry from thermal cracking, leaching of soluble minerals, frost and mechanical damage. Though the core construction of the capped walls cannot be read, their form is clear as a result ofthe sites closely mown lawns.

2.2.1 The Deficiencies of Hard Cappings

During much of the 20th century, accepted best practice for inhibiting the ingress of moisture to ruinous masonry was to apply hard caps to the heads of walls, using cement and latterly hydraulic lime mortars.

> *The principle of treatment is to start from the top of the ruin, which means scaffolding it, and then to work down to the original ground surface. After removal of vegetation, the top of the wall is reset in 'cement gauged' lime mortar so as to form an impermeable capping that will prevent water percolating down into the thickness of the wall. The object of the work is to renew the adhesion to the mortar. The surface joints are therefore raked out all the way down and pointed with fresh mortar, either directly into the cavities or over cement that has been used for 'tamping' at the back of the joint. If the mortar has lost its adhesion in the interior core of the wall, then liquid cement can be poured or pumped into it to set as a solid mass. The 'grouting', as it is called, tends to form a very rigid wall and, although a traditional method of treatment, is somewhat out of favour at present.*
>
> *MW Thomson, Ruins: Their Preservation & Display, 1981.*

Though successful and appropriate in some circumstances, such techniques have increasingly come to be viewed as unsatisfactory, with recognition that they often accelerate rather than impede decay, visually mis-represent the original fabric and require high levels of maintenance. These deficiencies, commonly found on narrow wallheads, are also apparent to a more severe degree on the tops of larger ruinous masonry structures.

Where the maintenance burden of hard cappings is high, or where the historic fabric is suffering accelerated decay, there is an increasing tendency to consider soft cappings as a remedial treatment.

a) Appearance and Rainwater Management

On complete but roofless walls the application of a hard cap alters the profile of the wall and can be difficult to apply to complex geometries, for example where built-in timber elements have decayed away. On fragmented wall masonry, typical practice would be to reset original masonry to mimic the original construction of an inner core and outer facework. However the need to create a surface that will effectively shed water conflicts with the desire to faithfully replicate the appearance of a broken wall, where the true geometry is more random and an unsatisfactory compromise between faithful presentation and durability often results.

Fig. 2.7:Loch Leven Castle, Kinross-shire. The consolidated wallheads do not preserve the original fractured masonry exactly as found, while focused rainwater run off results in unsightly surface staining. Note the natural colonisation by mosses of the lower walls, which do not have the domed profile of the higher wall consolidation

Unease about the results of such rough racking is reflected in formal guidance:

> *With rough racking it is important to ensure that water cannot collect and pond and that overhanging masonry is properly supported. But, in achieving this, every effort should be made to avoid changes which might be misleading, such as bringing the wall core too far towards the original face, or giving the core an excessively regular or domed profile to assist the rapid shedding of water.*
>
> *The Conservation of Architectural Ancient Monuments in Scotland: Guidance on Principles, Historic Scotland (2001), 3.21*

In attempting to shed water from the wallhead, rough racked surfaces tend to channel rainwater into focused routes, repeatedly discharging over the wall face in set patterns. The masonry face beneath suffers intensified wetting and drying cycles as a result, which can accelerate decay, particularly of sandstone and dressed stones. Uneven staining and growth of algae associated with these uneven moisture patterns further detract from the walls' visual appeal.

b) Climatic Exposure

The climatic exposure of wallhead masonry can contribute to accelerated decay. Differential thermal expansion between hard mortars and stones causes cracking in and between these materials. These cracks in turn allow channelled water into the masonry core, encouraging uncontrolled plant colonisation, thus creating hidden damage of the wall core. Where softer lime mortars are used, these can be prone to damage in freeze/thaw cycles. If unprotected in the initial period after repairs, lime mortars are also vulnerable to damage by solar radiation, wind and rain in exposed situations.

Fig. 2.8: Drumin Castle, Moray. The defective hard capping has developed frequent cracks, allowing uncontrolled natural colonisation by species with damaging woody roots. A well designed soft capping could control this relationship.

The vulnerability of hard cappings to environmental decay in the exposed conditions often found on the tops of ruined masonry, increases the need for temporary protection during and after conservation works. It also requires an ongoing programme of inspection and maintenance, to point up cracks, replace defective pointing and loose stones, and remove invasive plants.

Fig. 2.9: Hailes Abbey, Gloucestershire, England. Hydraulic lime repairs to cement hard caps can be difficult and expensive. The process of removing defective cement can also be very damaging to weaker stone types.

2.2.2 Thermal Blanketing

Thermal variation in masonry can lead to cracking through differential expansion of materials, especially on masonry with high solar exposure and where there is a relatively stiff mortar. Masonry that absorbs large amounts of moisture will also be vulnerable to loss of lime mortar cohesion, as ice crystals form and expand within it during cold weather. Fresh mortar is particularly vulnerable during the first winter.

Vernacular examples from Orkney (CS10) demonstrate the traditional use of the thermal blanketing effect of soft cappings to prevent frost damage to sandstone vulnerable to delamination. Conversely, icehouse construction used the isolative effect of soil and plants to limit absorption of solar radiation by the masonry, thereby keeping the masonry structure at low and even temperature, as well as dry.

Though not scientifically recorded, significant natural colonisation of some recumbent gravestones by moss has been observed to have a protective effect. In such situations, moss can absorb a significant proportion of precipitation and mitigate against thermal flux. However, in some circumstances moss can also cause damage, particularly when on weak sandstones.

Experimental tests of soft cappings by English Heritage (Viles, Groves & Wood, 2002), designed to mimic strong diurnal thermal patterns at Hailes Abbey in southwest England, demonstrated that soft caps lowered the maximum temperatures in the masonry by between 4.5 and 7°C, and created a thermal lag of up to three hours. 100mm and 200mm thick soils were tested at different moisture contents. Dry and thick soils were found to be more isolative than thin and wet ones. A similar rising of the minimum temperatures was also recorded, with the result that the thermal flux of the capped masonry was approximately half that of the exposed stone.

These results generally correspond with data available on ground soil temperatures at varying depths in Scotland. Relating this data to soft cappings requires some interpretation. While local climatic factors such as moisture, solar and wind exposure, as well the shape and size of the underlying masonry, can have a significant effect on the degree of thermal protection, there is sufficient evidence to demonstrate that in practice, soft cappings do give significant protection against temperature-related masonry decay.

Soft cappings are also suitable as a remedial repair over older hard cappings. Tests by English Heritage have demonstrated that the isolative effect of soft cappings can moderate the differential thermal flux in such cappings sufficiently to inhibit cracking. This is important as it can be difficult and expensive to remove such hard cappings and further damage to historic fabric inevitably results from such intervention. In contrast, soft cappings are eminently reversible.

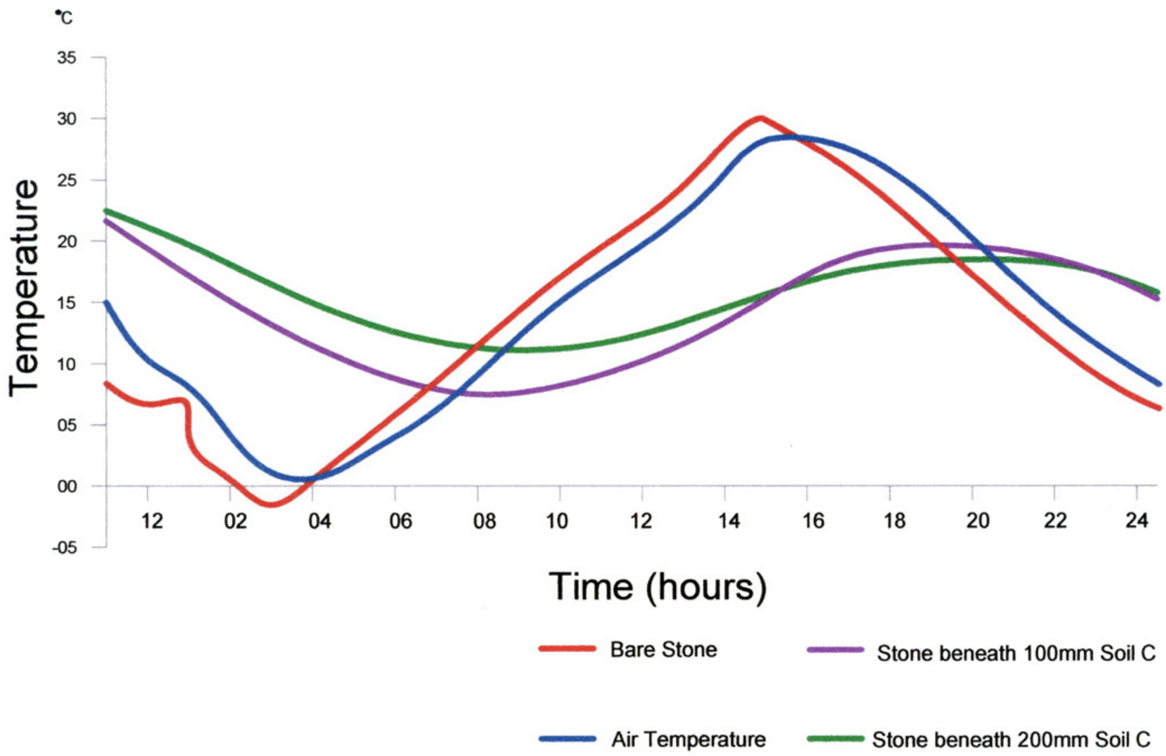

Fig. 2.10: Thermal flux in dry conditions (Viles, Groves & Wood, 2002.)

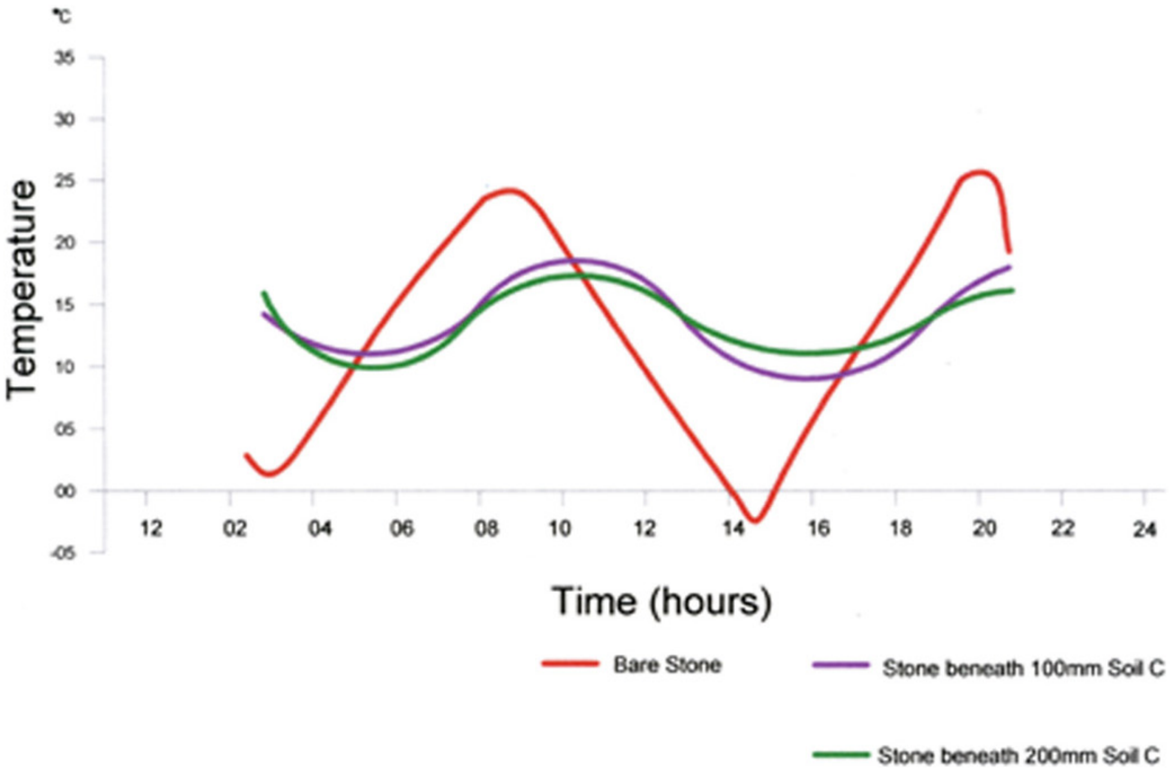

Fig. 2.11: Thermal flux in wet conditions (Viles, Groves & Wood, 2002).

2.2.3 Rainwater Regulation

Rainwater contributes to the decay of masonry by three main mechanisms; surface erosion, leaching of soluble minerals and ice crystallisation in freeze/thaw cycles. Soft cappings retard these mechanisms in two ways, by absorption and by dissipation.

Some of the rainfall onto a soft capping will be retained on the surface of the plants and soil and subsequently be evaporated back into the air. A further portion of rainwater will be absorbed through the soil into the roots, travel up through the plant and be transpired back into the air through the leaves. A few drought tolerant species, such as sedums, have the ability to regulate this flow through changing the shape of their leaves. Some of the rainfall will be shed off the sides of the foliage and, if the soil becomes saturated or has poor structure, some will pass through the plant and soil layers into the masonry material below.

The proportion of rainwater that follows these different paths varies considerably between cappings, depending on the geometry of the foliage, cap profile, soil type and depth, and the character of the rainfall. Research on modern 'green roofing' suggests that 40-60% of rainfall is commonly absorbed into plant and soil layers and later evaporated or transpired back into the atmosphere. The case studies demonstrate that conditions on soft cappings vary greatly and these figures can only be taken as a general indication.

Fig. 2.12: Kirkham Priory, Yorkshire. In tests, soft cappings have reduced rainwater runoff, lowering moisture levels on the upper face of the masonry wall. As a result, the dark stains of damp and associated microflora on the upper wall face have begun to fade.

Tests by English Heritage suggest that a typical Oxford rainstorm of 54mm rainfall in three hours, would not result in water penetration through 100mm of dry soil, but that, once saturated, soil takes a long time to dry out (Viles, Groves & Wood, 2002). In practice, the action of rainwater falling on soft cappings is complex and varied and the case study results defy simple modelling.

In general the Scottish patterns of rainfall are better suited to soft cappings than those in England, though within Scotland there is moderate regional variation. Although Scotland has higher overall rainfall than England, it has fewer, less severe thunderstorms and rainfall is more evenly spread through the year. This suits soft cappings, which can readily absorb and desorb much of this moisture and it provides a reasonably steady supply of moisture to sustain vegetation.

Fig. 2.13: St. Cormac's Chapel, Eilean Mor, Argyll (CS1). The natural vegetation acts as a living thatch. The complex matrix of foliage disperses rainwater runoff, which is largely cast clear of the wall.

The use of clay-rich soil as a waterproofing layer and moisture reservoir appeared to be effective in case studies where climates were not excessively dry. Even where the clay had completely dried out, cracks and fissures through which water could readily travel were rare (CS39).

Fig. 2.14: Black Castle of Moulin, Perthshire (CS13). Locally at an exposed end, the turf has died and clay dried out, though with only minor cracking.

In this research, generally the soft cappings were found to keep water out of the masonry, and only a very subtle level of moisture interaction between capping and substrate was usually identified (see 3.4.2). Among the case studies there were only four exceptions to this general finding, where there was evidence of significant moisture penetration through the soft capping into the masonry (CS1, 15, 27 and 39). Three of these were cappings of turf over clay onto flat masonry and one was a naturally established cap of dense sward, but thin soil, on a large sloping masonry surface.

In the clay cases, the clay soil became saturated and apparently had an insufficiently high clay content, or the clay type was insufficiently expansive, to create a waterproofing effect. It was notable that two of these cases were located in places of relatively low rainfall.

In the natural cap, the soil was too thin and open textured to retain significant amounts of moisture, and the rainfall was able to penetrate the dense sloping sward.

Fig. 2.15: Doune Castle Mill, Stirlingshire (CS15). The clay and turf cap fails to prevent moisture penetration into the wallhead.

In typical low intensity rainfall situations, relatively little rainwater falls off the edge of a capping. In more intense rainfall, the proportion will be higher, but it will never be as high as on hard cappings. A significant number of cappings had substantial mass of edge vegetation that formed a drip, casting water 25-50mm clear of the wall face. The apparently chaotic foliage patterns of soft cappings effectively dissipate water flow, ensuring an even cast along its length, whereas hard cappings tend to focus rainwater into isolated points of heavy edge discharge.

Fig. 2.16: Hugh Miller's Cottage, Cromarty, Ross-shire (CS20). The thick mossy capping has a high capacity to absorb rainfall, while its projection of up to 50mm beyond the wall face effectively casts runoff clear.

No indication was found in the case studies of masonry decay through atmospheric pollutants concentrated by the absorptive action of soft cappings or of acidification of rainwater runoff. Such decay is difficult to detect, unless severe, but these are not thought to be significant mechanisms in a Scottish context. Atmospheric pollution is negligible in the locations of all of the case studies and, although many of the soils were acidic, none of the substrates were limestone, which is particularly vulnerable to decay from acidic run off.

In summary, the capacity of soft cappings to absorb and dissipate moisture has been demonstrated to often significantly inhibit decay of substrate masonry. However, as in many other aspects of soft cappings, the particular should always be considered against the general. Scottish rainfall patterns generally suit soft cappings, but rainfall variation means that there are situations that are challenging because they are either too wet or too dry.

Rainfall also interacts with other climatic forces. In exposed sites, such as Eynhallow Monastery (CS18), the severity of wind-driven rain penetrating the face of the masonry made the protection of the head of the wall from vertically falling rain almost irrelevant to the rate of mortar decay. Drystone masonry is the extreme extension of such situations and in these cases moisture protection is not the key benefit of soft capping.

It is possible that in reducing the moisture on the face of a wall, decay will be encouraged by the establishment of wetting/drying cycles in masonry that was previously permanently wet. This is reported in England (C. Wood, pers. comm.) though no specific instance of this was recorded in the Scottish sites.

2.2.4 Protection from Mechanical Damage

On two of the case study sites, soft cappings had been specifically intended to inhibit damage by people climbing on the masonry. This can be a significant problem, especially at isolated unmanned sites. One of the sites was a ruinous drystone structure vulnerable to stone dislodgement (CS17) and the other was a roofless building of lime mortared masonry that had the ill fortune to be the only structure on an uninhabited island that attracts climbers to its cliffs (CS33). Climbers habitually camp near the ruin for shelter and practice climbing on it.

Fig. 2.17: Loch Leven Castle. Kinross-shire, Even on a manned site, rough racked masonry can suffer under the feet of visitors.

More commonly, stones can become dislodged by casual visitors. In visiting the case study sites, there seemed to be some evidence to suggest that people regard exposed masonry as secure, robust and attractive to climb over and play on, whereas plant capped walls were seen as more vulnerable and are therefore more often left alone.

Ironically, healthy soft capped walls have an even surface, cohesive root structure and self healing ability that can make them more robust than exposed masonry, which can have an irregular geometry and may be bound by mortar already weakened by other decay mechanisms. Drystone structures are particularly vulnerable. Nonetheless, people do walk on soft cappings and focused pedestrian traffic on soft cappings can cause them significant damage. In such situations the capping will act as sacrificial protection, reducing damage to the underlying masonry (3.6.1).

Fig. 2.18: Alvastra Monastery, Sweden. Pedestrian damage tends to be on focused routes, with the central grass more resilient than the edge sedums.

At unenclosed rural sites, the feet of grazing sheep attracted onto monuments by the vegetation can cause damage to both masonry and soft cappings. On St. Kilda (CS7) the activities of sheep are thought to be a significant contributory factor to the onset of decay. However, another probably more typical site where sheep accessed the capping demonstrated the risk of damage to the masonry and capping to be small and far outweighed by the control sheep exerted over undesirable species (CS3).

Fig. 2.19: Cleit 23, St. Kilda (CS7). Progressive decay of the soft capping may have been initiated by damage from the feet of sheep climbing on to graze.

2.2.5 Countering Wind Uplift

On severely exposed sites, soft cappings can significantly counter damage to masonry by wind uplift, especially on drystone or weakly mortared walls.

Fig. 2.20: Eynhallow Monastery, Orkney (CS18). Soft cappings here act as a weak ring beam, restraining movement in vulnerable wallhead masonry.

Fig. 2.21: Eynhallow Monastery, Orkney (CS18). Even dead cappings can protect loose masonry by their weight.

The 12th century Eynhallow Monastery (CS18) has a particularly vulnerable combination of an eroded clay mortar holding large flat wall capstones of thin sandstone, which may be significant as the remnant of the roof eaves course, in a location with severe wind exposure. Where the cappings are healthy, the rooty turf binds these stones in place, even when they are partly exposed, effectively acting as a ring beam to reinforce the wallhead. Where the cappings are in decay, their dead weight still had a marked effect in holding down stones that would otherwise soon be lifted off, exposing the vulnerable wall core.

2.2.6 Reducing Maintenance Needs

Soft cappings, in the long term, can often be a low maintenance, low cost conservation measure.

Soft cappings are sometimes promoted as especially appropriate for ruins in private ownership, where it is foreseen that there will be very little maintenance carried out after a programme of repairs (CS2 and CS16) as well as for property in state guardianship where hard cappings are proving ineffective and require a high level of maintenance.

Although there are climatic, practical and aesthetic limitations to the use of soft cappings, it can often be an appropriate remedial treatment for existing hard capped masonry, reducing decay and the ongoing maintenance burden. There are also compelling reasons to soft cap monuments that have not previously been repaired, especially where natural cappings are already established. In such cases, carefully applied soft cappings can ensure that minimal intervention will be required in the future (CS2).

Soft cappings should not be regarded as a 'zero maintenance' technique. The case studies demonstrated that, in a small number of severe situations, the capping may never fully stabilise, but can provide useful sacrificial protection as it weathers back over time. The protection of exposed lime mortar repairs as the mortar carbonates can be particularly helpful. Periodic renewal of such soft cappings, every few decades or more, is still often likely to be cost effective compared to the more frequent re-pointing and removal of vegetation required by hard capping and exposed mortar repairs.

Few sites showed significant evidence of colonisation by damaging plants and where there was a risk, it could normally be anticipated. In most cases where there is such a risk, removal of tree saplings or plants with taproots every three to five years should be adequate. Management of the setting of the site, through targeted control of potentially invasive species, may be a means of minimising this burden. On sites that are remote or at high level, the access and health and safety requirements of such soft capping maintenance can be significantly lower than that for mortared cappings.

Fig. 2.22: Doune Castle Mill, Stirlingshire (CS15). This isolated tree sapling would probably die naturally, but its removal would be prudent.

In many situations, where botanical and climatic conditions are favourable, well-designed cappings become self-maintaining with no discernable need for ongoing maintenance.

Fig. 2.23: St. Clement's Church, Roghadal, Lewis (CS37). This unmaintained capping has achieved a stable balance of species.

In some situations, where the cappings are low and wide, grazing by sheep can be an effective maintenance arrangement (CS3), though heavy grazing by rabbits on one site significantly accelerated decay of the capping (CS36) (see 3.6.2).

Fig. 2.24: Blackhouses, Dun Carloway, Lewis (CS3). A good example of benign maintenance by grazing sheep.

Of the twenty-three cappings assessed that were installed as a conservation measure, none had received significant maintenance nor had maintenance regimes in place. This supports the common perception of them as 'no maintenance' solutions. Although these cappings had been in place for three to fifteen years, the visible need for maintenance, that is removal of invasive plants, was more a result of the biodiversity of the surroundings than the age of the capping. Only two cases showed urgent need for maintenance and these were in very damp situations with a high level of invasive species in the immediate surroundings. With experience, the level and frequency of maintenance needs should be predictable.

Two very popular sites receiving large numbers of visitors were actively maintained by strimming (CS9 and 10) and this was for aesthetic rather than technical reasons.

Fig. 2.25: The Blackhouse, Arnol, Lewis (CS9). One of two sites where there was active maintenance.

The potential saving in time and resources that could be achieved by use of soft cappings will vary from site to site and suitable data was not available to make a statistical assessment on any of the sites. However, the site visits and interviews carried out with architects and masons gave strong indications that soft cappings could significantly reduce the maintenance requirements of masonry surfaces, especially those that are often the most exposed and difficult to access. There was insufficient data available during this research to quantify such savings.

2.2.7 Possible Disadvantages of Soft Cappings

There are few possible disadvantages to using soft cappings and any detrimental effects can usually be designed out by good specification and detailing.

No cases were found where any soft capping material had damaged masonry or by falling off, or in any other way, caused harm to the site, staff or visitors.

In one case study (CS16), there was some staining of the masonry surface by clay washed out from the soft capping. Such staining is ephemeral, the clay being washed away by subsequent rain.

A more significant risk arises if the soft capping becomes a seed bed for plants whose roots grow through the soft cappings and penetrate the masonry. The field assessments found this to be a very rare event. Where the surrounding vegetation provides such seeds, plants will inevitably seed in, but they usually die off in the unusual conditions that masonry cappings present. How receptive soft cappings are to colonisation by unwelcome species can be influenced by good capping design.

The main disadvantage of soft cappings is that it conceals the masonry it covers and the structure is less legible to the visitor as a result. The significance of this varies from site to site, depending on the nature of the structure and character of its masonry. Though soft cappings can be tailored to minimise this effect, in some cases they will be inappropriate because the loss of legibility they cause outweighs the protection they give the structure.

Soft cappings can fail, usually through progressive edge dieback of the vegetation followed by slow erosion of the soil, but no evidence was found of local or complete failure causing any physically damaging effect on the masonry substrate.

Fig. 2.26: Braemar Castle. The masonry wall face on the right is stained by soil washed off the failed capping.

A failing capping is unattractive and it is important to understand why failure is occurring. Failure can happen for a variety of reasons. In some rare cases the climatic and physical situation is simply not suitable to sustain the soft capping. More frequently, the materials, design or workmanship is not appropriate. Most often this is because conditions are too dry for the particular plant species.

2.3 The Aesthetic Context

Aesthetic considerations often underlie decisions made on masonry capping and there are diverse historical and contemporary cultural attitudes to the presentation of ruins. By presenting ruined structures in a manner that is more integrated with their natural environment, there can be an aesthetic gain in softening the starkness of some ruined structures and producing a more 'natural', 'romantic' or 'environmentally-friendly' image. Potential sites present a range of visual contexts that may influence the selection of technique or plants.

Fig. 2.27: Byland Abbey, Yorkshire. The allure of a wilderness ruin is temporarily restored to one corner.

2.3.1 Changing Approaches to the Presentation of Monuments

The UK has enjoyed a diversity of attitudes and approaches to the relationships of plants to ruins but during the 20th century the dominant view among statutory bodies was that plant growth on monuments was aesthetically inappropriate because it obscured the monument, and technically undesirable as it caused fabric decay.

Fig. 2.28: Urquhart Castle, Inverness-shire. This site presents the conventional 20th century approach of plant-free masonry set amid a landscape of abstracted lawns.

A great deal of naturally established vegetation was removed from ruins through the course of the 20th century, often associated with ground clearance and radical alterations to the setting of monuments. While this early work to reveal and conserve monuments was often less dramatic in Scotland than that carried out in England, it left a legacy of masonry ruins cleansed of organic growth rising amid clipped lawns. This reflects the concept of a ruin as a curatorial object. This is in stark contrast to the romantic engagement encouraged by the few private ruins, such as Jervaulx Abbey, where a different approach was consciously developed.

Fig. 2.29: Jervaulx Abbey, Yorkshire.

"...The picturesque beauty of [Jervaulx] ... is no accident ... it is one of the very few such ruins in Britain to show what it was about them that inspired and appealed to our ancestors in the Romantic period; the melancholy grandeur of crumbling walls, softened by a profusion of wildflowers. Instead of the slightly sanitised purity of most ancient monuments, Jervaulx offers charm, the picturesque, and a sense of living, continuing existence. Perhaps surprisingly, it appears that the vegetation growing among the old stones has often preserved, rather than damaged them. Of course, saplings with their long destructive roots have been a recurring problem; but the wonderful shaggy, living thatch which crowns the walls has actually served to throw off the rain, leaving the walls in a better state than at many rigorously weeded sites: nearby Fountains Abbey is a case in point, where mason's marks which were clearly legible twenty years ago are now hard to make out. The ruins of Jervaulx Abbey are in the middle of a long course of conservation, during which the plants that grow on them are being conserved. Jervaulx will remain true to its picturesque self.'

Jervaulx Abbey guide book

The desire to fully reveal ruinous remains of buildings in order to present the physical historical document to clear scrutiny was most keenly followed on religious sites. Here there was an academic desire to record the development of progressive architectural styles through exposure of the building plan, and an ability of such plans to aid accurate dating of construction. This often led to the exposure of very low-lying masonry remains, which are more vulnerable to decay because of high moisture contents. Paradoxically, in clearly revealing the masonry in an abstracted lawn landscape, the relationship of the building to its surroundings was often obscured. At castles and other building types, where stylistic development is less complex and therefore less academically interesting, and relationships to the natural landscape are often stronger, there was often less alteration to the landscape setting of monuments.

It has been acknowledged by English Heritage that the removal of ivy from some monuments, such as Fountains Abbey and Wigmore Castle, has led to accelerated decay of masonry. At some vulnerable sites, low lying walls have recently been re-buried in a manner where their form, if not their detail, can still be read.

Fig. 2.30: Hailes Abbey, Yorkshire. The altar (centre right) has recently been re-buried, though its form still reads within the low-lying consolidated limestone wallheads, which remain more vulnerable to decay.

While there has never been in Scotland a uniform ‘corporate branding’ approach to the presentation of monuments, there is now an increasing recognition of the benefits of a more pluralistic approach that reflects the individual character and cultural associations of a particular site. There has also been formal recognition of the importance of designed landscapes and recognition of the value of less formal settings.

> *‘A balance has to be struck between the conservation needs of the monument on the one hand, and its aesthetic qualities and ecological value on the other.’*
>
> *Architectural Ancient Monuments in Scotland: Guidance on Principles, 2001, 3.21*

In setting out conservation principles, the Burra and Stirling Charters have encouraged a broader view to be taken of the conservation needs of a monument to include its cultural value and setting, rather than exclusively focusing on the historic fabric. The building’s life as a ruin is increasingly recognised as part of its heritage value. Monuments frequently have been ruins for far longer than they were functioning buildings and they often have richer cultural associations as ruins than as building remains. Some of Britain’s most popular ruins illustrate this point.

> *The eighteenth-century landscaping at Fountains and Rievaulx is entirely misleading as it gives the visitor the wrong impression of their original aspect, but it would be unthinkable to alter it: the landscaping has assumed the importance of a monument in its own right. MW*
>
> *Thomson, Ruins: Their Preservation and Display, 1981, p33.*

In reassessing the role of vegetation in the presentation of monuments, it is recognised that techniques of soft capping have the potential to improve the technical conservation of original fabric as well as its aesthetic qualities and ecological value. However, it is important to recognise that soft cappings may be inappropriate for a particular monument, for reasons relating to any of these three criteria. Bringing assessments of cultural and ecological value into the process of monument inspection and conservation requires access to information and skills of analysis for which there are few established procedures and limited experience among those involved.

Fig. 2.31: The young Sir Walter Scott, by JMW Turner, 1831, with Smailholm Tower in the background. Turner’s image records the formative influence of Scotland’s picturesque romantic landscape on one its foremost writers.

The use of soft cappings in vernacular Scottish construction is not widely appreciated and has not influenced cultural attitudes to mural vegetation in Scotland. There is more awareness of Scandinavian vernacular examples, which are commonly viewed as an alien tradition, though the increasingly widespread use of ‘green roofs’ on modern buildings has fostered greater acceptance of the role plants can play in Scotland’s architectural culture.

2.3.2 Diversity of Appreciation

> *What should be the objective of display with a treated ruin? Different people will want different things, and all one can hope to do is provide sufficient information for each to choose what he wants.*
>
> *MW Thomson, Ruins: Their Preservation and Display, 1981, p33.*

The way monuments are repaired and maintained aims to accurately present the information contained in the original fabric as a historical document, to bring the past alive in the minds of the young, to preserve the cultural memory of the site and the events surrounding its destruction and to provide an attractive amenity space for public enjoyment. The balance of intentions in the display of monuments varies from site to site and the attitude towards vegetation can play an important role in defining its character.

To the conservation community, intelligibility of the monument as a historical document has long been the principal aim. While the amount that can be read into building remains depends on the level of understanding of the visitor, clarity and authenticity are critical so as not to mislead reconstruction in the imagination.

This academic interest is slightly different from the more general educational role of ruins, where a lack of original finishes and timberwork can generate a misleading impression of historic places, requiring a degree of interpretation and suggestion that may be conjectural.

The expectations of the general visitor to ruins vary and are heavily influenced by previous cultural experience. Wigmore Castle in Herefordshire, a ruin that carries a wilderness aesthetic of adventurous discovery that is highly valued by local residents, had this character carefully preserved through extensive conservation works and subsequent management. Other sites have a more theatrical romantic quality that is widely appreciated.

Fig. 2.32: Rieveaulx Abbey, Yorkshire. The masonry is fully revealed, but ubiquitous lawns obscure the original landscape setting and the building's relationship to it.

Fig. 2.33: Melrose Abbey. Visually uniform lawns suppress appreciation of the difference between spaces.

Fig. 2.34: Wigmore Castle, Herefordshire. The ruin is gradually discovered, apparently undisturbed amid ancient woodland.

Discreet signage makes the original plan intelligible. On the other hand, English Heritage has found that, on long-established sites of scrubbed masonry amid manicured lawns, there can be an adverse public reaction to more sustainable planting and management, with public complaints that grass hasn't been cut. Public explanation of changing habitat management may ease acceptance in such situations.

At sites where the naturally established vegetation survives to a significant degree, some find the rare habitats for flora and fauna often associated with ancient ruins, of more interest than the ruins themselves. This is especially true if the site is within, or overlooks, a SSSI or other wildlife conservation area.

The extent to which the desires of these different audiences can be satisfied on any particular site is limited. The case studies suggest that the most successful approach is to develop a presentation strategy based on the most important characteristic for an individual site, rather than trying to achieve all things for all people. This suggests a pluralistic approach to the presentation of monuments that respects the diversity of its heritage value and reinforces local character.

Fig. 2.35: The Nunnery, Iona, Argyll (CS28). The ruinous character of this public space is highly valued by locals and visitors in part because it contrasts so strongly with the full restoration that has transformed the Abbey, seen in the background. However the need to respond to the different user groups has led to what could be considered an inconsistent approach to vegetation on the site.

2.3.3 Clarity of Interpretation

In the conservation of architectural masonry, the need to distinguish repair from original fabric is a well-established principle, founded on a respect for authentic historic construction and an ethic of avoiding misrepresentation. In developing techniques for the use of plants and soils as conservation materials, a similar rigour should be followed.

The rarity and lack of recognition of vernacular soft cappings makes their physical and intellectual preservation increasingly important. It would be unfortunate if, in developing the use of plants on historic buildings, original fabric became confused as repair and appreciation of the important bio-regional character of vernacular construction techniques was reduced.

The visual differentiation of vernacular construction cappings from other forms of soft capping is aided by the fact that they generally sit on complete structures. It is more difficult to maintain clarity between decayed organic original construction resting on masonry remains, naturally established cappings on decayed masonry and mature soft cappings. For example, a collapsed blackhouse roof depositing soil and plant material on a wallhead could be hard to distinguish from a neighbouring wallhead that has had a conservation soft capping sensitively applied.

Fig. 2.36: Eynhallow Monastery, Orkney (CS18). The wallhead vegetation is conservation soft capping from several periods, dating back probably to c.1920.

Fig. 2.37: Ruined Cottage, Eynhallow, Orkney. Less than 1km from the monastery, the vegetation on this roof is a decaying part of the original roof construction of a cottage abandoned around 1851.

The argument for, for example, maintaining conservation cappings in a different manner from naturally established ones in order to clearly display the level of intervention, has limited attraction, given that it would increase maintenance burdens and that the intention with soft cappings is often to mimic natural processes for presentational reasons.

In time the natural process of species distribution will inevitably tend to blur distinctions between types of capping. Nonetheless, to the educated eye, there will remain a discernable difference between a carefully designed conservation capping and a natural one, even when they have matured.

2.3.4 Appropriateness to Situation

With careful control of technique, plant selection and maintenance, there is reasonable scope to regulate the appearance of soft cappings, giving conservators the ability to achieve an appearance in living materials that is appropriate to a particular site.

Most new cappings to date have used turf of limited species diversity and, particularly where commercial turf has been selected, a monotonous appearance tends to be the result. Such cappings are clearly an intervention, if one that is rather lacking in character.

Where more natural turf is sourced, or where natural cappings are reinstated, a much more diverse visual appearance usually results. Foliage, flowering and seeding patterns will tend to mimic those in the surrounding environment and a naturalistic appearance of apparent non-intervention can be achieved.

Fig. 2.38: Peebles Town Wall, Peebles, Peebles-shire. Commercial turf has resulted in low visual diversity, giving an even appearance, arguably appropriate for an urban setting.

Fig. 2.39: Skipness Castle, Argyll (CS35). A turf capping cut from the grazed field in the background has limited diversity, but arguably link the building to its setting and is in tune with the lawned monument grounds.

Fig. 2.40: Black Castle, Perthshire (CS13). The conserved cappings echo the botanical context, though this has become more overgrown since grazing cattle were excluded.

Creating the appearance of naturally established vegetation on the decaying remains of a masonry structure has been the most common approach in the minority of cases where there has been a conscious consideration of the aesthetic impact of soft cappings.

Such a naturalistic appearance is perceived as being an integral part of the ruination process, of marking the passage of time from an often violent act of destruction, and allowing the visitor to place the architectural remains within a historical perspective. The very ruinous quality of ruins is part of their inherent appeal to visitors and can generate deep cultural responses.

> *There has to be that interval of neglect, there has to be discontinuity; it is religiously and artistically essential. That is what I mean when I refer to the necessity for ruins: ruins provide the incentive for restoration, and for a return to origins. There has to be (in our new concept of history) an interim of death or rejection before there can be renewal and reform. The old order has to die before there can be a born again landscape. Many of us know the joy and excitement not so much of creating the new as of redeeming what has been neglected, and this excitement is particularly strong when the original condition is seen as holy or beautiful. The old farmhouse has to decay before we can restore it and lead an alternative life style in the country; the landscape has to be plundered and stripped before we can restore the natural ecosystem; the neighbourhood has to be a slum before we can rediscover and gentrify it. That is how we reproduce the cosmic scheme and correct history.*
>
> *The Necessity for Ruins, Jackson J. (1980) p. 102*

The fact that soft cappings have to date been mainly low maintenance solutions to relatively remote ruins or the retention of naturally established cappings, has encouraged the view that soft cappings are a 'rustic technique' more appropriate to ruinous than roofless structures, and rural rather than urban situations.

The logic of using soft cappings as an expression of the passage of time, reflecting place through local ecology argues against such narrow perameters. Urban and roofless structures are naturally colonised by vegetation in the same way as rural and ruinous ones, though the speed of the process and character of the results will be different. Indeed, in urban locations, there can be a benefit in foliage of distinguishing ruins standing amid a rich and diverse context of masonry structures and the cultural value of ruins can be all the more potent in settings of constant urban renewal.

Fig. 2.41 : St. Lar's Church, Visby, Sweden. One of a series of soft capped ruins in an historic urban setting.

Fig. 3.1: Cleitean, St. Kilda, Western Isles. Performance of individual cappings varies dramatically for reasons that are not fully understood.

3. FACTORS AFFECTING PERFORMANCE

Field Studies in Scotland have allowed an assessment to be made of soft capping performance across a broadly representative range of the country's climatic conditions, geographical locations, physical situations and ecological contexts. Investigation of cappings in other countries has further informed the assessments of climatic variation and technique. Though in isolated cases, a single factor can be of critical importance, generally performance of a soft capping is determined by a complex inter-connection of factors, which are sometimes difficult to assess separately.

This chapter gives a generalised description of these individual factors. The complex diversity presented by the case study material is indicated by the fact that there is commonly one case study whose individual data will contradict these generalised findings. While this illustrates the complexity of circumstance that affects soft capping performance, it also suggests that there is a diversity of possible approaches to the design of soft cappings, which, if better understood, would improve the success and technical diversity of conservation using this technique.

The climate data quoted in this chapter is generally sourced from Met Office thirty-year averages, 1971-2000.

3.1 Climate

Although in Scotland climatic conditions are generally favourable for soft cappings, climate is still the single factor that most influences their performance. Solar radiation and rainfall have the strongest influence. However, wind was found to be the only factor able to destroy a capping's long-term viability irrespective of other factors, in severely exposed situations. Wind is therefore suggested as a limiting factor to the north and west, just as solar radiation and rainfall are limiting factors to the south and east.

In the majority of climatic conditions in Scotland, soft cappings will be successful if appropriately designed and installed. The most consistently benign conditions were found in Argyll, where the high rainfall and mild climate generally overcome wind exposure. In contrast, difficult conditions were found in Fife and Angus, where sites exposed to sun and wind struggle with relatively long periods of drought. In Orkney, soft cappings in severely wind-exposed locations will not endure, despite mildness of climate and relatively low solar exposure, though the process of failure can be very slow and could be acceptable in some conservation situations. In individual locations, such regional climatic characteristics can be dramatically altered by local microclimatic factors.

3.1.1 Moisture

Rainfall patterns vary considerably in Scotland. Annual rainfall varies from under 500mm to over 4500mm, while measurable rainfall (above 0.2mm) occurs over 250 days per year in much of the Highlands, reducing to 175mm on the east coast. The maximum rainfall recorded in a single day is 238mm.

While there is a general reduction in rainfall from west to east, there are many local variations. Some areas, such as Argyll, have persistently high rainfall and associated cloud cover with much more rain in winter than summer. In Orkney and the Borders, there is a moderate or low quantity of rain, but it is spread over a high number of days. Other areas, such as Fife and Angus have relatively low rainfall and prolonged periods between rain events.

Relative humidity also varies geographically and seasonally. Scotland generally has high air relative humidity, typically ranging between 60 and 100%. Although values drop away from the coasts and major rivers and during the summer, low relative humidity did not appear to have significantly reduced the performance of any of the assessed cappings.

Lack of moisture had a significant effect on the performance of cappings in most of Scotland, apart from the west coast, and generally contributed to local edge dieback. Lack of moisture is created by several factors. The length of periods with little or no rain appeared more important than overall annual rainfall, as it coincides with periods of peak solar radiation.

Solar exposure levels have a closer correlation to annual number of rain days than annual rainfall. Rain days are a better indication of cloud cover. The number of rain days and wind exposure are usually the best indicators of climatic stress experienced by soft cappings. Wind exposure to edges can be a critical additional drying factor.

The ability of the cap soil to store moisture has an influence on moisture levels, which relates to soil depth, type and structure. Some naturally established soils appeared to have a hygrophobic quality that impedes deep rainwater penetration. The use of clay-rich subsoils, or clay mortar, seemed to have a beneficial ability to store moisture, though the degree to which plant roots were able to access this varied with the structure of the soil. In very wet conditions, however, clay cappings can become very slippery and a hazard to walk on at height.

High levels, or intensities, of rainfall only cause problems when there are other significant contributory factors. Soils with poor structure, such as sandy coastal soils, were vulnerable to erosion in heavy rain, heightened if they were thin or laid over an impermeable membrane or onto a dense concrete surface.

One of the two sites (both water mills) that had particularly damp conditions seemed to define an upper limit for moisture levels. Though it does not have the highest rainfall, Doune Castle Mill (CS15) has low evapo-transpiration created by shade, wind shelter and a short sward. The core of the clay cap remains moist through the summer, though the surface saturates in heavy rain. In winter the caps are likely to be wet through and this level of moisture seems to have retarded plant growth, which is low and thin. In one area of high deciduous shade, only moss grew and the clay cap was sliding off slopes.

Fig. 3.2: Doune Castle Mill, Stirlingshire. High levels of moisture seem to have inhibited growth, especially at the edge.

Fig. 3.3: Doune Castle Mill, Stirlingshire. While the surface of the clay soil was very wet, the core was still crumby. The core stores and releases moisture over a long period, while the thin plant cover struggles to retain rainwater, perhaps causing high edge runoff.

Fig. 3.4: Doune Castle Mill, Stirlingshire. A shaded cap is unable to sustain vegetation other than moss, with the clay saturated and sliding off steep sections.

3.1.2 Solar Radiation

Levels of sunshine vary considerably in Scotland, both geographically and seasonally. Parts of the east and south-west have over 1400 hours bright sunshine per year, while more mountainous areas have less than 1100 hours. The high latitude of Scotland means there is great seasonal variation, especially in the north, where there are some days when no bright sunshine is recorded at all. The maximum monthly bright sunshine was recorded as 329 hours on Tiree on the west coast in May, while the minimum of only 0.6 hours was recorded at Cape Wrath on the north coast in January.

Adequate levels of light are necessary for plant growth and these are generally available in Scotland, except in heavily shaded areas such as shown in Fig.3.4. Elsewhere, there were indications that in the relatively dry east, some shade can be beneficial to reduce evapo-transpiration in summer.

Fig. 3.5: WW2 Pillbox, Fife (CS12). The woodland shade reduces wind exposure and solar radiation and increases relative humidity.

Fig. 3.6: WW2 Pillbox, Fife. High solar exposure, along with wind exposure and density of the substrate, has contributed to complete loss of the capping.

Solar radiation has the effect of heating the plants and soil, encouraging transpiration and evaporation, thereby reducing the moisture levels in a soft capping. This was found to be a significant contributory factor in edge dieback in many cases, though only when combined with other factors, such as wind exposure, long periods of drought, inappropriate soil and plant selection or capping technique. While there is a marked seasonal variation in levels of solar radiation, there are also variations related to orientation and incline.

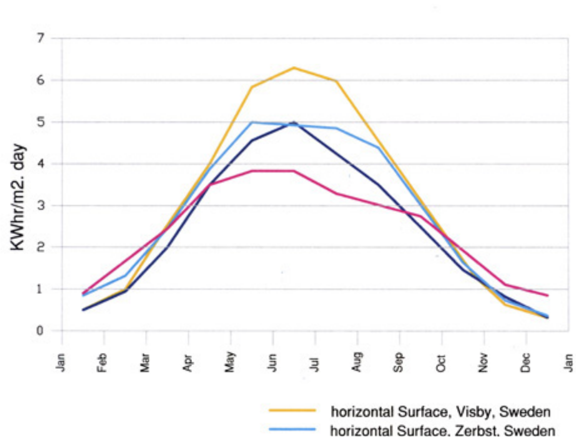

Fig. 3.7: Variations in solar radiation by season, location and angle.

South facing and horizontal surfaces gain most solar radiation. This can rapidly heat up masonry, especially if dark coloured, increasing evaporation of moisture and thermal currents, which reduce the moisture and thermal buffering effect the plants have on the air immediately around the cap. While masonry with high solar exposure can rapidly warm up, it also quickly cools and such surfaces therefore experience more diurnal thermal variation than, for example, north facing surfaces. However, north-facing surfaces experience more frost, which seems to have an effect on soft cappings comparable to drought conditions. East-facing surfaces will absorb less heat than west-facing surfaces, because of the change in solar radiation wavelength through the day.

Scotland's relatively high latitude makes these orientational effects less marked than in more southern countries and the case studies only showed a significant orientational characteristic on dry sites, usually on the east side of the country.

An interesting case study in this regard is Coupar Angus Abbey (CS14), a relatively dry, eastern site. Trees to the east and masonry to the south of the ruin shade the central, flat area of capping, and shelter it from wind and rain. In contrast, the western side contends with higher solar exposure, greater incline, and exposure to the prevailing wind and rain. The overall effect of these differences is probably determined by critical peak summer conditions when, depending on the climate of a particular summer, the edge suffers decay or growth, leaving it unstable. This illustrates the fact that moderated climatic conditions, which the caps create for the masonry they cover, are also beneficial to the condition of the capping itself. In time, the edge on this capping could stabilise through species variation.

Fig. 3.8: Coupar Angus Abbey, Angus. The west facing side is exposed to much more solar radiation than the rest of the capping, resulting in local dieback.

Fig. 3.9: St Nikolais' Church, Visby, Sweden. The effect of orientation on a site with high solar exposure and little ability to store moisture: sedum mats are failing on the south side, but stable on the north of shallow domes.

Fig. 3.10: Braemar Castle, Aberdeenshire. Following complete failure of the vegetation, the clay cap has dried and cracked. Such a surface could be colonised by more appropriate species in time.

3.1.3 Wind

Scotland is the windiest country in Europe, experiencing significant seasonal and geographical variation, with the north and west generally most affected. Wind can be a major factor in decay and failure of cappings. Wind frequently combines with solar radiation to dry out plants and soil. This particularly affects fresh cappings, where exposed roots are very vulnerable. Wind can cause significant mechanical decay through the abrasive action of loose soil and airborne sand, especially on coastal sites. Wind can also damage new cappings by physically lifting turfs off the wallhead.

Fig. 3.11: Scotland's average wind speed distribution.

Fig. 3.12: Eynhallow Monastery, Orkney (CS18). The effect of elevation on cappings about seventy-five years old. In this location, wind gives any capping at high level a limited lifetime, irrespective of other factors.

In several case studies, wind proved to be the major factor locally determining whether the turf survived or not. This, however, was usually associated with other contributory factors. Good edge detailing and fixing techniques can minimise the initial period of vulnerability. However, even on mature cappings, damage to an edge exposes soil and roots, and wind can cause progressive decay, preventing the cap edge from re-stabilising.

The particularity of each site is demonstrated by the vernacular cappings on St. Kilda, which has the highest wind exposure in the British Isles, with gale force winds (39 mph) recorded on one in four-and-a-half-days, and isolated wind speeds of over 120 mph. In this case, the effects of the severe winds were apparently significantly retarded by the densely developed root system, which bound the soil even when the vegetation has died.

Fig. 3.13: St. Kilda, Western Isles (CS7). Cappings that are thought to be at least a hundred years old, at 600m altitude, west facing, yet proving stubbornly resilient to North Atlantic winds.

Fig. 3.14: Isle of May, Fife (CS36). Large stones in the capping soil, exposed by accelerated wind erosion of the soil.

Fig. 3.15: Isle of May, Fife (CS36). Uplift from helicopters delivering materials lifted turfs off the caps during the works.

Fig. 3.16: St. Cormac's Chapel, Eilean Mor, Argyll (CS1). Localised effects are hard to predict. Wind currents here focus on an inner corner of the capping, scouring away any soil, while the exposed outside edge has stable, thick growth.

3.1.4 Salt Spray

Fig. 3.17: The Wine Tower, Fraserburgh (CS39). An example of high exposure to air-borne salts.

Salt spray can inhibit plant growth by coating the leaves and being absorbed into the capping soil. Vulnerability to salt varies between species, with Festuca ovina (Sheep's Fescue) noted as being salt tolerant. Damage to masonry can also occur through salt crystallisation as a result of drying out from cappings or, more likely, temporary protection during conservation works (CS19).

Seventeen of the case study sites were located within a kilometre of the sea and some were highly exposed to air borne salt, but decay or impaired growth directly attributable to salt was rarely observed. St. Kilda, Western Isles (CS7), is perhaps the exception. Here, waves breaking on the coast reach over 10m high and salt spray carried all across the island is noted as affecting vegetation. It is reported that soft cappings usually erode from the seaward side.

3.1.5 Pollution

Direct pollution of cappings has not been recorded in the case studies, other than perhaps excessive bird droppings, which can have a toxic effect (CS36). Atmospheric pollution can result from air borne particulates deposited by precipitation. It is also possible for rainwater to have an acidic effect through absorption of soluble chemicals in the atmosphere.

In practice, no evidence of atmospheric pollution was found in the case studies. However, as the sites were all located in places where atmospheric pollution is very low, it is possible that soft cappings could be detrimentally affected in areas where pollution levels are more significant.

3.2 Host Structure

Soft cappings were found to have successfully inhibited decay across a range of substrate materials and forms. Within a wide range of situations, the dominant application of soft cappings in conservation has been onto roughly flat, relatively narrow, fragmented, lime mortared igneous and sandstone rubble wallheads in rural locations.

3.2.1 Substrate Form

The most important factors relating to the form of the host structure are surface incline and shape, specifically, the ratio of edge to enclosed area. The steeper a surface is, the more likely a capping is to fail. The rounder its shape is, the more likely to succeed. Both of these factors can significantly affect the viability of a capping.

	Conservation (deliberately applied)	Original Construction	Naturally colonised
Fragmented wallhead	13	1	2
Complete wallhead	15	4	1
Inclined wallhead	5	-	-
Vault or roof	4	4	1
Ground level remains	3	-	-

Table 1: Frequency of different types of capping on different host structure forms.

a) Fragmented Wallheads

On broken wallheads, the malleable and cohesive nature of many soft capping materials allows a good bond to the substrate and a controlled top surface geometry to be achieved. In a few case studies, the masonry had been consolidated to a water-shedding surface as a secondary precaution in case the soft capping should fail. More commonly, the original masonry was retained without alteration.

Where a damp proof membrane has been used between a soft capping and wallhead masonry, the bond was less good, with examples in Sweden where this had directly led to failure of the cap. There were no examples recorded where damp proof courses immediately below cappings had proved successful.

Fig. 3.18: Skipness Castle, Argyll (CS35). The soft capping varies in depth to provide a regular, water-shedding surface.

Though most wallhead cappings were 400-800mm wide, they ranged up to 3m wide. Cappings narrower than 400mm experience higher levels of stress due to the greater degree of edge exposure.

b) Complete Wallheads

On complete wallheads of roofless structures, soft cappings perform in a similar manner, though sometimes the voids associated with missing timber elements create a complex, angular geometry that makes a continuous cap difficult to achieve.

Whilst there is some debate over whether soft cappings are aesthetically appropriate on complete wallheads, this was a capping situation commonly found in the field research. Indeed, in two case studies (CS21 and CS35) soft caps had been applied to intact wallhead walkways but not to adjacent rough racked parapet masonry.

Fig. 3.19: Pabbaigh, Western Isles (CS33). The soft cappings, two layers of turf, root to root, are worked into the sockets left by decayed timber rafters. A permeable geo-textile membrane, used as a defining layer, can be seen being installed on the left.

Fig. 3.20: Inverlochy Castle, Inverness-shire (CS21). The cappings are applied to the walkway surface but not to the parapets.

Fig. 3.22: Monimail Tower, Fife (CS27). Cappings on the gable have tended to stabilise onto shallower inclines, as a series of stepped cappings.

c) Gables

Gables combine the stress conditions of narrow and inclined surfaces and soft cappings were often found to have partially or completely failed on gables at sites that had successful cappings on other surfaces. Where gable cappings partially succeeded, the cappings tended to stabilise into a series of steps relating to the underlying masonry surface.

Fig. 3.21: St. Cormac's Chapel, Eilean Mor, Argyll (CS1). Although the large inclined, and narrow flat surfaces are naturally colonised, the narrow, inclined gable remains essentially bare.

Fig. 3.23: Kilmory Chapel, Argyll (CS23). The mild, sheltered conditions on this site allow the steep gable in front to be successfully capped. The rear gable still retains its natural vegetation.

d) Vaults

Vaults have a plan shape well suited to soft capping, but sometimes have the disadvantage of being either too steeply sloped or too flat. They were generally found to support very successful cappings on inclined surfaces. There was often a natural thinning of the cap towards the top and sides and a vertical zoning of vegetation species, relating to moisture movement and force of gravity.

Fig. 3.24: St. Cormac's Chapel, Eilean Mor, Argyll (CS1). The capping thins towards the ridge and eaves.

Fig. 3.25: Monimail Tower, Fife (CS27). The flat upper surface allows some moisture to penetrate through the capping. A thicker clay layer might have adequately improved performance.

Soft cappings over masonry structures that had a flat surface over a vaulted chamber exhibited varied performance, with a tendency to inadequately shed rainwater. In one case, a clay and turf cap had been re-applied with a damp-proof membrane beneath because there had been severe water penetration through the soft cap (CS39). However, in some situations, soft cappings can be successful on such surfaces without need of membranes (CS14).

e) Ground Level Remains

The sites with ground level remains were usually the result of recent archaeological excavations and as a result the masonry had relatively high moisture content. Theoretically, soft cappings can protect such masonry by impeding over-rapid drying out, though no direct evidence of this was found and the masonry had usually been exposed for some time during the course of excavations, before being capped. Otherwise, the benefits of reducing climatic decay were similar to those on higher structures.

Where they survived, soft cappings clearly protected vulnerable low-lying masonry from unintended damage by pedestrians on heavily visited sites. On well-maintained sites, they could also assist the clarity of presentation of the site by raising the wall lines higher above the ground plane.

No examples of vegetation protecting flooring or gravestones were found to be sufficiently clear to merit detailed examination.

Fig. 3.26: Monimail Tower, Fife (CS27). An excavated wallhead protected by soft cappings.

3.2.2 Substrate Texture

The surface texture of the substrate was found to generally have a minor effect, but was more significant where it was very smooth, or on a steep incline.

Attempts to improve wind resistance by increasing surface texture were only partially successful, appearing to slow rather than prevent loss.

Fig. 3.27: Kilbrannan Chapel, Argyll (CS22). The smoothness of the dressed cope edges meant the soft capping stabilised ~50mm back from the edge, a feature not found on the rough racked wallhead.

Fig. 3.28: Eynhallow Monastery, Orkney (CS18). Surface texture created by lime mortared stones fails to prevent wind decay.

Fig. 3.29: Varberg Fortress, Sweden. Textured wallhead with bitumen remnants failed to withstand wind decay

	Conservation (deliberately applied)	Original Construction	Naturally Established
Lime mortared stone masonry	**20**	**2**	**2**
Clay mortared stone masonry	**3**	**1**	**1**
Drystone masonry	**2**	**5**	**1**
Turf wall	**-**	**1**	**-**
Cement capped stone masonry	**4**	**1**	**-**

Table 2. Frequency of Host Material in Case Studies

3.2.3 Substrate Materials

Soft cappings have been applied onto a range of construction materials, broadly representative of vernacular masonry construction. No non-masonry substrate applications of soft cappings were recorded, though these do occur in vernacular traditions.

The viability of the capping and its effect on the host material varied to a minor degree, depending on the type of substrate. This seemed to be mainly due to its ability to act as a background moisture reservoir, though this was rarely found to be the determining factor in the performance of a capping.

Concrete surfaces seemed the least supportive of cappings, and sandstone the most. Interestingly drystone walls, though they lacked mortar, also seemed to be good hosts, suggesting that permeability is the key factor.

a) Lime Mortared Masonry

Soft cappings seemed effective in preventing leaching of lime binder, frost damage and cracking caused by thermal movement. Of the conserved sites, half were repaired with lime prior to the capping. Soft cappings proved beneficial in initially protecting these lime repairs from precipitation, frost and solar exposure. Indeed, in some cases soft cappings were applied primarily as temporary protection, with limited expectation of their long-term durability.

b) Clay Mortared Masonry

There was a reasonable sample of clay mortared walls, sometimes originally having lime pointing. In these cases the soft cappings had significant clay soil layers below the turf and they were generally found to have given the wallheads a good degree of protection. No significant root penetration into the clay mortar was found and the materials seemed highly compatible. In one case where the capping was an emergency application and had subsequently suffered severe dieback, there had been a good degree of temporary protection (CS32). In one case, the cappings were found to have given good protection against wind uplift to the masonry, which was weakly bound by decayed clay mortar (CS18).

c) Drystone Masonry

Soft cappings generally have had a beneficial effect in prolonging the durability of drystone masonry, by protecting it from wind and mechanical damage. This is true of naturally established, original and conservation cappings. Mature soft cappings can have a complex root structure that locks onto the irregular shape of the wallhead stones, binding them individually and acting as a weak ring beam to the whole structure.

Fig. 3.30: St. Clement's Churchyard, Roghada, Western Isles (CS37). The vernacular soft cappings bind the drystone masonry at the vulnerable wallhead.

No significant damage from root penetration was found in the drystone walls studied. In some cases the soft cappings had attracted the attentions of grazing animals, which sometimes caused damage to the masonry by climbing over it to access the turf, but generally the benefit of protection was greater than any such damage.

d) Turf Wall

While no conservation applications onto turf walling were found, reconstructions of turf walls demonstrate that the moisture retained in the lower turf improves the viability of a turf cap, in comparison to caps over stone materials (CS6).

Fig. 3.31: Leannach Enclosure, Culloden, Inverness-shire (CS6). The turf walls sustain good living wallheads, but little vegetation grows on the face.

The increased quantity of soil did not seem to increase the viability of invasive seeding, indicating moisture content was within a critical range; sufficiently high to aid capping viability, but low enough compared to the natural soil, to prevent invasive colonisation. However, because of its extreme rarity as a protected structure, the potential for soft capping onto turf materials is very limited.

e) Concrete and Cement Capped Masonry

Concrete and cement substrates seemed to lack the ability to act as a moisture reservoir that stone and, to a greater degree, clay and turf demonstrate. Although a minor effect, it was another contributory stress factor in the cases with concrete structures.

Several of the examples were onto hard caps, which had not performed well, and here the intention of soft capping was as much to conceal the cement as to reduce damage from moisture ingress and thermal expansion. Bitumen coatings onto such caps did not seem to make a major difference. Soft cappings over concrete seemed more vulnerable to mechanical damage, especially from pedestrian traffic.

Fig. 3.32: Inverlochy Castle, Inverness-shire (CS21). Asphalt coated concrete cappings revealed after erosion of the soft capping by pedestrian traffic.

3.3 Plant Materials

The plant constituent of soft capping has several effects. Its surface sheds rainwater off the wallhead and shades it from solar radiation. The sward creates a zone of still air, moderating temperature and relative humidity. The plant's roots absorb moisture and bind the soil layer. It can have ecological and habitat value and contribute to a naturalistic or picturesque affect.

3.3.1 Biodiversity

Diversity of species in plant systems is recognised as having both ecological and aesthetic benefits.

> *Although the ground plan of the church can be identified, there are only fragments of the original walls visible along the entire 270 ft., and a few column bases springing up from the undergrowth. However, the real beauty of the church now takes the form of a profusion of wild flowers decorating the ancient stones, and providing a colourful carpet across the nave. In total, there are believed to be some 200 different species growing amongst the ruins.*
>
> *www.jervaulxabbey.com*

> *Diversity in vegetation is generally agreed to confer some resistance to environmental change and pests and disease. The greater the number of plant species within a system, the more attractive it is for feeding and shelter to wildlife, and to predator species. Diversity also implies complexity and visual richness.*
>
> *Landscape and Sustainability, Benson& Roe, 2000*

The complexity of the plant layers in the case studies varied in relation to the age and geo-botanical context of the capping. Mature caps, taken as those over 100 years old, could be very bio-diverse. In sheltered, bio-diverse locations, a complex variety of species could develop fairly quickly (CS30). However in very exposed sites, the number of species was always limited.

Fig. 3.33: Gordon Castle Estate, Moray (CS4). A bio-diverse setting, for mature, un-maintained soft cap.

Fig. 3.34: Dun Carloway Broch, Western Isles (CS17). A low bio-diversity setting with an exposed cap, suppressed by strimming.

While natural turf cappings generally had a dense root mat that tended to exclude invasive seeding, commercial turf, being thinner and less well developed, tended to accept colonisation more readily.

In some cases, it was accepted that the applied vegetation was unlikely to thrive but that it would act more as a temporary covering that would gradually be naturally colonised by more appropriate species.

Diversity of species has several advantages. A more geometrically complex sward is created, trapping and shedding water more effectively than one or two leaf shapes. The capping has a better ability to survive unusual climatic periods because of the diversity of response of different plants, whereas a single species may have a particular vulnerability. Bio-diverse cappings can also have greater ecological value and aesthetic appeal, with their visual character changing through the seasons as different plants grow, flower and recede.

Table 3 (see accompanying Excel file) gives a comparison of plant species recorded on the case study sites, though this should be taken as indicative rather than comprehensive, due to the survey limitations. A total of 149 species were recorded on the surveyed cappings, with a maximum of thirty-nine on a section of Gordon Caste Estate walls (CS4) and a minimum of four on Dun Carloway Broch (CS17).

Appropriate bio-diversity in a soft capping will reflect the variety of species that naturally occur in this type of habitat in the particular location. This means that generally, to promote appropriate bio-diversity, only locally native plants should be used. Situations where exceptions to this general principle are appropriate include where non-native plants are a long-established feature of a monument, or where non-native species would be beneficial for visual or technical reasons.

3.3.2 Species

a) Grasses

Grasses are one of the most widespread and diverse plant species, covering a quarter of the world's land surface and having adapted to environments including the Arctic, desert fringes and flood zones. The key attribute that makes grasses so successful is that they grow from the base rather than from the head; thus they can be repeatedly grazed or mown, yet continue to grow. This gives mature plants a strong root structure, well suited to soft capping conditions.

Grasses were generally the dominant species found on soft cappings, apart from at some woodland sites, and twenty-three different species were recorded in the case studies. Red Fescue (Festuca rubra) was the most common. This plant has strong drought tolerant characteristics with fine leaves that can curl in to reduce transpiration; and a stabilising mat of fine roots.

With climatic conditions often extreme, Red Fescue true to character, often became overwhelmingly dominant if undisturbed (no grazing), to the exclusion of any low growing herbs or, in some cases, other less aggressive grass species. An example of this is found at Black Castle (CS13) where Sweet Vernal Grass (Anthoxanthum odoratum), which occurred within the original lifted turf, was almost entirely eradicated in favour of Red Fescue within a few years.

Sheep's Fescue (Festuca ovina) was also very common and is similarly drought tolerant, though its tendency to form clumps of roots can create isolated stands that are more vulnerable than Red Fescue's carpet.

Fig. 3.35: Cleitean, St. Kilda, Western Isles (CS7). Red Fescue creates a root-dense mat.

Fig. 3.36: Coupar Angus Abbey, Angus. Sheep's Fescue stands as distinct clumps.

Common Bent (Agrostis capillaris) was another common species. It was recorded at shady or sheltered areas, where it could become dominant, especially under dense shade, as well as at open or exposed sites. Other species which occurred in a wide variety of situations included: Perennial Rye Grass (Lolium perenne), a species less characteristically suited to the stress conditions of cappings, was nonetheless recorded on a number of occasions; Cock's Foot (Dactylis glomerata) which tended to be no more than a scattered component; and also Creeping Soft Grass (Holcus mollis).

Some species, such as Crested Dog's Tail (Cynosurus cristatus), Smooth Meadow Grass (Poa pratensis) and Early Hair Grass (Aira Praecox), were only recorded on relatively open or exposed sites and never more than occasionally.

Though reasonably common, the frequency of Poa genus grasses did not quite reflect its description by Darlington (1981) that 'some variety or other is practically certain to appear sooner or later on any wall anywhere capable of supporting vascular vegetation' with Poa pratensis noted as being 'rare on walls'.

Sweet Vernal Grass (Anthoxanthum odoradum) was only recorded at two sites, although at one (CS4) it was abundant in places on long established sections of wall. Again False Oat Grass (Arrhenatherum elatius) (CS4) and also Common Couch (Elytrigia repens) (CS2) were only recorded on long established walls where the accumulated turf soils were deeper.

Yorkshire Fog (Holcus lanatus) was rarely recorded, with the exception of Kilmory where it comprised a high percentage of the locally sourced turf.

It should be noted that the frequent occurrence of Fescues, Common Bent and also Perennial Rye Grass, was in part due to the fact that these species were often the main components of recently applied commercial turf mixes.

Some grass species, those with deep and invasive root systems, are considered potentially damaging to masonry. These include Cock's Foot, Common Couch, False Oat Grass, Tufted Hair Grass and Yorkshire Fog, which were recorded in the field surveys. However, in none of these cases was such damage recorded.

b) Ruderals and Herbs

Eighty-six different species of ruderals and herbs were recorded, with most occurring only on a small number of caps, indicating a regional or local distribution. The variety in the composition of the herbs and ruderal species across individual sites was due to a wide range of factors: the age of the topping (older sites generally producing more variety); whether a commercial turf had been used; the successful establishment of any turf topping; the type of soils (infertile soils generally tending to be more uniform); climatic conditions; exposure to wind, drought or frost; shade; etc.

Some species were recorded relatively frequently, the most common being the following (number of sites in brackets): Broadleaved Willowherb (9), Cleavers (7), Common Mouse-ear (5), Common Sorrel (5), Creeping Buttercup (5), Creeping Thistle (5), Daisy (7), Dandelion (13), Nettles (6), Ragwort (11), Ribwort Plantain (11), White Clover (8) and Yarrow (7).

The most common species included both beneficial and damaging ones. Plantago lanceolata (Ribwort Plantain) was found to help stabilise edges on a number of caps, while Achillea millefolium (Yarrow) was more generally benign. Thyme was a stabilising species on some thin caps.

Plants recorded in the case studies that were potentially damaging to the masonry, can be divided into three main categories:

i) High Risk - those presenting a high level of threat to the masonry once established and capable of doing significant damage. This relates to plants which, once established are deep rooting, generally large, robust, highly competitive and difficult to eradicate. In particular, Creeping Thistle, Dandelion, Nettles and Ragwort (all of which occurred on five or more of the sites). In addition, Bramble, Broadleaved Dock, Cow Parsley, Ivy, Raspberry, Rosebay Willowherb, Bracken and Spear Thistle were also recorded.

Fig. 3.38: The Nunnery, Iona, Argyll (CS28). Removal of natural caps has allowed colonisation by roses and dandelions, whose penetrating roots will damage the masonry.

ii) Medium Risk - those posing a medium level of threat to the masonry once established. This relates to plants which, while not generally so aggressive, still pose a threat to the masonry in the long term, due to the their invasive root systems and/or competitive nature. This includes a wide variety of species some with deep taproots such as Angelica, Broadleaved Willowherb or Birdsfoot Trefoil, also several creeping species (either by stolons or rhizomes) such as Creeping Buttercup, Cleavers, Yarrow or Daisy.

iii) Low Risk - those considered to only give a low level of threat or no obvious threat at all, such as Herb Robert, Ribwort Plantain, White Clover, Germander Speedwell or Lady's Bedstraw.

Colonisation by deeply rooting, and therefore damaging, plants was relatively rare on conservation caps. While such plants would seed in, often they would fail to thrive under the stressful conditions and would die within one or two years. The dense clay soil layer in many conservation caps assisted this, whilst the more open structure of natural soils was more prone to deep rooting.

Fig. 3.37: The Nunnery, Iona, Argyll (CS28). Ribwort Plantain among natural cappings.

Though often in relatively small quantities, or colonising particular areas of capping, ruderals and herbs greatly contributed to the visual interest of cappings, especially in mature cappings where a surprising number of different species could accumulate over time. When one species is very common on a cap, its flowers could be visually dominant, transforming the ruin's appearance.

On rural sites, lichen was frequently associated with mosses and could be significant in a similar manner. On old sites, the growth of lichen on masonry faces could be significant and this is described in Chapter 8. The presence of lichen often has visual appeal, though they can damage metals and some stone types through acidic depositions.

Fig. 3.39: St. Cormac's chapel, Eilean Mor, Argyll. Diversity of ruderals and herbs gives great visual interest.

Fig. 3.40: Gordon Castle Estate Wall, Moray (CS4). Mosses form a stable central cap, augmented by lichen, through which grasses rise thinly.

c) Mosses and Lichens

Mosses have the exceptional ability to prosper in very damp conditions and yet survive complete drying out. They do not have a formal root system and tend to create a uniform carpet. Unable to compete aggressively with other plants, they tend to thrive in places where other plants cannot survive, making them a useful specialist for stabilising soft cappings where there is not high wind exposure.

Mosses can contribute to the character of an historic building, but when growing thinly directly onto porous masonry substrates they can encourage frost related damage by inhibiting drying out.

Mosses were found fairly frequently on cappings. While they occurred as a general cover in the dampest locations, they are more commonly established in particular locations on a cap. Typically mosses formed a strip at the edge, where conditions were too extreme for other plants, tending to get very wet in high rainfall and very dry in periods of drought.

Zoning could also be vertical, with mosses existing as a general low mat, and taller plants growing through as a thin, higher layer. In mature cappings, moss growth could be quite thick, up to 100mm, though they were never strongly attached to the soil below and could be easily lifted up as a mat. They seemed suited to sites prone to drying out, but without high wind exposure or risk of abrasion from visitors.

Fig. 3.41: Hugh Miller's Cottage, Cromarty (CS20). Mosses form a thick mat, especially at the edges.

d) Ferns

Occasionally, ferns were recorded on cappings. While a number of the small ferns species may cause relatively superficial damage to the toppings, the larger ferns, Male, Broad Buckler, Lady and Bracken, once established are all capable of doing significant damage to masonry through root growth.

e) Sedums and Sempervivums.

Sedums are naturally adapted to grow on stone surfaces and are fairly commonly found on masonry, though their presence is not always welcomed in conservation publications:

> *Stonecrop….. are pleasant, but they usually indicate decay and poor maintenance. Indeed the presence of growth often indicates that the pointing has perished, in which case it should be renewed as soon as is feasible, incorporating a toxic agent in the mortar if plant growth is a constant nuisance.*
>
> *Feilden, Conservation of Historic Buildings (2004).*

Sedums are not, as suggested by Feilden, indicators of fabric decay, merely of environmental conditions. Frequently found naturally established on roofs, sedums have a succulent quality, which makes them tolerant of drought conditions. They have a fairly open texture and a loose shallow root system. These characteristics mean sedums suit conditions that are difficult for more aggressive species, principally dry edges and areas of shallow, free draining soil. On edges, the pendulous growth of some species can create an attractive effect.

Fig. 3.42: Sedum alba naturally established on a sandstone slate roof in Angus.

Fig. 3.43: Sedum alba stabilising a sloping edge at Cressford Castle, Roxburghshire (CS2).

Sedums spread by division and transfer by gravity, wind, birds and animals. This quality also makes them vulnerable to mechanical and wind damage, and potentially invasive of surrounding areas. There are three species native to Scotland, Biting Stonecrop (Sedum acre), White Stonecrop (Sedum album) and English Stonecrop (Sedum anglicum). Modern 'green roof' sedum mats, grown within a plastic mesh commonly also include other non-native sedum species.

Sedum acre is most abundant where the surrounding soils are base rich, while Sedum anglicum is less common and dislikes alkaline substrates.

Surprisingly, sedums were infrequently recorded in the case studies, though their considerable potential to stabilise edges has been exploited in Swedish soft cappings since the 1930s.

Fig. 3.44: Alvatsra Monastery, Sweden. Pieces of sedum have dropped from the main capping to colonise ledges below, naturally spreading to protect vulnerable masonry surfaces.

Fig. 3.45: Alvatsra Monastery, Sweden. The sedums finish well on complex edge shapes.

Fig. 3.46: Sempervivum, Monimail Tower, Fife (CS7).

Sempervivums have a succulent quality similar to sedums, but spread by offshoots. They can create very dense coverings, and were used historically in Sweden on urban 'green' roofs for their fireproof qualities. Their rate of growth is quite slow and they are shallow rooted and prone to be being picked out by blackbirds, who hunt for worms in the holes created. While this slow growth and vulnerability was demonstrated in the experimental planting of sempervivums for edge stabilisation at Monimail Tower, Fife (CS7), it is thought that they are likely to survive and create an increasingly stable edge.

f) Trees

Trees were reasonably frequently recorded in the case studies, though they were usually saplings, which commonly failed to thrive in the stress conditions that cappings present. Nonetheless, in some situations trees will grow to become a nuisance, and the largest single example recorded was over five metres tall (Fig.3).

3.3.3 Zonal Distribution

Local conditions for the support of plants within cappings vary considerably, as they are locally affected by the same factors that affect the capping as a whole. This effect can be seen in the distribution of species, with increasing specialisation and reduction of bio-diversity in the more stressful locations. These are mainly edges and significant slopes, especially those facing south. Many case studies demonstrated dominance, colonisation or absence of vegetation at edges, where stress conditions are focused. In mild locations, the change of condition was reflected in a change in sward height or thickness.

Species which were noted as locally dominating at edges included mosses, Ribwort Plantain (Plantago lanceolata) and Biting Stonecrop (Sedum acre).

Fig. 3.47: Coastal Defences, Moray, constructed c. 1941. A tree invades the capping vegetation, which fulfilled the same camouflage function as that painted on the walls. This exceptional tree is a direct result of the bountiful supply of pine cones, shade and shelter provided by the surrounding forest.

Fig. 3.48: Doune Castle Mill, Stirlingshire. Originally soft capped with commercial turf, dieback has allowed moss and lichen to colonise the sides, while trees invade the grass on top

Fig. 3.49: Bohus Fortress, Sweden. A designed soft cappings, with a central strip of grass, sedum edge, and later colonisation by moss.

3.3.4 Seeding

The inclusion of seeds within a capping soil gives it greater potential for successful establishment, particularly if it is foreseen that the initial turf may locally fail because of short-term factors. The retention and re-use of soils from natural cappings allows accumulated seeds to be retained, though they may include seeds of undesirable species.

One of the case studies (CS28) included two tests of a seeded soil cap, without turf, but given initial protection by hessian. These suffered significant initial soil erosion, but one was reasonably successful in the long-term. Seeded soil is unlikely to be a viable capping technique because of its initial vulnerability to wind erosion and colonisation by undesirable species. The seeding of soils beneath turf cappings could be appropriate in situations vulnerable to initial dieback, encouraging secondary growth within a dying root mat.

Fig. 3.50: The Nunnery, Iona, Argyll. Partially successful test of a grass-seeded soil capping.

3.3.5 Plug Plants and Cuttings

The use of plug plants, to selectively introduce species to alter the botanical balance of capping vegetation, can be useful where it is foreseen that a turf material may benefit from increased bio-diversity, for example at edges. In such circumstance, the turf provides temporary protection to the plug plants while they become established, allowing them to dominate it, as the turf gradually fails.

This technique was not recorded in any of the case studies but was noted in Sweden and has since been used experimentally in Scotland.

3.3.6 Provenance of Plants

Native plants are well adapted to the Scottish climate and soil types and therefore appropriate native species tend to establish easily as soft cappings, proving disease resistant and requiring little maintenance. Some non-native species would also prove suitable for Scottish conditions, but in considering nature conservation, bio-diversity and aesthetic suitability, there are good reasons to exclude non-native species as far as possible.

There is considerable regional and local variation in the distribution of species. The use of species found around the new capping site will generally enable the goals of local distinctiveness and sense of place to be met, by emulating and connecting with natural vegetation around a site. In this way, the natural distribution pattern of plant species and local ecology can be strengthened, contributing to local bio-diversity directly, but also indirectly through provision of food sources to dependent fauna. However, as soft cappings can present locally rare habitat conditions, a more regional basis for species selection may be necessary to achieve appropriate species.

The importance of local genetic identity in plant ecology is a subject of differing views and few established facts. However, acting on a conservative precautionary principle, it is prudent to obtain plants whose provenance is as close to the site as is practical in order to minimise disruption to local botanical gene pools.

These general principles support the local sourcing of turf and discourage the use of cultivated turf containing commercial cultivars, which might out compete, or genetically infect, local plants. The use of non-local species should be limited to specialist plants, such as sedums, which are found on natural cappings as locally rare species, and have a particularly useful role in capping design. The use of non-native plants should be carefully considered. It should be possible to collect local seed and plant materials or propagate suitable materials with a specialist horticultural company.

3.4 Soil Materials

Some amount of 'soil' is necessary to provide the plant layer with moisture and nutrients, though the amount of soil and its character was found to vary greatly.

The soil layer has a protective effect through thermal buffering and moisture absorption and dissipation. The degree to which protection is provided by the soil or plant layer varies greatly between the case studies. At Eilean Mor, Argyll (CS1), the effect of the soil was largely insignificant, whereas at Gordon Castle, Moray (CS4) it provided the main protection and the additional benefit of the vegetation was almost superficial.

There was a similarly large variation in the ability of the soil layer to resist decay. At Gordon Castle, Moray (CS4) and St. Kilda, Outer Hebrides (CS7) exposed soil showed great resilience, but at the Isle of May, Fife it rapidly eroded when exposed.

Under the influence of vernacular construction techniques, a common approach in new cappings has been the use of clay subsoils. The case studies demonstrate that this type of soil can prove both successful and unsuccessful, depending on climatic circumstances.

Fig. 3.51: St. Kilda, Outer Hebrides. Soil depths vary up to over one metre.

3.4.1 Soil Depth

A deep soil usually makes more nutrition and moisture available for plant growth than a shallow soil, but it can also allow more deeply rooting and less marginal species to become established. Deeper soils give more thermal and moisture protection to the substrate than shallow soils, though this cannot be taken as a direct correlation, due to the complex interactions of plant, soil and substrate layers with the environment. Shallower soils tend to dry out quicker and be less bio-diverse.

Soil depth increases through time by deposition of humus from the plant layer, windblown particles and from decay of the host structure. However soil depth can also decrease through water, wind and mechanical erosion. The deepest soils were over one metre thick, found on the cleitean of St. Kilda, Outer Hebrides (CS7), while the shallowest recorded were only ten to forty millimetres deep, naturally accumulated on Eilean Mor, Argyll (CS1). Both were supporting healthy plant layers in exposed situations, but the thicker cap was giving great thermal and moisture protection to the underlying structure, while the shallower soil was probably relying on some moisture storage from the host masonry to sustain its verdant cover.

While most new conservation cappings have a soil depth of 100mm to 200mm, there are instances where two layers of turf have been used without soil. In these situations, there is always some soil lifted with the turf and the lower layer gradually decomposes into soil, though the root system gives it good temporary structure.

Fig. 3.52: Eilean Mor, Argyll .The thin, rooty soil is only 10-40mm deep.

3.4.2 Soil Structure and Moisture

Conventionally, a well structured soil has vertical channels to facilitate movement of rainwater and is adequately open to allow good root penetration. These are rarely desirable characteristics in soft capping soils. In the case studies, the soils were usually poorly structured, though in markedly different ways.

Soils that were naturally established, such as Cessford Castle, Roxburghshire (CS2), were frequently very loose and unbound, being largely composed of desiccated plant matter and wind-blown particles. This type of soil could have a hygrophobic quality akin to peat, where the surface became an oily crust, while the soil at depth was very dry. Soils near the coast, such as Skara Brae, Orkney (CS10) and the Tentsmuir Icehouse, Fife (CS11), could contain a high proportion of sand and be very free draining.

Most modern Scottish cappings have used a soil layer of alluvial clay, tempered with sand to different degrees. The clay was often from the same source, a clay pit on the Carse of Gowrie near Errol. This tempered subsoil usually performed well in storing and releasing moisture, though it could fail in very wet or very dry environments. These soils tended to produce a very well bound, fine grained layer that was relatively difficult for roots to penetrate in order to access moisture and nutrients. This led to significant edge dieback in drier climates, such as at Aberuthven, Perthshire (CS38).

Where a large, coarse aggregate was included, as at Peebles Town Wall (CS31), root penetration was better, to the apparent benefit of the turf. Clay soils could suffer from excess moisture because of the slow rate at which it could be absorbed into the mass of clay. This especially affected the surface layer, and there was evidence that this could lead to a relatively thin plant cover (CS15).

While mortared masonry seemed to have a fairly neutral effect, dense substrates, such as concrete, or waterproof layers, such as proprietary damp proof membranes, had a negative effect on the vegetation, especially at the edges (CS26). This suggests that in times of drought soft caps are able to draw low levels of moisture from masonry, to mitigate the effect of solar radiation. Though they lack the cohesion of a relatively vapour permeable lime mortar, drystone masonry structures perform better than large concrete substrates in this regard, suggesting that there is still a low level of moisture flow between the cap and substrate, which enhances the durability of the cap without facilitating decay of the masonry.

One case study used a polymer additive to attempt to artificially increase moisture retention within the soil during an initial period, with the effect declining over ten years (CS28). There was some evidence that this was of benefit, but it is not seen as being significant.

Some contractors experienced in soft cappings and clay/turf ridges to thatched roofs, have increasingly come to the view that the vegetation layer is much more important than the soil layer, in a cap's overall performance. While evidence from the case studies supports this view, it is somewhat simplistic, with some examples illustrating the exact opposite.

3.4.3 Fertility

The types of natural grassland found on rocky outcrops, which soft cappings try to emulate, are generally associated with soils of low fertility. This reinforces the stress conditions that suitable plants are adapted to, inhibiting competition from some potentially damaging species.

There has been considerable work carried out in recent years on the restoration of natural grasslands, which has informed the understanding of such low fertility situations.

The case studies showed no clear evidence that lack of fertility had been a significant factor in the decay or failure of cappings. Several of the case studies, clearly had low levels of soil fertility. Nonetheless, in several instances, there had been attempts to manipulate the fertility of soils in order to alter the performance of cappings.

On St. Kilda, Outer Hebrides (CS7), the soil applied in repairs has used a mixture of re-cycled capping soil and sheep dung. Along with significant aftercare watering, this seems to have encouraged lush, but shallow-rooted turf that does not survive well in the long-term. This suggests that increasing soil fertility may be counterproductive in tempering stress conditions in the short-term. In recent repairs, the proportion of sheep dung has been reduced to no apparent ill effect.

At Eynhallow Monastery, Orkney (CS18), the soil used in repairs was a mixture of re-cycled capping soil and a commercial garden compost, intended as a slow-release fertiliser. There was no evidence that this had significantly affected the performance of the cappings.

At the Nunnery on Iona, Argyll (CS28), local topsoil had been mixed with well-composted seaweed to improve fertility. This may have improved growth, but may also have encouraged colonisation by undesirable species.

In all these cases, the possible benefits of altered fertility were much less significant than other factors, especially climate. These experiments were apparently the result of a perception that some observed failure was caused by fertility being gradually depleted over time by plant growth, though no testing had been undertaken to evaluate this theory.

At Vadstena Castle in Sweden, where medieval embrasures were being re-created, the soil used in cappings was tested for fertility after significant levels of grass failure. While the levels were below those specified, when additional fertiliser was added, there was no significant improvement in performance. The good performance of a grass strip in the shade of corner towers, suggests that moisture was the critical factor, not fertility, and this seems likely to be generally true.

Fig. 3.53: Vadstena Castle, Sweden. Increased soil fertility has not improved performance on a site prone to drought conditions. In contrast, shade provided by corner towers encourages the desired grass growth over sedum.

The types of plants appropriate for soft cappings are those that suit low fertility levels, as well as other stress conditions. Although clearly there are absolute limits, none of the case studies demonstrated that fertility was a significant issue, though no testing was undertaken to allow a conclusive evaluation.

The annual deposition onto cappings of humus from decaying plant matter, along with wind-borne particles and guano is thought to provide adequate levels of continuing fertility in most situations. At Varberg Fortress in Sweden, there has been concern that fertility levels of the soil were too high and experiments are being undertaken to reduce fertility by the removal of cut sward and burning of standing sward.

While the clay soils commonly used in new Scottish cappings are relatively nutrient rich, these nutrients can be difficult for plants to access because of the density of the clay. Recent experience has led some practitioners to reduce the richness of clay soils, thereby improving root penetration.

It is possible that soil fertility could be enhanced in a more targeted way, for example: by using phosphorus to promote root development. However, based on the results of this research, such manipulation would rarely be merited.

3.4.4 pH

In a manner similar to low fertility, there are benefits to having mildly acidic soils in creating stress conditions that are unattractive to undesirable competitive species.

Raised pH indirectly increases fertility, by increased microbial nitrogen mineralisation and availabilityof other nutrients, such as phosphorus. As pH approaches neutral (pH 7.0), an increasing number of plant species are able to grow in the soil. Lime and cement can both increase pH.

There was no deliberate attempt to manipulate pH in any of the case studies, though current practice in the Faroe Islands is to apply lime and fertiliser to turf before application on roofs, in order to increase fertility.

However, conditions that are too acidic also have disadvantages. Rainwater runoff and leached water from such soils can be acidic, especially if the rainwater is already acidic through atmospheric pollution. This can cause decay of masonry, particularly limestone. Theoretically, lime mortar or plaster could be similarly affected. While acidic runoff is a significant concern in England, it has not been in Scotland, largely due to the rarity of limestone in Scottish ruins

Although no testing has been carried out, it is thought that most of the case study capping soils will be naturally slightly acidic and that the pH did not significantly affect performance. The one case study where the soil was reported to contain lime mortar residue (CS26), did not appear to have significantly enhanced fertility or species diversity. There was no evidence of acidic runoff damaging masonry, though none of the Scottish case studies had limestone masonry.

3.4.5 Micorrhiza

There are thousands of different kinds of micorrhiza; fungi found in soil that have symbiotic relationships with particular plants. These can be of benefit in germination and plant development. Local and re-used cap soil will contain micorrhiza associated with the cap plants, but commercial soils and soils within commercially grown turf will not. However, the degree of benefit derived from the presence of micorrhiza in soft capping soils is currently unclear.

3.5 Technique

While there is limited diversity in current Scottish soft capping techniques, there are subtle differences in practice that are sometimes an intentional attempt to tune the capping to site conditions and sometimes a result of unavoidable circumstances.

3.5.1 Profile

The typical profile for wall cappings is an arched shape.

A high arch creates more difference between the conditions on the top, which is flat and has a thick layer of soil below, and the sides, which are at a steep incline. This shape also creates more climatic difference between one side and the other, if these are orientated north and south. Rainwater runoff will be greater, which may cause soil erosion, but inhibit saturation in wet situations. Wind exposure will be greater, however meeting the wall at ninety degrees gives good protection to cut edges of fresh turf.

Grass grows vertically, irrespective of slope, and can struggle to stabilise on very steep slopes. In exposed climatic conditions, such profiles frequently display a marked difference between lush growth on top and thin plant cover, or exposed earth, on the sides.

Fig. 3.54: Gordon Estate Walls, Moray. An old vernacular capping with a high arched profile giving steep sides.

A low arch creates more even conditions across the cap. More rainwater will be retained, with less side runoff and potential for soil erosion, though increased risk of saturation in wet situations. The amount of soil in the cap is less, reducing thermal and moisture buffering, though rarely significantly, and increasing the potential for drying out. The main problem with shallow profiles is that the edges become increasingly vulnerable to drying out and decay, due to the thin layer of soil beneath and high climatic exposure.

Fig. 3.55: St. Clement's Churchyard, Roghadal, Western Isles (CS37). This recent capping is flat, with no soil layer beneath the turf.

Vernacular and older conservation cappings seem to be taller, semicircular in many cases, while more recent ones are shallower, reducing their visual impact. Cappings in England and Sweden seem to be shallower again, amounting to flat caps with curved corners in some situations. Two examples of flat wall cap profiles were found in recent Scottish work (CS34 and 37) and both were where there was no formal soil layer, merely a thick turf with soily roots. Though in quite different climates, neither of these cappings had fared well.

In capping larger areas of masonry, a profile can be built up by using gravel, beneath a layer of soil, to ease installation and manipulate the soil layer's performance (CS 27).

3.5.2 Edge exposure

The edges of cappings are invariably where failure of the capping begins, with wall ends being especially vulnerable. Sometimes failure will stabilise, as species distribution adapts and the plants root in, binding the soil. Sometimes the edge of the vegetation stabilises at a high level, leaving soil exposed below on the sides, which may be sufficiently robust to endure without plant cover, or alternatively may progressively erode, leaving a top surface of living turf undermined, with roots exposed.

While the climatic context of a particular site is the most significant factor in this process, the initial period after the application of the capping is when the edge is at its most vulnerable. Before the turf has rooted into the soil layer, its roots can easily dry out under solar and wind exposure. If the sides are at a high angle, or if the soil is dense clay, rooting in is more difficult.

Fig. 3.56: Kinloss Abbey, Moray. Severe and progressive edge decay over an asphalt capped concrete cap.

If a cut end of turf is exposed, there is little defence against the onset of decay in sites that are not mild and sheltered. The cut ends of turf are protected if they meet the masonry at ninety degrees, or if the turf is tucked under, to form a double layer, with a rounded end, sometimes with earth sandwiched in the middle. If the turf edges are not well fixed, they can be lifted by the wind or by birds, damaging root establishment.

Fig. 3.57: Whitby Abbey, Yorkshire. The doubled-under edge turf has failed to root into the soil bed, leaving it vulnerable to wind lift.

3.5.3 Layering

Conservation caps in Scotland have often used two layers of turf, applied root to root across the full wallhead width and with staggered lateral joints. Single layers have also frequently been applied and occasionally, single layers with the ends tucked under to form a double layer along the edges. This latter technique is the standard practice in England.

The choice of layering often seems to depend on the quality of available turf, climatic conditions and the level of available aftercare. Two layers are meant to allow the top layer to root well in, while the lower layer slowly decomposes, while retaining some structural benefit. This is seen as being a more robust technique, suitable for exposed situations, even though rooting into the soil layer is impeded. The additional soil and root mass may also be of benefit where the turf is being laid directly onto relatively dense clay soil. Much depends on the quality of the turf, however, and on occasions a single layer of thick, rooty moorland turf has been preferred to two layers of commercial turf, which tends to be thin and have poorly developed root systems.

Fig. 3.58: Coupar Angus Abbey, Angus (CS14). A single multi-species layer of dense turf has remained stable while the species balance adapts to a new environment. Heather has died, but has left a strong structure for the growth of other species, mainly mosses and Sheep's Fescue.

3.5.4 Damp Proof Layers

Incorporating damp proof courses (dpc's) or damp proof membranes (dpm's) under soft cappings can have the benefit of ensuring a complete barrier to water penetration, should this be required to protect the host structure, or if there is little confidence that the soft capping will perform adequately or survive in the long-term. Slate courses are not considered dpc's under this definition. Dpc's can be metal, bitumen or plastic. Historically, coal tar was also used.

Fig. 3.59: Alvastra Monastery, Sweden. Sedums struggle to stabilise on a smooth, dark, impermeable membrane.

Fig. 3.60: Saddell Abbey, Argyll. The slate dpc has contributed to unstable edge conditions and visually detracts from the original masonry wallhead.

The possible disadvantages of dpc's are numerous. If they are laid immediately below the capping they can act as a slip plane on non-flat surfaces. They can concentrate moisture and drying, especially at the edges, as the soft capping loses the benefit of subtle moisture exchanges between substrate and cap. They can be visually intrusive, especially if the coverings subsequently fail. If the dpc's are incorporated into the masonry lower down, the historic fabric of the host structure can be significantly disturbed in trying to achieve this.

Dpc materials have poor sustainability characteristics, including high embodied carbon and toxicity. Lead and copper materials have a toxic effect on plants that is accumulative. Bitumen can include early stages of dioxin and is a potentially dangerous source of organic compound seepage. Coal tar had a high content of polycyclical aromatic hydrocarbons.

The acidic nature of some soils can attack metals and bitumen in dpc's, reducing their effective life. The alternatives of plastic materials are environmentally damaging in production to varying degrees and break down when exposed to ultraviolet radiation or significant changes in temperature. Differential thermal movement can also cause problems.

Damp proof layers were rarely found in the field research. One of the case studies, Melgund Castle, Angus (CS26), used a bitumen-coated lead dpc, covered by masonry and mortar below the capping. Failure of the soft capping, on steep slopes and at edges of flat areas, exposed the dpc and its shallow mortar coverings, which subsequently failed, causing further exposure. It is possible that the presence of the dpc contributed to edge stress in the soft capping and therefore the onset of this progressive decay process.

Fig. 3.61: Melgund Castle, Angus. Soft cappings fail over shallow masonry on bitumen-coated lead dpc's.

At Inverlochy Castle (CS21), soft caps were applied over old asphalt coated caps and proved successful in concealing them, except when pedestrian traffic wore away the soft cap (Fig. 3.63).

At the Wine Tower, Fraserburgh, Aberdeenshire (CS39) a bitumen asphalt membrane was laid below a soft capping as a replacement to a failed clay base layer. Though there has been significant edge dieback on the new cap, the delicate stone vault beneath has much greater protection. The lack of a slope was probably a significant factor in the failure of the clay to provide adequate waterproofing.

This circumstance, large, flat surfaces, especially with vaults beneath, of which Kinloss Abbey, Moray (CS24) is another example, is one of the few situations where the use of dpm's below soft cappings has proven beneficial. These cases are not complete successes however, and a proprietary bentonite clay membrane may be more effective in such situations if adequate depth of soil cover can be achieved.

Frequently, tall masonry structures receive large quantities of wind-blown rain on their faces, making attempts to provide a completely weatherproof capping futile.

Significant dampness was found in the sloping masonry surfaces at Eilean Mor, Argyll (CS1), which experiences high rainfall onto thin soil cappings. However, the application of a membrane to this type of structure would create a slip plane and change the environmental conditions of both the soft capping and host structure, probably to the detriment of both. Although damp, the current conditions on this monument are fairly stable. If intervention were merited, a clay layer could be considered.

There is no known use of dpc's below soft cappings in England. In Sweden, dpc's are almost always used, which relates less to the country's relatively low rainfall, than to their development of soft cappings from vernacular green roofing traditions using birch bark as a waterproof membrane. Metals, bitumen and plastics have been used beneath Swedish soft cappings and have frequently demonstrated problems of slip planes and focusing of thermal and moisture stress at the edges.

A noticeable toxic effect on vegetation was not recorded in any of the cases where dpc's were used.

3.5.5 Fixings

Fixings are necessary to hold turf to non-flat surfaces and where the wind or birds could lift turfs from the capping before they have rooted in. Fixings are therefore essentially a temporary form of initial protection.

One case study, Cessford Castle, Roxburghshire (CS2) demonstrated a different approach. Here, a polypropylene netting was laid over the caps and fixed to the masonry joints with stainless steel fixings. This was intended as permanent protection against falling masonry, enabling masonry consolidation to be limited to the edges and avoiding the need to disturb the central areas of naturally established capping. A consequence of such netting is that it will reduce the habitat value of the capping.

a) Pegs

Typically, timber pegs are used to fix the turf into the soil layer along the edges. Best practice is to set these at an angle to avoid creating routes for rainwater to penetrate deep into the capping.

b) Mesh

Fairly frequently, mesh is applied over the top of, and occasionally between, turf layers to restrain them against wind or animal disturbance. Natural mesh degrades as the sward establishes itself. Jute mesh is most frequently used, having a lifetime of about three years, though coir mesh has also been used, which has a lifetime of about seven years.

Plastic mesh has occasionally been used, and this is very long lasting. After several years this frequently becomes loose at the edges and proves unsightly. It can also entangle birds, causing individual death and loss of habitat value. There is no benefit of plastic materials over natural, biodegradable ones.

Fig. 3.62: Black Castle, Perthshire (CS13). Plastic mesh proved problematic in the long-term.

Mesh sizes varied in the case studies between 10mm and 100mm. This did not seem to significantly affect their performance. One report that a tight mesh size was a major contributory factor in the perceived failure of a capping (CS18) did not seem to be substantiated. Mesh is commonly laid beneath the capping on one side and draped over the completed cap, to be pegged at the other.

The widespread use of mesh in Scotland is a response to the importance of wind as a climatic factor. In England and Sweden mesh is rarely used, even though they have some sites of high wind exposure.

3.5.6 Aftercare

Aftercare was very limited in the case studies, mainly amounting to watering on a few sites, which was intended to retard the drying effects of climate on vulnerable newly laid turf. The degree to which this is beneficial varies with site conditions and time of year. Prolonged and unrestrained watering runs the risk of creating temporary conditions that are not stressful, promoting a shallow root system in the new turf and benign conditions, which favour the species within the turf that are less hardy in the long term.

The degree to which aftercare is possible depends on the site and contract conditions. Often soft cappings will be applied at the end of a programme of masonry repairs and shortly before the scaffold is removed and contractors leave, giving limited opportunity for watering to promote root establishment. On other occasions, the site may be at low level, but remote and unmanned.

Watering of new caps, and of natural caps that have been temporarily removed, can be an onerous task in summer conditions, especially where mains water supply is not available.

In general, the case studies showed that there was some benefit to watering, particularly immediately after application and during summer conditions. However, in at least one case, there was some suggestion that overly benign conditions had been created in the short term leading to a reduction in long-term performance (CS7).

Damage to commercially sourced turf rolls was noted where they were stored on site for some time prior to use, even though watered (CS36). This problem rarely affected locally cut turf, which was usually lifted immediately prior to use.

3.6 Humans, Animals and Birds

The activities of fauna are generally benign, indeed they often have an important role in sustaining eco-systems, particularly as a natural means of seed dispersal. However, when their activities are focused, fauna can be a significant contributory factor in decay of soft cappings.

3.6.1 Humans

Human activity rarely causes significant damage to soft cappings, but occasionally locally severe damage can result.

On heavily visited sites, where cappings are at low level, informal pedestrian activity can rapidly erode cappings, especially once routes become ‘established’. On one unmanned site, high level cappings had also been badly damaged by pedestrian traffic (CS21). Where cappings are within reach, inquiring hands and casual abrasion can cause significant damage to edges, which often have more vulnerable and slow growing species.

On more remote, unmanned sites, visitors climbing on masonry can damage capping materials, especially where these are sitting on complicated or uneven masonry surfaces.

Fig. 3.63: Inverlochy Castle, Invernessshire(CS21). Although these high level soft cappings have been damaged by visitors, they have effectively protected the masonry beneath.

One site (CS24) had been subjected to acts of vandalism, which included ripping up areas of soft capping.

Fig. 3.64: Kinloss Abbey, Moray (CS24). Vandal damage to soft cappings.

3.6.2 Animals

Small animals, insects and the like, help a mature ecology to develop on a capping. Larger animals only occasionally have an effect on cappings. This can be benign, but also sometimes damaging.

On St. Kilda, Outer Hebrides (CS7), Soay sheep like to graze on the turf roofs, as the quality of the grass is good and there are fewer parasites than at ground level as the sheep's dung rolls off the roofs. This has the secondary effect of increasing fertility around the base of the cleitean, locally increasing grass growth.

Sheep were historically excluded from many of the cleit areas, but this is no longer possible and the sheep are thought to be a contributory factor in the onset of capping decay. Their feet break the surface of the capping at the edge, facilitating the onset of erosion by other mechanisms.

Conversely, sheep can have beneficial effects in other circumstances. In comparing two ruined blackhouses at Dun Carloway, Lewis, Outer Hebrides (CS3), the one that is ungrazed has suffered considerable damage from the roof growth of colonised bracken, while the one that is grazed by sheep has a closely cropped grass capping, with few invasive species and only minor damage to the masonry caused by the sheep's feet.

One possible benefit is that a close cropped sward allows better interpretation of the underlying form of the masonry.

Fig. 3.65: Dun Carloway Blackhouse, Lewis, grazed by sheep.

Fig. 3.66: Dun Carloway Blackhouse, not grazed by sheep.

On balance, in this case, the sheep are a benign form of maintenance, encouraging a good root structure in the grass and removing undesirable species.

Grazing also has a more subtle effect on species diversity, by encouraging the growth of some grass species, normally the fescues, in preference to others. Although those effects of grazing reduce bio-diversity, they are also generally beneficial.

Grazing by rabbits was found to be a contributor to failure of low-level cappings on one island site (CS36), where a large rabbit population has unrestricted access.

3.6.3 Birds

Fig. 3.67: Black Castle, Perthshire. Birds overlook the surrounding fields.

Birds perform a useful role in seed distribution, but can occasionally be detrimental in a number of ways. On one island site that hosts a major seabird colony (CS36), birds, especially kittiwakes, removed pieces of freshly laid turf for use as nesting material and this is thought to have been a significant factor in failure of the cappings. It should be noted that these cappings did not have netting protection.

Soft capping sites can also present locally rare habitats for birds. At Cessford Castle, Roxburghshire (CS2) there was evidence of ground nesting birds making burrows in the natural cappings and of owls using the wallheads as a hunting base that provided a good view of the surrounding countryside. These caused no significant damage, but at Gylen Castle, Argyll (CS19), rock doves habitually sat on the new turf, trampling the grass and depositing faeces, which damaged the turf with toxic run off.

At Black Castle, Perthshire (CS13), the use of plastic netting to restrain new cappings inadvertently entangled birds as they landed or nested on the wallheads. Two dead birds were found entangled during the survey.

Fig. 3.68: Black Castle, Perthshire. Two birds died through entanglement in plastic mesh.

3.7 Practicalities

A variety of practical circumstances were found to affect the performance of a capping.

3.7.1 Season of Application

The season when soft cappings are applied can have a significant effect during the critical initial period when root establishment is taking place. The fact that the case studies recorded work undertaken from March through until December, demonstrates that the seasonal factors affecting construction quality often don't determine works programmes. These are more frequently determined by financial, logistical or site management considerations. On several sites a very narrow window for works was created by the proximity to protected ground nesting bird habitats and this impaired performance.

The period from April to August presents the least suitable time for capping, due to low rainfall and high solar radiation levels. Spring presents a suitable time for the application of cappings, but without aftercare the onset of summer leaves the new cappings vulnerable to drought conditions, before roots have become well established.

The period from September to December presents the best time for soft capping, with good levels of moisture and low solar radiation for four to six months after application. Red Fescue (Festuca Rubra), in particular, benefits from a period of autumn growth in such programmes. Good fixings should prevent damage due to high autumnal winds. There was no evidence of frost damage to new soft cappings.

The importance of seasonality varies between sites. In Argyll, the mild, damp conditions mean soft capping work can be undertaken at any time of the year. In the dry east, however, summer work would require lengthy aftercare.

3.7.2 Site Accessibility

Three of the conservation caps were in very remote locations where there were significant logistical difficulties affecting the works. Three case studies were on uninhabited islands that were SSSIs, two for ground nesting birds. While remote locations favour local sourcing of turf, several sites were of archaeological interest, which limited opportunities to disturb the ground surface. Remote locations frequently have high climatic exposure and limited potential for aftercare during the works. In some cases, even sourcing water is difficult.

On one of the two remote sites (CS36) where all materials had to be brought in by helicopter, the uplift from its rotors lifted turfs off the soft caps. On the same site, turf could not be cut from the site for habitat protection reasons and unpredictable weather conditions meant that the turf was cut on the mainland and brought to site some time before use. This resulted in a reduction of turf quality.

3.7.3 Effects of Other Works

Soft capping frequently accompanies lime mortar repairs and in two case studies protection for lime works from climatic exposure led to failure of soft cappings. Rain was prevented from falling on the caps and they were also shaded. However, in one exposed case, a similarly protected section of capping performed better than unprotected sections, due to the shelter afforded from winds.

3.7.4 Maintenance

Well designed and built soft cappings in benign conditions will effectively be self regulating, in that they do not present conditions where damaging plants will survive long enough to affect the fabric. In most situations, only occasional removal of tree saplings or ruderals will be necessary. In situations where there is a mild, sheltered climate and high local bio-diversity, more frequent intervention may be required. On highly visited sites, maintenance may be carried out for presentational reasons.

Few of the case studies had formal maintenance plans in place. On one site (CS30), which was very vulnerable to undesirable colonisation, a planned maintenance regime had not been implemented, leading to significant colonisation, though actual damage was slight.

Fig. 3.69: Skara Brae, Orkney. This site had the highest level of maintenance of the case studies. Edges that were difficult to cut were in the best condition.

Skara Brae, Orkney (CS10) is a World Heritage Site with very high summer visitor numbers and here the cappings were very frequently closely mown for presentational reasons. Under strongly drying climatic conditions, this level of maintenance demonstrably had a negative effect on the cappings.

Mown edges showed considerable dieback, as the short sward created little shade or wind shelter, increasing drought stresses and leading to significant, unattractive failure. Edges that were difficult to strim had taller growth, and a variety of wild flowers were able to flower, seed and thrive alongside the grass species. This created a denser sward and root mat, which kept these edges in good condition.

As a whole, these case studies demonstrated the importance of assessing the individual maintenance requirements of any particular capping during its design and subsequently monitoring and reviewing its performance.

Fig. 4.1: Vernacular soft capped drystone enclosure walls, Glen Lochy.

4. SOFT CAPPINGS AS ORIGINAL CONSTRUCTION

Recognition of the importance of turf and earth as traditional Scottish construction materials, in all geographical areas and in a diverse variety of forms, has increased in recent years through research, conservation projects and publications. For this report, relevant examples of traditional construction were examined to inform an understanding of the performance of the materials and identity relevant practical issues relating to their use in conservation.

With all these techniques, it is difficult to determine how representative a particular example is of traditional practice, but their technical diversity and long-term performance are informative and they remain valuable examples of Scotland's built heritage.

This review included techniques that can only now be assessed through documentary evidence. It excluded uses of turf and earth materials where they are not directly relevant to the stress conditions of soft cappings, for example the use of soil and turf embrasures and casemates in fortifications, such as at Fort George, Inverness-shire (Fig. 1.4), and the use of puddled clay and turf in Neolithic structures, such as Maes Howe, Orkney.

4.1 Survival and Recording

The surviving heritage of vernacular buildings constructed from these biodegradable materials in Scotland is small and not representative of their historical importance or diversity. This restricts how much can be understood about historically traditional techniques and the performance of their materials on built structures over long periods of time. The skills and knowledge base for using these vernacular techniques, and for conservation of related original fabric, is also very limited.

However, better rates of survival of vernacular structures and a greater continuity of living traditions exist in some comparable bio-regional countries, such as Sweden and Iceland, and this wider context has allowed a better informed assessment to be made.

4.1.1 Vulnerability to Decay

Biodegradable materials by their nature are vulnerable to decay over time. However, while earth and turf materials are vulnerable to climatic decay, colonisation by plants and mechanical damage by birds and animals, they do not easily change their fundamental qualities where they do survive. In this respect they are more likely to survive than most other organic materials, for example timber or thatch. Living plant structures endure better than dead plant structures. Where structures are of composite construction, the weakest material will have most effect on overall durability of the structure.

4.1.2 Cultural Context

While earth and turf were used as materials from the earliest period of human architectural endeavour in Scotland, in post-medieval times they came to be viewed as products of poverty and increasingly gained a cultural association with low status and transient buildings.

With changes in agricultural and land management practices, rural depopulation and the development of an industrialised construction industry, the use of earth and turf in building retreated to marginal applications. Perhaps surprisingly, some use of earth and turf in construction continues to this day, though the knowledge of the materials and skill in their use has been reduced to two narrow applications; turf capped drystone walls and turf ridges to thatched roofs.

4.1.3 Identification and Recording

There are several reasons why the position of earth and turf construction in the catalogue of recorded and protected structures in Scotland is not representative of its architectural heritage importance.

Where such materials do survive, they are often in ruinous or altered buildings. Ruinous earth and turf structures lack the visual appeal of ruinous masonry structures and are often less easy to identify. Even with knowledge and experience, it can be difficult to distinguish building remains from 'natural' landscape without archaeological investigation. These structures are sometimes overlooked because they are perceived as being culturally insignificant.

It is therefore important that, in using soft capping techniques in conservation, original historic fabric made from similar materials is not destroyed, overlooked or confused with modern repairs.

4.2 Enclosure Walls

4.2.1 Turf Enclosure Walls

Fig. 4.2: Remnants of turf field walls, Harris, Hebrides.

A variety of turf wall construction techniques existed historically in Scotland, as has been described elsewhere (Walker, 2003). While the surviving remnants of such walls are usually too badly decayed to give useful information, modern reconstructions at Culloden Battlefield, Inverness-shire, (CS6) and the Highland Folk Museum, Newtonmore, are relevant.

Fig. 4.3: Culloden, Inverness-shire (CS6). Reconstruction of an historic turf dyke.

Enclosure walls at Culloden, which existed during the battle in 1746, were rebuilt in accordance with historical records. These have proved durable, with adjacent potentially damaging species, such as nettles, failing to colonise. They proved vulnerable to damage from grazing cattle, but not from sheep. Grass grows healthily on the top of the turf wall, but not on the near-vertical faces, where the enduring root mass makes the wall effectively an earth/fibre block construction with a soft capping.

Fig. 4.4: Highland Folk Museum, Newtonmore. Composite turf and stone wall.

4.2.2 Drystone Masonry Enclosure Walls

The use of turf and turf/soil caps to drystone masonry walls survives as a contemporary regional construction technique within Scotland, as well as in Cornwall and Wales, and is documented in historic and contemporary sources. The regional distribution has been attributed to the lack of suitable coping stone in these areas (Brooks & Adcock, 2004).

While several Scottish techniques are described historically, only two techniques apparently survive in practice today, mainly in the Highlands and Borders.

a) Double Turf

In this technique, two layers of turf are laid on the wallhead, root to root. The lower turf provides a base for the upper turf to root into and prevents wet soil falling into the wall, where it could promote collapse of the masonry if subject to expansion by freezing. By the time the lower turf rots, the upper turf has become well established.

Turf, 75 to 100mm thick, with a good root stock is recommended, cut in a diamond section to prevent open joints on shrinkage, as can be seen in historic earth construction at Corse Croft, Huntly, Aberdeenshire and in Iceland. The turf should be laid across the wall, overhanging the edge by 25 to 50mm to allow for shrinkage.

b) Domed Turf

A turf, half the width of the wall, is laid root up over the centre heartening, followed by a second full width turf, root down, compacted over to form a dome with the cut edge butting against the edge of the top of the wall.

This technique has the advantages of not exposing cut turf edges and of requiring less turf. The preparation of foundations for original wall construction is likely to have yielded sufficient turf for such cappings.

Walker (1996, p.20) also describes three layers of turf as being a common specification.

Contemporary guidance (Brooks & Adcock, 2004) suggests that such cappings become acidic very quickly, due to the free drainage, though this may have more to do with the nature of the soils in the upland areas where such techniques tend to be used. Mosses and lichens are said to quickly replace the grass, which still functions, but is less strong. Fertiliser, chalk and lime are listed as possible additives to reduce acidity, while in coastal areas seaweed can be sandwiched between layers to promote long-term fertility.

Large stones are placed on the end turfs to prevent them becoming displaced, falling off or drying out, and sometimes these stones are carried along the wall to counter the activities of cattle and high winds. Historically, upstanding stones would have been used to support iron rails, for stock proofing and to prevent grazing, with sheep noted as a cause of rapid failure.

Sometimes a stone coverband was used below the turf to improve moisture retention in the turf, keep soil out of the wall, or as a precaution in case of the decay of the turf. There are also examples of another layer of turf instead of a stone coverband.

Vernacular examples of domed turf capping were assessed at Roghadal Churchyard, Harris (CS37), together with attempts at replication. Modern reconstructions can be seen at the Highland Folk Museum, Newtonmore and at Culloden Battlefield, Inverness-shire.

Fig. 4.5: Stones to counteract wind uplift, Roghadal Church, Harris (CS37).

Fig. 4.6: A domed turf capping, with wire fencing as stock proofing, Roghadal Church, Harris (CS37).

Fig. 4.7: Reconstruction at the Culloden Battlefield. The poor condition of the turf capping contrasts with that of the adjacent reconstructed turf wall, Fig 3.31, suggesting that the greater moisture retained by the turf was significant.

Two other examples at Roghadal, Harris (CS37) and West Linton, Peeblesshire, illustrate a different technique. While both examples were of sufficient age to obscure the finer detail of their original construction, both had a mound of soil beneath a turf cap. In the Roghadal example, this seemed to be a more durable technique than the pure turf cap, which was used in recent reconstruction.

Fig. 4.8: Turf and soil dome capping, near West Linton, Peebles-shire.

Fig. 4.10: Roghadal, Harris (CS5) Turf and soil dome capping.

Fig. 4.9: West Linton, Peeblesshire. Over time, there has been a significant decline of grass species and development of a thick moss mat.

Fig. 4.11: Roghadal, Harris (CS5). The turf soil is clearly lighter than the soil dome beneath. Note the deep root penetration.

4.2.3 Mortared Masonry Enclosure Walls

Similar soft capping techniques were historically applied to mortared masonry enclosure walls, whose mortar binder, whether clay or lime, was more vulnerable to moisture than drystone construction. Several fleeting documentary sources are given by Walker (2004), who suggests that turf cappings alone prove totally inadequate and that a layer of blue or other puddle clay is necessary to protect the masonry.

One successful vernacular example of such a capping occurs at Gordon Castle, Moray (CS4). A tall dome of clay mortar, with a turf cap, was applied on the head of several miles of boundary walls, thought to have been built originally with a clay mortar and lime pointing.

Fig. 4.12: Gordon Castle Estate, Moray (CS4). An extensive, mature and bio-diverse vernacular capping.

While the vegetation on this cap varies widely with the exposure and surrounding vegetation in different locations, the underlying clay mortar cap remains in good condition. Even where the steep sides will not support vegetation, there has been minimal decay of the clay earth dome, with the holes for timber fixing pegs still crisp, though the pegs themselves have long since vanished. The masonry beneath is in good condition, despite reportedly not having had maintenance for at least fifty years.

In this situation the vegetation is of secondary importance, with the main protection provided by the clay earth cope. The remarkable durability of this earth mortar is due to the particular clay type and grading of this local soil. This is clearly demonstrated in one location where visibly different clay has been used in a sheltered location, and suffered considerable erosion. Comparable results indicating variable durability of soils were found with materials assessed in Historic Scotland TCG's Earth Structures Renders and Plasters research project.

Fig. 4.13: Gordon Castle Estate (CS4). The holes from timber pegs, which held down the original turf layer, remain clear.

Fig. 4.14: Gordon Castle Estate (CS4). The original domed profile of the clay cap is revealed where there is no plant cover.

The regional or local character of these surviving vernacular techniques is illustrated by the fact that several relatively modern walls near the Gordon Estate, including one of concrete block, have been capped in a similar manner.

Fig. 4.15: Gordon Castle Estate (CS4). Where the clay changes to a red colour, it is much less durable.

Fig. 4.17: Modern turf walled building at the Highland Folk Museum, Newtonmore. The verdant face of the turf wall, compared to the dry turf and stone enclosure wall, is a result of rain shed from the roof onto the wall face.

4.3 Walls of Buildings

4.3.1 Turf Building Walls

There is considerable documentary evidence of the use of turf in the construction of walls of buildings in many geographical locations in Scotland into the 18th century and in isolated locations until the 20th century. In most of these examples the turf was intended to fully dry out and act as a fibre-reinforced earth masonry block. Nonetheless, some examples are relevant to soft capping.

Fig. 4.16: Sheiling, Ness, probably c. 1958. The post and wire fence suggests that sheep grazing of the roof, if not the wallhead, was not welcomed.

Sheilings constructed with balla cheap (Fig 4.16) had wallheads exposed in a similar manner to many Lewis Blackhouses (CS9). The turf would have been in a similar condition to the turf dykes at Culloden, except that on buildings they would have benefited from rainwater run-off from the roof.

This type of turf construction is thought to have been used for Blackhouse walls, prior to the introduction of drystone faces to earth cores. Comparison can be made with the living tradition of turf buildings in Iceland, where similar bio-regional climatic conditions and cultural traditions prevail.

Fig. 4.18: Turf wall construction continues in Iceland, as part of the same bio-regional tradition that existed in Scotland.

4.3.2 Stone Building Walls

The construction of soft caps on stone building walls seems to echo the different relationship to the substrate found in enclosure walls, in that a clay underlayer becomes important to protect the mortar binding the masonry. However, the surviving examples and archive images show a more complex design than the classic dome of clay mortar applied to the enclosure walls at Gordon Castle (CS4).

Fig. 4.19: Sheiling, Ness, c. 1958, The good condition of the thin turf covering to the stone wall suggests it may benefit from moisture retained in the earth wall core, as well as water received from the area of turf roof.

As documented by Walker & McGregor (1996), this construction relied on a thin layer of a specific type of blue clay, with an oily character, to waterproof the head of the thick walls, formed of two drystone faces and a vulnerable earth core. A thin layer of turf was laid over the clay to protect it from drying out in the sun and wind, except at valley gutters, where the turf would have grown into the thatch. The turf was turned up against the roof, under the thatch. This form of construction at the Arnol Blackhouse is described in detail in CS9.

Fig. 4.20: The Blackhouse, Arnol, Lewis (CS9). The low pitch of the wall cappings implies that much of the rainwater from the roof was not shed off. The profile of the building is testament to the power of the wind.

Fig. 4.21: The Blackhouse, Arnol, Lewis (CS9.) The valley gutter has clay, but not turf.

4.4 Thatch and Timber Roofs

The eminent biodegradability of structures combining timber, soil and turf has left little in the way of ancient physical examples or historic images, though the continuing tradition of turf ridges bears some examination.

4.4.1 Timber Roofs

Historical records describe a diverse range of combinations of timber and turf, though in little detail. Some historic images and continued traditions in Iceland and Scandinavia indicate the potential diversity of this vanished heritage.

Fig. 4.22: Cruck framed building, Inverness-shire, 1920s. Apparently a living heather turf over timber framing at steep pitch.

Fig. 4.23: Sheiling Lewis, dated 1958. The turf roofing has apparently continued to grow for some time.

It is reported that the clay layer invariably dries out and cracks and that waterproofing is primarily achieved by the turf layer alone. (J. Cox, thatcher, pers. comm.). This is reported in repairs to thatch roofs carried out in such climatically diverse locations as dry Collessie, Fife and wet Auchindrain, Argyll.

The clay is found useful in adhering the turf to the thatch, but selection of high quality turf, often with a heather or blueberry content and about 75mm thick, is more important for long-term durability than the presence of clay. This implies that sufficient moisture is retained within the thick rooty mass of the turf, despite its exposure to sun and wind, and that little reaches through to the clay layer, which lies on dry thatch.

Fig. 4.24: Seasonal hut of the Sami people, Sweden. The birch bark layer under the turf was a valuable resource and often re-used. Birch poles over the turf prevent wind damage to the turf.

4.4.2 Thatched Roofs

The use of puddled clay and turf capping as ridges on thatched roofs survives as a traditional Scottish technique. While there is some regional variation, typically a dome of tempered clay is applied to the ridge of a thatched roof and two layers of thick, coarse turf applied on top, root to root, with staggered joints. The clay used is typically a clay mortar rather than an oily blue clay.

Fig. 4.25: Cottown, Perthshire. A layer of clay being laid over the thatch ridge, to be covered with two layers of turf, root to root.

In Brittany, there is a tradition of planting thatched roof with living lilies, though no detailed information was found on this technique.

4.5 Stone, Brick and Concrete Roofs

The greater durability and perceived value of buildings with heavy roofs has left a larger number of physical examples and diversity of types of plant capping than exist on biodegradable roofs.

4.5.1 Stone Roofs

In Orkney, there is a continuing tradition of covering low-pitched, stone slabbed roofs with a single layer of turf over a thin layer of soil, reportedly sometimes restrained with ropes. In many locations, the climatic conditions, and in particular the severity of winds, mean that the cappings slowly erode and require periodic renewal.

The purpose of these cappings, which occur on all types of buildings, is to protect the underlying sandstone slabs from delamination, by reducing moisture ingress and flux, as well as exposure to frost. A similar covering of turf applied onto pantiled roofs, to prevent them being lifted by the wind as well as for draft proofing and insulation, is reported in Moray by Walker (2003).

Fig. 4.26: Dounby Click Mill, Orkney (CS7). Roof renewed c. 1980 in a relatively sheltered location.

Fig. 4.27: Eynhallow, Orkney. House abandoned c. 1851, in an exposed location.

The cleitean of St. Kilda (CS7) are another remarkable local tradition. Approximately 1430 cleitean survive in varying conditions, dating from prehistory to the early 20th century. The construction of these structures, which is not fully understood and has little historical record, comprises a mound of soil, varying in thickness from 200mm to 1m, with a turf covering, laid over a flat stone slabbed roof, sometimes mounded with smaller stones, bearing on drystone walls. Stones were often laid on top as a restraint against wind uplift.

Fig. 4.28: Cleitean, St. Kilda (CS7). The diversity of cappings is not well understood.

Fig. 4.29: Cleitean, St. Kilda (CS7). The soft cappings sit on a layer of small stones, over large stone slabs.

Fig. 4.30: Cleitean, St. Kilda (CS7). Progressive collapse of the masonry inevitably follows decay of the soft capping.

4.5.2 Icehouse Roofs

There are no surviving examples of the historic short-term turf ice stores constructed by fishermen in remote west coast locations. However, a variety of larger, permanent icehouses survive from the 18th and 19th centuries, and these demonstrate the unusual character and sophisticated design often employed on such economically important buildings.

Scottish icehouse construction used turf to a greater extent than elsewhere in the United Kingdom, perhaps reflecting greater vernacular use generally. Some of the less subterranean examples are relevant to soft capping design.

Fig. 4.31: Tugnet Icehouse, Moray, reputedly the largest icehouse in Britain.

Great efforts were made to exclude sunlight from icehouses, to the extent that trees could be planted on top to provide shade. Nonetheless, because of the physics of ice storage, considerable heat could build up within the chamber. There was therefore a desire to dissipate heat, as much as to insulate the contents. Similarly, although ice is a form of water, great efforts were made to keep it dry in order to impede melting. The function of soft cappings, which were often employed on such structures, was therefore to keep heat from the sun out of the building and prevent ingress of moisture.

While contemporaneous design guides recommended a variety of increasingly complex constructions, including the use of puddle clay, there has been little systematic investigation to determine to what extent these were actually employed in practice.

The case study example of an east coast fishery icehouse at Tentsmuir, Fife (CS11) has a soil and turf layer, about 300mm thick, over brick barrel vaults. The local soil is very sandy and free draining and yet seems to have been used without a puddle clay layer. This is a relatively dry location and the cold, dry interior of the building would suggest that the combination of roof shape and thick turf are adequate to exclude precipitation and solar heat.

Fig. 4.32: Icehouse, Tentsmuir, Fife (CS11), early 19th century. The ice storage room has a steeper vault than the preparation chamber, presumably to keep the interior drier.

4.5.3 Concrete Roofs

The use of soft cappings on concrete roofs is largely restricted to fortifications from the 20th century, where the purpose of the soft capping was principally to act as camouflage against aerial photography, as well as to give a degree of impact resistance in the event of attack.

Such structures having predominantly flat roofs, were hastily erected for short-term purposes and were often located in exposed, relatively dry, east coast locations. Consequently, the survival of soft cappings on these types of buildings is relatively poor. Recording and protection is also limited. However, a few isolated examples have retained significant amounts of soft capping and thus much of their original appearance.

This physical record provides useful information on the performance of soft cappings, usually in relatively difficult climatic conditions and on a dense substrate. They also provide a record for any future conservation or restoration work on this type of 20th century fortification.

Fig. 4.33: Gun Emplacement, Moray Costal Defences, constructed c. 1941.

4.6 Conservation of Vernacular Soft Cappings

The low cultural value commonly associated with soft capping materials and the vernacular buildings they survive on is compounded by their vulnerability to loss, but contrasts dramatically with the diversity and longevity of the building traditions that they represent. In the survey of vernacular techniques assessed for this report, structures that are recorded and protected were notably rare. This low level of recognition generally leads to poor levels of physical conservation. A number of notable isolated examples had been the subject of active conservation and indicate the potential for conservation in this field.

The apparent loss of all the turf sheilings recorded in photographs from the latter 20th century leaves Scotland without a known vernacular example of this important bio-regional type. Any substantial remains of such a structure could merit conservation. Better understanding of the traditions of these materials and, in particular, their regional, local or typological character, would facilitate the conservation of any surviving examples.

4.6.1 The Development of Conservation Techniques

While there were several examples of renewed or replicated vernacular soft cappings, only one example of a conservation intervention to conserve a soft capping was found in this assessment. The National Trust for Scotland has been pioneering the development of appropriate conservation techniques in their work on the cleitean of St. Kilda over the last six years (CS7). The limited success that these efforts have had to date demonstrates the complexity of factors affecting the work, as well as the lack of precedent or guidance to inform the development of appropriate and successful techniques.

Although the cleitean are unique structures, the factors affecting their conservation illustrate problems found more widely in the field:

- A lack of documentary evidence inhibits a full understanding of the original construction methods.
- The archaeological and natural heritage sensitivity of the site constrains local sourcing of soil and turf, while also preventing their import to the site.
- Climatic conditions and the island's remoteness limit the window for conservation activity to sub-optimal times of the year and preclude aftercare.
- The forms of construction are unique and the patterns of decay defy simple analysis.
- The rarity of the building type and heritage value of the site makes conservation important and curtails experimentation.

A more systematic approach to the development of appropriate conservation techniques, related to other vernacular typologies, could inform these works and conservation work at other sites throughout the country.

Fig. 5.1: St. Cormac's Chapel, Eilean Mor , Argyll (CS1), naturally established over around 200 years.

5. NATURALLY ESTABLISHED SOFT CAPPINGS

Fig. 5.2: Howmore Churchyard, South Uist. Amid a bio-diverse setting, only a limited number of relatively benign species have colonised the masonry.

It is rare to find a surface on our planet that is completely devoid of plants. Even natural rock faces attract the microflora of algae and lichen, while more complex stone surfaces naturally accrue a covering of plants and soil, especially in the benign bio-climatic conditions found in Scotland.

Thus it is inevitable that buildings become a canvas for natural flora. The way this flora develops, particularly as part of a process of ruination, can be aesthetically attractive and ecologically significant, but also retard the process of decay of the host structure.

5.1 The Process of Natural Establishment

The rate at which soil and vegetation naturally develops on built structures, their character and the effect that they have on the host structure, depend on three main factors: climate, local bio diversity and the condition of the host structure.

Although there are isolated places with severe climatic exposure where significant colonisation was found not to occur, generally in Scotland built structures will naturally become colonised by plants, though species diversity and speed of colonisation varies considerably.

5.1.1 Propagation

The principal source for seed is wind-blown material from the immediate vicinity. The ability of seed to travel on the wind varies between species, but distances of over 100m are very common and up to 100km possible in some conditions. Wind-borne seed species include grasses, as well as fern, moss and lichen spores.

Birds deposit seeds mainly from trees and shrubs with berries, such as elder, yew and bramble. Seeds that have an oily coating or structure known as elisome, such as Herb Robert, are a food source for ants, who can transported them up to 60m.

Such dispersal of seed by wind and animals is seasonal. Plants that spread by division, such as sedums, readily break off in small pieces that can be transported to new locations by gravity, wind or birds. This is not seasonal.

5.1.2 Soil Formation

Beyond the establishment of algae and lichen, colonisation of structures by 'higher order' plants depends on the accumulation of sufficient soil to allow germination and supply of nutrients. The quantity of soil that is necessary for this purpose can be small, as evidenced by the growth of grass in blocked gutters (Fig.5.3). Generally soil accumulation is a continual, slow process, ultimately controlled by wind erosion. Soil can accumulate on structures by several means.

Fig. 5.3: Grass established in a gutter, collecting deposited material and decayed plant matter.

The supply of minerals through the decomposition of material in the host structure, by processes of climatic decay, depends on exposure and the type of host material. Mortars decay to sand if the binder, often lime, leaches out, and this will mix with plant humus. Mortar decay can be accelerated by root systems aggressively developing into mortar joints. This usually only occurs in exposed masonry where seeds can establish into open joints. Established soft cappings tend to inhibit such rooting in by presenting a stable and continuous surface.

While every piece of masonry has a unique character for damaging colonisation, there are some common patterns. The process of rooting into cracks will generally occur more quickly with dense materials, where cracks can be caused by shrinkage and thermal movement. Cement mortared walls, for example, are thought to commonly support flowering plants after between forty and eighty years. Counter-intuitively, softer materials such as clay mortar, can be remarkably durable. One site displayed clay mortar, thought to have been exposed for more than 100 years, without significant decomposition and only local colonisation (CS 4).

Decomposing plant matter helps build the soil layer, and this can come both from the establishing community of vegetation on a structure itself and from neighbouring plants. Overhanging trees can have a major effect by depositing decaying leaves.

Solid wind-blown particles can accumulate to a significant degree, especially once foliage develops. However, wind-blown sand can also act to erode exposed soil, especially on coastal sites.

The influence of fauna on formation of soil, by their decomposition onto the structure or deposition of faeces, is minimal, though the burrowing of ants can be important for surface disturbance. The chemical content of bird guano tends to inhibit development of vegetation.

5.1.3 Deposition of Decaying Organic Fabric

The decomposition of organic materials from a building's fabric, typically from a collapsing roof, can be very effective in establishing a protective soil and vegetation layer before the wallhead masonry is exposed. Thatch, especially where it has a turf underlayer, is particularly effective (Fig. 5.4). The decomposition of timber elements is less significant, as these tend to rot away without providing a good host surface for colonisation.

It is unlikely that the seeds of plant materials forming original fabric will remain viable for more than two years after construction, but materials such as thatch and turf underlay provide an excellent surface for the capture of wind-blown seed. The species found in such situations therefore do not represent the species of the original material, which could be of conservation interest, rather they reflect the current local seed bank.

The process of decay of such structures can be protracted; allowing a mature capping to become established by the time the roof finally collapses.

Fig. 5.4: Decaying Blackhouse, Berneray. A decaying roof deposits composted thatch and turf underlay.

Fig. 5.5: Decaying Blackhouse, Howmore, South Uist. The process of deposition is complete. Note the lack of plants on the chimney head and window sill.

5.2 Characteristics of Surveyed Examples

The detailed information gathered in the case study assessments included several sites where there was a significant naturally established element, which bears some analysis.

5.2.1 Distribution

The site surveys recorded where significant natural cappings were found and how they related to new soft capping works, as follows:

1 site where the natural soft capping was consciously retained without intervention.

1 site where the natural soft capping was retained without intervention through benign neglect.

5 site where natural soft cappings were partially retained in situ.

2 site where natural soft cappings were removed and reinstated after repairs.

10 site where natural soft cappings were removed and replaced by new soft cappings.

While natural cappings were found in all geographical areas except St. Kilda and Orkney, they were found more often on remote, rural, infrequently visited and privately owned sites. These are the sites that had had little or no history of conservation intervention.

5.2.2 Host Structure

Surface incline, shape, size, smoothness and exposure were the determining characteristics. The best-developed natural cappings were found on broad areas of relatively flat masonry surfaces. Narrow, steep gables only supported natural cappings in sheltered, mild locations.

5.2.3 Climatic Influence

The climatic factors that affect the natural establishment of soft cappings are essentially similar to those that determine the viability of new soft cappings, described in 3.1. While climatic variation can have a great effect on the rate at which soft cappings will naturally establish and their character, severity of wind was the only factor found to have prevented the process entirely. This occurred on St. Kilda and Orkney. Elsewhere, conditions were found to be generally favourable.

5.2.4 Bio-diversity

The survey found a large variation in the amount of species diversity in the natural cappings. Although the cappings were often very exposed to wind and therefore to collecting dispersed seed, they also tended to be in remote locations with relatively low diversity of plants. The number of species recorded in Table 4 primarily relates to climate and location, and perhaps more significant is the number of species recorded that are not found in the sites immediate environs.

This record suggests that the age of the cappings can be significant in two respects. Natural cappings may act as a refuge for species that have disappeared from an area due to changing land management practices and climatic conditions. In addition, over a long time, the undisturbed and unusual conditions presented by natural cappings may prove favourable to colonisation by relatively rare species.

Case Study	Capping Age	Soil Depth	Species Recorded on capping	Ones not Recorded nearby
Eilean Mor	**~200 years?**	**10-40mm on slopes**	**11**	**7**
Melgund Castle	**~ 300 years?**	**<300mm**	**10**	**7**
Ardkinglas Mill	**~ 150 years?**	**~120mm?**	**25**	**11**
Black Castle	**~ 500 years**	**~350mm?**	**19**	**15**
Gylen Castle	**~360 years**			
Nunnery, Iona. Area 2	**~ 330 years**	**~200mm?**	**3**	**1**
Cessford Castle	**~ 365 years**	**<450mm**	**18**	**14**

Table 4: Age, Thickness Species Diversity of Natural Cappings

It should be noted that some plants may have colonised the host structure before its deterioration, indeed the process of colonisation can be said to begin as soon as a structure is completed.

5.2.5 Soil Characteristics

Significant variation was found in the quantity and quality of naturally accumulated soils on sites over 150 years old.

The depth of accumulated soil varied from only 10-40mm on an exposed 200 year old forty-five degree roof (CS1), to approximately 600mm on the flat top of a vault, overhung by trees (CS7). The evidence suggests that soil depth directly relates to incline, area and wind exposure, with 1mm per year being a very rough average rate of accumulation.

Accumulated soils tended to have poor structure and low fertility, making them vulnerable to wind erosion. In exposed situations, this seems to be linked to a content of desiccated plant material and sand. A high proportion of desiccated plant material appeared to give the soil a hygrophobic quality. Where conditions were sheltered and damp, and the host structure was low, deposition of organic material from neighbouring trees could occur, therefore the soil was richer and had better structure (CS27).

5.2.6 Effect on Host Structure

The natural soft cappings generally appeared to have had a beneficial effect on the host structure, reflecting laboratory test results showing the moderation of thermal swings and reduction in the penetration of precipitation into the masonry (English Heritage, 2002).

The field assessments indicated that they could also help stabilise loose core masonry through the establishment of a fine root matrix or soil encapsulation.

Shrubs and other plants with potentially damaging taproots were found in natural cappings only on very mild and sheltered sites where such plants existed in the immediate vicinity (CS23 and CS30). Trees were more commonly found, though these were more often rooted into fissures in the masonry than into substantive natural cappings. This suggests that the deposition of seeds by birds occurred beneath where they perched, or nested in more sheltered nooks, rather than the more open areas where cappings developed.

5.2.7 Suitability for Re-use

In four cases, areas of natural capping were retained, where their condition and that of the underlying masonry was assessed as stable. In at least one case, this was with the specific intention that they would act as a seed bank for the adjacent less bio-diverse new cappings, applied over repaired masonry (CS13).

Fig. 5.6: Black Castle, Perthshire (CS13) Central section of natural capping retained as a seed reservoir.

In three cases natural caps were removed, carefully maintained and subsequently reinstated after the masonry was repaired (CS13, 19 and 30). Such natural turf appeared often to be more suited to wallhead climatic conditions than turf cut from nearby ground. It also had a richness of plants, invertebrates and seeds not found in commercial turf.

However, it should be noted that re-use of naturally established vegetation is not always beneficial or practical. Natural cappings may contain plants that are not desirable and which are difficult to separate. Natural vegetation may be difficult to remove from complex masonry in re-usable sections. Space and facilities to store and maintain the cappings may be difficult to achieve on building sites.

Fig. 5.7: Drumin Castle, Moray. Plants removed from the walls before the repairs were reinstated, with biodegradable mesh as a temporary fixing.

Fig. 6.1: Kilmory Chapel, Argyll (CS23), soft capping in progress.

6. SOFT CAPPINGS IN CONSERVATION

The purpose of this report is to assess the potential of soft capping techniques to assist in the conservation of historic structures. This chapter examines specific issues affecting such practice.

6.1 Assessment and Retention of Natural Cappings

There is logic in extending the principle of 'preserve as found' to vegetation that has become naturally established on historic structures, where it is assessed as having natural heritage or ecological value. A separate assessment of the degree to which such vegetation retards or accelerates decay of the host structure should consider the individual circumstance of the monument, as well as local variations of vegetation and host within it.

In making these assessments, a judgement needs to be made of the stability of the established capping against the potential for improved performance from intervention.

6.1.1 Full Removal of Natural Cappings

To date, the common approach in soft capping historic masonry structures has usually been to entirely remove any natural cappings, fully consolidate the masonry structure and install new soft cappings with a different structure and material from the natural ones. This is a high degree of intervention, which gives full access to the masonry for inspection and repair, but loses the botanical and aesthetic value of the original plant caps.

6.1.2 Re-use of Natural Cappings

Several of the case studies retained the removed vegetation, and less commonly the soil, for re-use in the new cappings (CS13, 19 and 30). Such an approach retains the value of the original material and allows full repairs, but can require considerable effort to maintain the vegetation in good condition.

6.1.3 Selective Removal of Natural Cappings

Two other case studies made only localised interventions to remove natural cappings, consolidate masonry and apply new cappings, following a careful assessment of the wallhead condition (CS2 and 13).

Commonly, physical investigation found the masonry required some mortar consolidation, but that the core was sound. The wallhead edges were therefore stripped and repaired, with the natural cap retained as a central strip. This approach has the benefit of minimising intervention, which is targeted at the areas where masonry is unstable or actively decaying. It also retains the benefits of the natural cap, which acts as a reservoir for plants, seeds and invertebrates to colonise the new caps.

Fig. 6.2: Cessford Castle, Roxburghshire (CS2). Masonry repairs were only required at the edges.

In removing vegetation, which has become naturally established on a masonry ruin over a long period of time, an established balance can be disturbed. The climatic exposure of the masonry can be significantly increased, especially exposure to wind-driven rain and thermal flux. In some situations, this will accelerate decay of the masonry, which in turn may subsequently require a higher level of conservation intervention.

Selective removal of damaging species and low-level management of the vegetation should always be considered in such situations. If full removal is proposed, an assessment of how this will modify decay mechanisms should be made.

Fig. 6.3: St. Mary's Church, Banff, prior to intervention.

Fig. 6.4: St. Mary's Church, Banff, after removal of vegetation: fabric decay accelerated.

Fig. 6.5: St. Mary's Church, Banff, after full restoration.

6.2 The Development of the Technique in Scotland

The case studies demonstrate that soft cappings have been used in Scotland as a conservation technique on masonry ruins since before 1924 and that it was a technique applied to northern monuments, such as brochs and Eynhallow Monastery (CS18), in the early decades after monuments began to come into state care. It is possible that the early soft capping work to Eynhallow Monastery was carried out by the English Arts & Crafts architect, W.R. Lethaby in 1897. However, although it has not been possible to trace records, the balance of evidence is that soft capping was widely used in this region by the Ministry of Works in initial works to consolidate and present ruins after they came into state guardianship.

The earliest recorded British guidance that the author identified is contained in 'Notes on the Repair of Ancient Buildings', published by the Society for the Preservation of Ancient Buildings (SPAB) in 1903, which states that: 'in protecting the tops of walls an effort must be made to do it in such as way as not to be an eyesore. This can be done in most cases by clearing the top of the wall of rubbish, and covering it with a layer of ashes and gas-tar or other water-proof material; this may then be covered with earth and turf, so that the walls may be green at the top, and yet the roots of trees and the like will be unable to penetrate them.' (SPAB, 1903, p.71).

The approaches advocated by SPAB are known to have heavily influenced early state conservation practice, but there also seems to have been some influence of local, traditional soft capping techniques in Orkney and the Hebrides, which survived in use until those times. In more southern areas outside this influence, rough racking and hard capping seem to have dominated practice during this period.

The more widespread use of soft cappings since the mid 1990s has been based on an increasing awareness of the deficiencies of hard capping techniques. It has also been influenced by the development of knowledge and technique in the conservation of vernacular earth structures. The revived traditions of earth construction, especially the use of tempered clay mortars, has influenced the development of soft capping technique in Scotland in a way that is akin to how the use of dpc's in Sweden reflects the vernacular use of birch bark waterproofing layers.

The development of technique has also been influenced by conservation principles such as minimal intervention, the desire to achieve low maintenance solutions in remote locations, practical construction constraints and personal intuition. This has led to a degree of individual experimentation as well as to some prescriptive standardisation of soft capping design.

There has been very little scientific design or evaluation of the techniques used, in a way that would be comparable to the methodical approaches brought into the conservation use of other materials, such as stone or mortar. This is probably primarily due to the absence of any methodical recording, analysis or detailed technical guidance on the subject.

In recent years, there has been some change in opinion among practitioners over the relative importance of the soil and vegetation layers in soft cappings. This has moved away from considering that a clay soil layer was most important, with the turf layer's main role being to protect the clay from drying out, towards the view that a high quality turf layer is more important as the first line of defence, with the clay layer's role being mainly to sustain the vegetation.

Analysis of the case studies found a complexity of relationship and individual circumstance to the performance of soft cappings that defies simple prescriptive solutions. However, a guiding methodological framework for designing, specifying and programming soft capping works could be created that would optimise the designed performance of an individual cap across a range of weighted criteria.

This would include assessments of:

- Historic fabric condition
- Climatic patterns
- Technical and botanical context
- Maintenance plans.

Preliminary guidance on good soft capping practice is given in Appendix A.

6.3 Materials Sourcing

The re-use of existing cappings should be the first option considered and this is discussed in 6.2.7 and 7.1.

6.3.1 Using Local Turf

The use of locally sourced turf has the benefit of containing local genetic material and plants that are adapted to the general climate, though conditions on the host structure may vary significantly from the source area. It also means that turf can be cut shortly before use, minimising the potential for roots to dry out.

On five of the case study sites, it was possible to visit the locations where the turf had been lifted and regeneration rates seemed to be good within two years, with no discernable long-term damage apparent.

There can be limitations placed on local sourcing on turf because of ecological or archaeological interest, which can affect the quality of the turf. On Pabbaigh (CS33), a scheduled monument and site of archaeological interest, the turf was lifted from an area that had been cultivated historically, as it was agreed that shallow excavation in this area would not disturb any archaeology. The result was that the turf came from an area of improved soil where a different mix of grasses prospered compared to the rest of the island, with Lolium perenne unusually dominant. This may have meant it was less-hardy in the capping stress conditions.

Similarly in St. Kilda (CS7), a World Heritage Site, practice has sometimes been to lift turf from immediately around the cleitean, because of the archaeological sensitivity of the island and the prohibition of importing plants to the island. The turf here is often highly fertilised by the droppings of sheep that graze on the grass cleitean roofs, and this may make it less suitable for soft cappings than other turf on the island.

6.3.2 Using Commercial Turf

The use of commercially produced turf has been fairly common in recent soft cappings, proving a quick and simple source. This type of turf tends to be thin and more vulnerable to drying out than a thicker local turf. Low in diversity, the grass species tend to be improved cultivars, which are not well adapted to local conditions and may pollute the local botanical gene pool. Commercial turf also tends to be grown in fairly sterile conditions, with few invertebrates, or micorrhiza.

For these reasons, commercial turf is generally regarded as of inferior quality for soft cappings and is used only for expediency. In mild conditions, such as Peebles Town Wall (CS31) it can perform well, though giving a very uniform appearance, but it is more likely to fail in stressful situations.

6.4 Skills and Information

A detailed assessment of the natural heritage and ecological value of a monument's vegetation requires surveying skills rarely found within the architectural conservation community. SNH is the natural partner to assist in such evaluations and local liaison on the maintenance of monuments within SSSI's is already routine in many cases.

The development of local relationships between Historic Scotland and Scottish Natural Heritage personnel could be mutually beneficial and lead to a progressive development of soft capping techniques responsive to local ecologies, built heritage and climatic conditions.

The soft cappings carried out in the case studies were generally undertaken by masons involved in stonework conservation. Though more practised in the removal of vegetation, their skills and knowledge seemed quite adequate for the tasks of cutting turf and installation of caps.

Two case studies used voluntary labour (CS7 and 34). Though usually adequate, this is less satisfactory as the consistency of work quality and thoroughness of aftercare can vary significantly.

6.5 Legal Context

There are a number of laws and regulations that may affect work that changes the natural ecology of a site.

6.5.1 Scheduled Monument Consent

The Ancient Monuments and Archaeological Areas Act 1979 protects scheduled sites from damage and requires written consent for works which disturb or alter the monument. The sensitivity of plants within the site depends on the nature and circumstance of the monument, but removal of turf from the ground and removal of plants from the masonry may require such consent. Structures where the vegetation is ancient or formed part of the original construction will be especially sensitive. Specific guidance should be sought from HS before disturbing existing, or adding new plants to scheduled areas.

6.5.2 Listed Building Consent

The Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997 gives protection to listed buildings, requiring consent for works which affect the character of a building or its setting. Again, much depends on the nature and circumstance of the site, but alteration to plants on or near a building may come under this legislation and advice should be sought from Local Authority Planning and Conservation Officers, or Historic Scotland.

6.5.3 Designed Landscapes

Landscapes designated under the Inventory of Gardens and Designed Landscapes in Scotland (1988) are afforded statutory protection and works may require consent. Historic Scotland or Scottish Natural Heritage can advise on individual cases.

6.5.4 Natural Heritage Protection

There is a range of legislation that might apply to work on sites designated for their natural heritage, notably SSSI. Non-designated sites may also have protected plant species, which should be identified by an early botanical survey.

The disturbance of protected fauna and their habitats can occur as a result of work to masonry, especially where there are well-established existing cappings and advice should be sought from SNH.

All public bodies have a responsibility to promote bio-diversity under the Scottish Bio-diversity Strategy and local bio-diversity strategies can be a useful reference in some cases.

6.6 Health and Safety

Site work involving soft capping techniques generally presents a low level of hazard, often lower than that associated with comparative hard capping techniques.

The research for this project did not record any health and safety incidents relating to soft capping techniques. However, a number of relevant issues did emerge.

Specific issues relating to soft capping work that should be considered as part of risk assessments and method statements in any project's Health and Safety Plan include:

- **Dust**
  Removing established natural cappings, and handling new turf that has dried out, may create dust, which could affect the eyes, skin or respiratory system. Such dust should not present the same level of hazard as masonry dust, whose silica content is linked to silicosis. However, the dust may contain lime, masonry or more complex organic particles. Normal measures to control the affects of dust, including masks, should give adequate protection.
- **Working at height**
  Soft cappings are often undertaken at heights that present a hazard of falling. Normal safety practices in regard to working practices, including scaffolding and reaching over wallheads, should be adequate. Special care should be taken if vegetation is being stored on the scaffolding before application, including any watering equipment.
- **Lifting heavy materials**
  Soil and vegetation can present a significant weight, requiring mechanical means of lifting. Any loads of loose materials should be adequately secured.

- **Manual handling**
  Soil and plant materials can present heavy or cumbersome loads. Loads should be limited to those within the Manual Handing Regulation (25kg). Routes should be kept free of obstacles, with knees bent and backs straight.
- **Storage of materials**
  Materials, especially living plants, may require unusual storage conditions, including watering. These should avoid presenting a hazard by restricting movement routes on site, or creating slippery surfaces.
- **Protection of general public**
  Soft capping materials have an initial instability, which reduces as the plants become rooted into the soil. During this period, there is a risk of materials being blown or knocked off, if they are not adequately secured. This risk is heightened if the plants fail to root in and temporary restraints loosen. Periodic inspections of the structure after the work should identify any such risk.

Fig. 7.1: Mature conservation cappings. St. Nickolai's Church, Zerbst, Germany.

7. EXPERIENCE IN OTHER COUNTRIES

The particular range of climatic, built heritage and cultural circumstances found in Scotland overlaps with those of other countries and considering these experiences from abroad informs the context of Scottish practice.

In several other countries in north-west Europe, soft cappings are used as a conservation technique for masonry structures, while some others have relevant experience from vernacular construction. In some countries soft cappings have been a long-standing technique, while in others it is relatively new. In all of the countries with which contact was made, there was an active and increasing interest in the development and application of these techniques.

Experiences in these countries demonstrate a wider range in soft capping performance due to climatic variation than is found in Scotland, but there are also significant cultural differences in the way techniques have developed and are being applied, which relate to different building traditions and aesthetic attitudes. All of these factors could influence the understanding and development of practice in Scotland.

Fig. 7.2: The Alvastra Monastery, Sweden, a good example of the picturesque achievements of contemporary soft capping.

7.1 Sweden

Sweden has a long-standing interest in the conservation applications of soft cappings, in the context of a drier climate and distinct construction traditions and cultural values. The results bear interesting comparison with work in Scotland. While similar traditions and differences exist in other Scandinavian countries such as Denmark, they are most clearly demonstrated in Sweden.

The main, populous southern half of Sweden is at a latitude comparable with Scotland, though the climate is significantly different, being under more continental influence, characterised by colder winters, hotter summers, lower overall rainfall and longer periods of drought. There is also significant climatic variation across the country, with the west coast being milder and wetter than the east. With less cloud cover, solar radiation is higher and orientation becomes increasingly influential to the east.

In common with other northern latitude countries in Europe, including Scotland, Sweden has a vernacular tradition of using both living and dead turf in construction. The main form this takes is as soft toppings on timber roofs of 10-15 degree pitch.

The traditional use of birch bark as a waterproofing membrane has apparently influenced the development of soft capping techniques, which have commonly been laid over damp-proof membranes of different types, including lead, copper, asphalt, rubber and plastic. These membranes largely remove the waterproofing function of the soft caps, though they still retain important thermal and rainfall dissipation functions.

Fig. 7.3: National Building Museum, Stockholm. Within Sweden, vernacular roof cappings have little regional variation.

Twelve regional examples of historic buildings with living roofs, dating from the 18th and 19th centuries, are preserved in the national building museum in Stockholm, together with an example of a seasonal Sami turf hut.

A variety of modern underlying membranes and turf sources have been experimented with in the conservation of these buildings during the 20th century. None proved successful and contemporary conservation practice has returned to the traditional methods of laying blocks of living turf, about 100mm thick, over multiple layers of birch bark.

Although there is good building clay available in Sweden, the widespread availability of timber dominated vernacular construction techniques. The single example of the use of a puddled clay layer beneath a turf roof found in this research was unrepresentative and the only use of clay in contemporary soft cappings is with proprietary bentonite membranes, the results of which are unclear.

The inheritance of traditional knowledge in sourcing suitable turf is also apparent. The most detailed current guidance is to use turf from natural, grazed, south facing slopes. The orientation and slope improves the turf's ability to withstand sunlight and dry soil. Grazing creates short and durable vegetation, the right kind of thin compacted grass. Long, lush grass by comparison will dry quickly, the roots will die and be unable to retain the soil (Pers. Comm. Stina Wedman).

Fig. 7.4: National Building Museum, Stockholm. Grass and sedum over birch bark.

There was a tradition, indeed a legal obligation in urban areas, of plug planting sempervivum into turf roofs. Succulent sempervivum were recognised as having good fireproofing qualities compared to grass which, being less drought tolerant, could prove a fire hazard in summer conditions. Modern cappings have focused on the use of sedums in combination with grass, with some success.

Swedish cappings show a wide range of bio-diversity levels. Many have very low species diversity, but some are also very high. This reflects the fact that there is relatively little consideration of ecological issues in the design of cappings.

The development of modern soft cappings in Sweden has been primarily influenced by aesthetic considerations. A range of projects demonstrates a desire to conceal failing hard caps, to convey a 'natural' picturesque aesthetic and to reinstate the original appearance of fortifications. There has been little comparative research or formal guidance.

The west coast presents the mildest climatic conditions, with an annual rainfall of around 700mm, comparable with the east coast of Scotland. A series of coastal fortresses have used soft cappings on ruined masonry and in the restoration of historic fortifications.

Fig. 7.5: Bohus Fortress, west Sweden, soft cappings on ruined masonry.

Fig. 7.6: Carlsten Fortress, west Sweden, recreated embrasures.

One of these, the Bohus Fortress, displays the typical historical progression of Swedish capping techniques. Between 1898 and 1925, the ruined walls were capped with concrete. Thermal movement cracks through the masonry associated with these hard caps can still be seen. As a result, practice changed and between 1925 and 1955, guidance on ruins was that *'a continuous layer of mortar should under no circumstances cover the wallhead as such a measure eventually will crack. … the wallhead should preferably be coated with a thick layer of asphalt or be covered with a thick clay layer. In both cases there must be a fall for the run off of water. Finally the wallhead is covered, where suitable, with a double layer of grass turf with the pieces placed root to root so that they will grow together…. (Sven Brandel, 1926).*

The double layer of turf replicated traditional roofing practice, aimed at producing a large root mat without a heavy weight of soil. This new technique was 'more ensuring and durable than the concrete earlier used' (Gothenburg Trades Magazine, 27.7.26).

Recommended grass species for fortifications with only a thin soil cover included Agrostis stolonifers, Poa pratensis, Festuca ovina tenufolia and Trifolium repens. Lolium perenne was also recommended, as it would help to quickly establish a turf, before dying (Claes Grill, fortifications officer, Gothenburg, 1901).

Evidence from a number of sites suggests that this grass technique would have suffered significant edge dieback, especially on south-facing sides. From the 1930s, sedum was experimentally planted into the turf, with the conclusion in 1954 that Sedum spurinum 'binds the earth and the water so that the soil is neither rained nor blown off' (Adolf Tell 7.8.54). Sedum has subsequently been widely planted, particularly on wall edges, at Bohus and other monuments.

Between 1966 and 1990, new synthetic materials came on the market and many caps were renewed with mesh reinforced concrete, covered with two layers of mineral felt/ aluminium foil, covered with a layer of gravel in warm asphalt, covered with two layers of 150mm turf, root to root. Today these methods are felt to have been rather brutal and hydraulic lime mortar is used in repairs.

Fig. 7.7: Bohus Fortress, west Sweden, wallhead soft cappings over bitumen membranes.

Fig. 7.8: Bohus Fortress, west Sweden, east facing walls. The soft cap achieves a stable edge, but the species clearly indicate this a modern conservation capping, rather than a natural or vernacular cap.

The legacy of these historic techniques can be read on the walls of Bohus. Recent investigations have shown that although the underlying 1930s bitumen coating has deteriorated badly, the soil covering was largely dry and no intervention was required. The more recent asphalt and aluminium foil membranes have deteriorated badly where exposed at edges, and the underlying concrete can also be seen as a result.

The sedum-edged turf caps are generally successful, though southern solar and local wind exposure, as well as the impermeable, smooth membranes do contribute to local failure. Although there is some native Sedum acre, the main species, Sedum spurium, is introduced. The well-defined edge fringe this produces on the walls does not seem quite natural, but their pendulous character does successfully conceal the edges of the concrete cappings.

Fig. 7.9: Bohus Fortress. The edge is well defined, while concealing the hard cap.

A similar sequence of techniques is demonstrated at many historic sites, but with local variations and experimentation, in both technique and management regimes. At another west Sweden site, Varberg Fortress, the historic time-consuming practice of cutting grass with scythes was replaced by the simpler method of burning. This led to erosion problems and increased rabbit populations. As a result, in 1995 cutting was reinstated. This has led to a denser sward, though botanists have recorded the decline of one particular species, which is nationally unique to these western fortresses, as a result of the change in management practice.

Fig. 7.10: The Alvastra Monastery, central Sweden.

The ruined Alvastra Monastery in central Sweden has one of the most aesthetically successful applications of sedum cappings. Very well established, the sedums successfully colonise isolated ledges and provide sufficient cuttings for ongoing repairs and new cappings. However, their dominance is more than was intended and attempts to increase the ability of grass to compete have been unsuccessful. The site also demonstrates the problems of using smooth rubber or plastic membranes.

Fig. 7.11: The Alvastra Monaster, nave detail

At Vadstena Castle, an attempt was made to reinstate the appearance of original turf embrasures with soil and turf thin coverings over the concrete roof of a new building containing national archives.

Fig. 7.12: Vadstena Castle, central Sweden.

The 500mm thick cappings at 45 degrees used proprietary sedum and grass mats over a low fertility, reinforced soil. The dominance of grass on the horizontal tops contrasts with the dominance of patchy sedums and wildflowers on the slopes. The unsatisfactory failure to replicate the original grass-dominant appearance is probably due to the inability of roots to access sufficient moisture. This is apparently due to the combination of a thin soil and the dry summer climate, with a fine reinforcement membrane perhaps also inhibiting deep root penetration.

Although on an island, Visby has the most continental climate of the visited sites, being located off Sweden's east coast. Annual rainfall is around 500mm and there are often long dry periods. In 2009, there was little rain at all between April and August. This World Heritage Site has a number of large ruined medieval churches nestled within a currently prosperous walled city, where a well-developed public appreciation of ruin aesthetics finds varied expression.

Although turf was widely used in cappings in Visby through the 20th century, and is more prominent on monuments in rural Gotland, recent work in Visby has focused on the use of specially grown sedum mats on thin soils over membranes. These have been generally successful, though conditions are locally too dry even for sedums. It is accepted that the purpose of these cappings is essentially aesthetic, to cover earlier concrete and asphalt caps, and some edges have been carefully designed to be seen from below as a green fringe.

It is perhaps surprising that the use of membranes in Sweden is so persistent, despite relatively low rainfall, and that the thermal blanketing effects of soft cappings have not had a more prominent role in a climate with greater thermal extremes than are found in the UK. The use of membranes can be understood as a legacy from vernacular construction and, beyond that, aesthetic considerations seem to be dominant in soft capping design.

This is exemplified in the approach to St. Olof's Church, where no conservation intervention has taken place, in contrast to all the other churches in Visby. At St. Olof's, secluded in the setting of a botanical garden, nature has been given free reign and the resulting verdant cloak is highly valued.

The experience of soft cappings in Sweden suggests that the use of sedums could be developed to stabilise edges in vulnerable Scottish sites, especially on the drier east side of the country. These Swedish sites would provide useful precedent for work to adapt the technique and optimise performance in Scottish climatic and cultural conditions.

7.2 England

Fig. 7.13: Kirkham Priory, Yorkshire.

We are increasingly trying to show the way in which buildings change over the years. Periods of use, alteration and adaptation, and even of disuse and dilapidation are as much a part of the history of the monument as its initial design and construction.

English Heritage, Annual Report 1986-7.

The climatic conditions in England are generally favourable to soft capping, though the south-east has a more challenging climate. Rainfall patterns are generally more focused than in Scotland, with less average annual rainfall and longer periods of drought, but also more severe and frequent thunderstorms. Solar radiation is significantly stronger towards the south-east, with the result that orientation has more influence on cappings.

While English and Scottish approaches to conservation philosophy are very close, cultural influences are slightly different, with a stronger romantic tradition in England. This has a particular association with ecclesiastical ruins dating from the Reformation, as well as with neo-classical monuments. In this cultural context, the picturesque appeal of vegetation on masonry ruins has been recorded in a wide variety of artistic media and academic forums from the 17th century to the present day.

In a context of no relevant vernacular traditions and little use in private practice, the use of soft cappings in England has been pioneered by English Heritage in a small number of conservation projects over the last ten years. This has happened amid increasing concern over the decay and maintenance of ruins that were hard capped earlier in the 20th century.

This technical and financial concern has been accompanied by a reassessment by English Heritage of their approach to landscape and the presentation of monuments:

There has … been a dramatic shift away from a narrow definition of the historic site itself, in favour of a much wider interpretation casting it in the context of the broader landscape and socio-economic environment of the time. Partly as a result, the early twentieth-century aesthetic of the clipped and trimmed landscape is no longer viewed as always the most appropriate or pleasing setting for historic properties, while advances in conservation science have shown that this approach is frequently not the best way to ensure the physical preservation of the fabric.

Anna Keay, Director of Properties Presentation, English Heritage, 2005.

Fig. 7.14: Wigmore Castle, Herefordshire.

Fig. 7.15: Wigmore Castle, Herefordshire, the archetypal wilderness ruin.

The clearest example of new approaches to the conservation and presentation of monuments came with the transfer of Wigmore Castle, Herefordshire, to state care in 1995 as a ‘proper ruin, undamaged by earlier intervention, and important in the public perception as a romantic ruin’ (Coppack, 2002). No archaeological excavations were carried out and the fabric remains were carefully preserved in their wilderness setting, with subtle access improvements and a gentle maintenance regime established.

This approach recognised the potential to reduce the monument's cultural significance through more robust intervention techniques.

> *When the ruin that was neglected and let go is put into a state of preservation and tidied up, we do actually lose something that is irreplaceable, and that is the vivid presentment of the ravages of Time. We may also lose certain artistic values, which used to belong to the ruin when it formed the keynote of a wild setting.*
>
> *Edmund Vale, Ancient England: A Review of Monuments and Remains in Public Care and Ownership, 1941.*

The extensive soft capping work carried out during these repairs achieved high ecological standards and good levels of technical success. The extensive natural caps were carefully removed, with loose soil bagged and vegetation kept alive during storage on the scaffold, watered by dedicated drip pipes. Soil and vegetation were both subsequently reinstated into their original locations on the repaired masonry.

The re-use of capping soil ensured that invertebrates and seeds were not lost, though this would also have retained seeds of species that were undesirable. Undesirable plants were selectively removed, though this was less extensive than is common practice with, for example, wild roses being retained.

Overall, the project was highly successful in conserving the masonry remains, the individual character of the site and its ecological habitat value. A methodical approach was an important factor in this success, with detailed discussion and planning among a multi-disciplinary team that included ecologists from an early stage, as well as close liaison with the local community.

While the approach at Wigmore Castle stands as a rather isolated example of best practice in exceptional circumstances, it does reflect a broader change in conservation culture.

Fig. 7.16: Wigmore Castle, Herefordshire. Very few species were selectively removed, although the site has a fairly aggressive botanical context.

Fig. 7.17: Wigmore Castle, Herefordshire. The ruin emerges amid ancient woodland, that was itself undisturbed for hundreds of years.

Fig. 7.18: Wigmore Castle, Herefordshire. While ivy was removed, other wall face plants were not.

The apparent success of this, and other lower profile projects, has not stimulated widespread use of soft capping techniques in English conservation. However, it has been followed by a formal assessment by English Heritage of the technical benefits of thermal blanketing and rainwater regulation given by soft cappings, in a series of laboratory experiments and field tests on prominent monuments.

Fig. 7.19: Whitby Abbey, Yorkshire, experimental capping to test the effect of high winds.

Fig. 7.20: Whitby Abbey, Yorkshire, edge dieback is severe.

Fig. 7.21: The species seem different in naturally colonised sheltered locations.

These trials of soft cappings on English Heritage monuments focus closely on their use to inhibit masonry decay associated with hard cappings applied during the 20th century to monuments in state care. The trials have commonly used British Standard loam soils and turf cut from within the monument site. There has been no use of clay in cappings in England and fixings are generally light, if they are used at all. New cappings typically use a single layer of turf, folded under at the sides to give a double layer, thereby avoiding exposed cut edges. Dpc's and defining layers are not used.

The trial cappings show some variation in performance relating to microclimate. The most stressful test site is at Whitby Abbey, an exposed location on the east coast, subject to salt spray in an otherwise relatively dry location. Here, there has been considerable edge dieback and some damage by wind uplift.

Climatic conditions seem more favourable in milder southwest sites, such as Hailes Abbey, Gloucestershire, compared to the eastern sites, such as Rievaulx in Yorkshire, though there are other, more complex, differences between the tests, which make such comparative analysis over simplistic.

Fig. 7.22: Hailes Abbey, Gloucestershire. tests show good lush growth, but some failure of small sections.

Fig. 7.23: Kirkham Priory, Yorkshire. The species seem different in naturally colonised sheltered locations.

Fig. 7.24: Byland Abbey, Yorkshire. The managed cappings contrast uneasily with the close mown lawns.

Fig. 7.25: Rievaulx Abbey, Yorkshire. Failure of turf on relatively sheltered sills, though rainwater penetration and run-off may still be reduced.

Fig. 7.26: St. Nicolai's Church. Zerbst, Germany.

7.3 Germany

The capping of St. Nicolai's Church in Zerbst, undertaken in 2002, is the only significant project identified in Germany. The approach was developed by Architect, Professor Dr. Klaus Kreuziger and Engineer Marco Dittwe. This followed studies of soft capping conservation techniques in Scotland, rather than being a development of indigenous vernacular techniques or a response to naturally established caps. Nonetheless, there seems to have been some technical influence from the sophisticated clay building and green roofing sectors that currently exist in Germany.

There is a traditional technique of creating a wallhead trough to contain plants for aesthetic effect, but this is recognised as not protecting the masonry and is not relevant to St. Nicolai's Church project.

The continental climatic conditions at inland Zerbst, located some 300km south of the Baltic and 1200km east of the Atlantic, are tempered by the influence of the nearby River Elbe. Peak solar exposure levels are comparable with Scotland, though they last about twice as long, reflecting summer temperatures that are higher and periods without rainfall in recent years of up to six weeks. Annual precipitation, at about 500mm, is lower than both Scotland and Sweden, though more evenly distributed throughout the year.

The church has been roofless since 1945, with level wallheads 18.5m above ground level. Some vegetation had naturally established on the wallheads over a sixty-year period (Fig 7.30) and this gave an incomplete plant cover, with significant areas of exposed and loose stonework. The natural vegetation was largely removed during preliminary work stages, though some seeds were recovered from these plants and subsequently sown into the cappings.

A stepped central section was built in brick and lime mortar onto the wallhead masonry to reduce the bulk of soil and act as a moisture reservoir. Over this, clay was applied in a shallow domed profile, with a lower layer of 3:1, coarse sand : clay, and a leaner upper layer of 6:1, fine sand : clay. This was covered and allowed to dry for between three and four weeks, during which time fine cracks appeared.

Fig. 7.27: St. Nicolai's Church. Brick profiles, intended to store moisture.

Fig. 7.28: St. Nicolai's Church. Turf rolled over carefully prepared clay caps.

Fig. 7.29: St. Nicolai's Church. Hessian protecting the finished capping.

Vegetation mats of five species of drought resistant grasses and three species of herbs obtained from a local horticultural supplier, were applied on top and watered for two weeks by hand. The plants were grown in a geotextile fabric, 0.5m x 2m, to give strength during transportation and installation. The fabric will biodegrade after a few years. Coir netting was applied on top for wind protection.

The cappings were applied in early autumn to allow some root growth before winter and it was found that good root bonding into the clay had occurred within two weeks.

It was anticipated that there would be some variation in success between the different planted species and some natural colonisation by other species, which would cause their appearance to mature with increasing complexity. Initially, the cappings suffered significant dieback on the south faces, due to solar radiation. There has also been considerable local damage caused by pigeons. However, there has since been some recovery and colonisation and, three years after application, the general performance was very good (Fig. 7.32).

Fig. 7.30: St. Nicolai's Church. The natural vegetation did not give a stable wallhead.

Fig. 7.31: St. Nicolai's Church. Initial dieback was locally severe.

Fig. 7.32: St. Nicolai's Church. After three years the wallhead was stable and attractive.

This project highlights the potential of species diversity to overcome initial dieback and create a naturalistic appearance. The success of this high level capping, exposed to strong drought conditions could inform practice on drier Scottish sites, such as Aberuthven (CS38), which have proved challenging.

7.4 Other Countries

There is some relevant experience in most other countries across the north-west fringe of Europe, though information available at the time of writing this report was limited.

7.4.1 Denmark

Experience in Denmark has many similarities to that in Sweden, though there is perhaps a greater masonry heritage, including many brick and fewer stone ruins than Scotland.

There has been less use of soft capping techniques than in Sweden, though there are one or two notable and documented projects.

7.4.2 Faroe Islands

The use of turf roofs is a widespread living tradition in the Faroes, which follows the Scandinavian model of low pitches and underlying membranes, traditionally birch bark.

Damp conditions mean there is no seasonality to such work, with little experience of failure. Turf is usually mown and treated with lime before cutting for use.

7.4.3 Iceland

Iceland has an ongoing vernacular tradition of using living turf as cappings to turf walls as well as roofs over timber structures. Failure is rare, helped by the mass of material beneath. Although Iceland has relatively moderate rainfall, cold temperatures and low humidity help avoid damp conditions developing.

Fig. 7.33: Traditional parallel ranges with turf over timber structures and turf cross-walls.

Fig. 7.34: New capping and turf wall.

7.4.4 Poland

There are reports of soft cappings being used in conservation projects in Poland, but no specific information has been found.

7.4.5 Ireland

There has been soft capping works in Eire, which would be interesting to correlate to the Scottish experience, but limited information on this was found during research.

Fig. 8.1: Howmore Kirkyard, South Uist. Lichen colonising a ruined wall.

8. A NOTE ON GREEN WALLS

The steepest pitch at which soft cappings were found to have been successfully applied was around 60 degrees (CS23). This is closer to being a vertical surface than a horizontal one.

There is no reason, in principle, to assume that vertical masonry surfaces could not benefit from the same thermal buffering and moisture inhibiting effects that vegetation commonly gives to horizontal ones. An assessment of the potential for such 'green walling' shows that exactly the same issues pertain as apply to soft capping, though plant species vary, different technical approaches are required and aesthetic considerations become more important.

The removal of mural vegetation from monuments is a standard procedure of long standing, based on the premise that climbing plants, especially ivy, cause damage by rooting into masonry, while also obscuring the monument.

However, there has been some recognition of the potential protective benefits of plants on walls:

> *Some kinds of wall climbing plants do not damage masonry directly but must none the less be kept away from the eaves and gutters to avoid blockages. These include Ampelopsis veitchii, a form of Boston ivy with small ovate or trifoliated leaves, which is often incorrectly referred to as a Virginia creeper; Hydrangea petiolaris, a climbing hydrangea; and Hedera canariensis, Canary Island ivy. The last is evergreen and can be grown over unburnt brickwork that is decaying due to frost as a form of protection.*
>
> *Feilden, 2004*

English Heritage have recognised that the removal of ivy from some monuments has accelerated masonry decay, by increasing the climatic exposure of the wall faces (pers. comm. A. Cathersidea). Examples include Wigmore Castle and Fountains Abbey. A similar consequence has been noted in Sweden.

There is no doubt that climbing plants can cause damage to masonry walls in certain circumstances. They can root into decayed mortar and stone. Their growth can also add a significant load to masonry structures. However, there are many examples where attempts at complete ivy removal have been unsuccessful, triggering exactly the decay mechanism that was being targeted. If the lower stems are cut, removing plants' source of ground moisture, tendrils of climbing plants will seek out moisture by growing into the masonry. Even if a substantial amount of the plant subsequently dies and is removed, such rooted-in tendrils may be impossible to remove without considerable disturbance of the masonry. Systemic poisons must be comprehensively applied in such circumstances.

As with wallhead vegetation, it is prudent to undertake a careful assessment of the benefits and disadvantages of all individual mural plants, to inform a targeted programme of intervention and long-term maintenance, which sensibly might include some retention of vegetation.

In only one case study (CS 28) was there evidence of deliberate retention of plants growing on the faces of walls. These were small plants, which were recognised as being an important part of the character of the place.

The romantic associations of mural vegetation have long been recorded, especially in England. These have been echoed in the designed green walls used in a number of recent high profile new buildings. These have been a logical development of the increasing use of green roofs in new buildings, especially in urban areas, to reduce heat gain, improve air quality and enhance bio-diversity.

Fig. 8.2: St. Olof's Church, Visby, Sweden. The ruin is utterly cloaked in ivy, an enigmatic form in the botanical gardens.

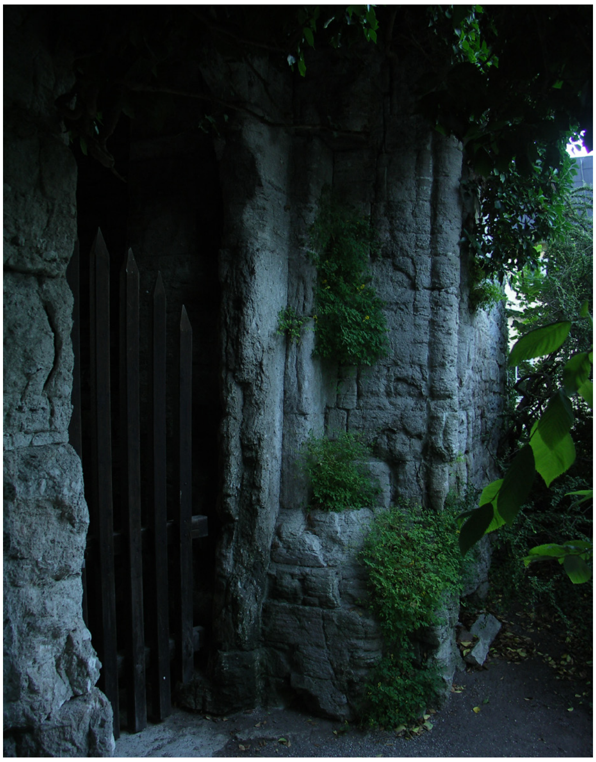

Fig. 8.3: St. Olof's Church, Visby. Entrance is carefully preserved.

Fig. 8.4: St. Olof's Church, Visby. The verdant veil has a picturesque appeal prized by local people.

Fig. 8.5: St. Olof's Church, Visby. The ivy stems grip the masonry, causing local damage.

Plant species suitable for growing vertically tend to differ from wallhead species and their growth can be more difficult to control without intervention. Nonetheless, there can be environmental gains as well as aesthetic and conservation benefits. In particular, the flowers of ivy are among the last to supply nectar, and their berries are an important early season food for birds.

The only significant example of green walling noted in the case studies, is of dense lichen growth, possibly the result of around 2000 years growth on a broch in Lewis (CS17). As well as indicating the age of the monument, the lichen, by growing in the open joints, may help to stabilise the structure.

Fig. 8.6: Dun Carloway Broch, Lewis. Lichen growth is focused on the south side.

Fig. 8.7 Dun Carloway Broch, Lewis. Lichen growth grows densely from the open joints

The practice of green walling is in its infancy, with no known examples of applications as a conservation technique, as opposed to the deliberate retention of naturally established plants for their aesthetic and protective benefits, of which there are several examples.

It is reasonable to assume that some use of green walling in conservation could develop, especially in the context of a more pluralistic approach to the presentation of monuments. However, it is important that any development of green walling techniques in conservation, follows detailed case-specific technical and environmental assessments, rather than simply being proposed on an aesthetic basis.

It has been suggested that techniques of training plants up stainless steel wires or onto frames might be used, where plants might damage the masonry:

> *The architect may well come into conflict with a client who is a keen gardener and puts the life of his plants before the maintenance of his building, or the architect may himself think the building looks better covered up. In such cases it is good practice to insert galvanised vine eyes and use stainless steel straining wires. Alternatively, the plants can be grown on frames; an advantage of this is that when superficial maintenance of the walls is required the frame can be unfixed and the plants bent forward intact on the frames.*
>
> *Feilden, 2004*

If an appropriate methodology is developed, there is potential for green walling to develop as a minor and more specialised partner to soft capping in the armoury of conservation techniques.

Fig. 9.1: Melgund Castle, Angus (CS26), where the role of vegetation in a restoration project was well considered.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

Soft capping is demonstrably a viable conservation technique that can offer masonry a significant degree of protection from climate-led decay in many common Scottish circumstances. As a reversible and low maintenance technique with low environmental impact, it has obvious attractions in countries, like Scotland, which have a substantial heritage of climatically exposed masonry ruins.

9.1.1 An Increasingly Complex Context

In tune with wider progress towards sustainable construction practices, soft capping also sits comfortably within an increasingly pluralistic approach to the presentation of ruins. While inhibiting the uncontrolled natural colonisation by plants, soft cappings mimic the natural progress of a structure as a ruin, marking the passage of time and visually linking it to its setting.

Soft capping techniques highlight the concepts of botanical heritage and the ecology of ruins, bringing recognition of the common ground between the sister disciplines of architectural and nature conservation and fostering inter-disciplinary links, to the benefit of both.

This increasingly rich context in which nature co-exists with built heritage should bring greater sophistication to decisions over whether soft cappings are appropriate or desirable to a particular situation. A greater understanding of the technical benefits and limitations of the technique is the other key requirement to ensuring it is used appropriately.

9.1.2 A Growing Technical Understanding

This report is a milestone in the understanding of the issues that affect the performance of soft cappings in Scotland. Cappings were found to perform well in many circumstances, reducing the decay caused to masonry by moisture and thermal flux. However, some cappings fail and some situations call for very carefully designed caps. There is clearly scope to improve the design and performance of soft cappings by better detailing, sourcing of materials and understanding of climatic and botanical contexts.

Further research and experimentation could significantly broaden the diversity of potential soft capping techniques and the range of host structures on which they can suitably be applied. One area where technical development could focus is the dry stress conditions typically leading to failure on east coast sites. The experience of using sedums in Sweden is relevant in this context.

9.1.3 Characteristics of Existing Sites

This research has highlighted the low public profile of historic structures that used plants and soil as part of their original construction. The conservation of these structures has close parallels with the use of plants and soil to protect standing masonry, though the technical issues are often more complex. There is a need to develop appropriate techniques to protect such structures, which are often isolated and important examples of their type.

Although naturally-established mural vegetation is increasingly recognised for its aesthetic, ecological and conservation value, there are no established standard procedures for its recording or evaluation.

Lack of a coherent holistic approach to mural and landscape vegetation often disturbs the visual balance of larger sites.

9.1.4 Aesthetic Effect of New Cappings

The natural debate over where soft cappings are and are not aesthetically appropriate has been constrained by limited variation in soft capping techniques.

While most new soft cappings aim at producing a naturalistic effect, low species diversity often leads to little visual complexity or ecological value.

In developing better methodologies for soft capping and extending their applications, it is important that there is a heightened awareness and consideration of their aesthetic impact. Special consideration should be given to avoiding original turf construction being mistaken as a soft capping conservation intervention and for clarity on sites where there are complete wallheads as well as fragmented masonry.

9.1.5 The Basis for Guidance

Useful guidance is unlikely to be in the form of a prescriptive set of recommendations. Rather more desirable would be detailed technical information on a range of possible approaches and a methodical system for assessing their appropriateness in the individual circumstances of any potential site.

This approach recognises that there is considerable variety in the physical circumstances of the masonry structures that might benefit from these techniques, and that their climatic, aesthetic and ecological contexts also vary significantly. A holistic, performance-based approach is therefore most likely to promote best practice.

9.2 Recommendations

1. Promoting Best Practice.

The guidance given in Appendix A of this report should be promoted within Scotland. This will allow HS to respond systematically to requests for advice and in considering approaches to property in care. In complex cases, more specific advice should be sought from consultants with relevant expertise.

2. Recognising Natural Heritage.

Methodical recording of mural vegetation should be promoted as part of standard best practice in the surveying of historic sites, with procedures established for circumstances that require more specialist botanical survey. SNH, and other local nature conservation groups, could be key partners in this area and local relationships should be fostered between the building and nature conservation communities.

3. Improving and Developing Techniques.

Further research is needed to develop soft capping techniques that are appropriate and successful in a wider range of masonry circumstances and climatic conditions. Countering edge dieback from wind exposure is a key target, especially on sites with high solar radiation and low rainfall. Greater species diversity and aesthetic impacts are other key areas.

Field trials would probably be the most effective method of methodical experimentation. Live conservation projects could provide a suitably wide range of opportunities for such research, in a cost-effective way that would also serve to disseminate best practice.

4. Promoting an Aesthetic Debate.

The aesthetic and philosophical context of decisions affecting vegetation at historic sites is complex and debate of this subject should be encouraged. An ongoing discourse should involve those outside the architectural conservation community and help inform decisions and guidance.

5. Valuing Vernacular Construction.

The understanding and conservation of historic structures that included living plants as original construction materials should be promoted, in the recognition that this is a technically complex and often difficult field.

6. Fostering International Links.

The experience of practitioners in other countries is a valuable resource for developing technical understanding and practical methodologies. Links with such countries should be fostered and attempts should be made to identify relevant work in countries other than those identified in this report. A network might be established to promote international discourse.

10. BIBLIOGRAPHY

Ágústsson H. (1968) Islandsk byggeskik i fortiden, Norræn byggingardagur X. Reykjavík 26-28 August 1968 (article in precedings for conference on Nordic construction)

Armit Ian (2003) Towers In The North: The Brochs Of Scotland, Tempus ISBN 0-7524-1932-3

Ashurst, John ed. (2007) Conservation of Ruins, ISBN 978-0-75-066429-0

Bailey B. (1991) Great British Ruins, Cassell Publishers Ltd. ISBN 0-304-31855-8

Beamon P. Sylvia and Roaf Susan (1990) The Ice-Houses of Britain, Routledge ISBN 0-415-03301-2

Benson J. & Roe M. (2000) Landscape and Sustainability, Spon Press ISBN 0-419-25080-8

Berge B. (2000) The Ecology of Building Materials, Architectural Press ISBN 0-7506-5450-3

Blent K. (2000) Skansens torvtak, inventering och åtgärdsförslag, Kulturhistoriska avdelningen Skansen, Stockholm

Brooks A. and Adcock S. (2004) Dry Stone Walling: a practical handbook , BTCV ISBN 0-946752-19-2

Channer J. (2001) Dore Abbey, SPAB news, Vol 22, No 4

Cooper E.A. (1997) Summary descriptions of National Vegetation Classification grassland and montane communities, Joint Nature Conservation Committee ISBN 1-86107-443-3

Coppack, G. (2002) Conserved in the Gentle Hands of Nature, Context 73

Darlington Arnold (1981) Ecology of Walls, Heinemann Educational Books Ltd. ISBN 0-435-60222-5

Dunnett N. & Kingsbury N. (2004) Planting Green Roofs and Living Walls, Timber Press Inc.,

Dramstad W. Olson J. and Forman R. (1996) Landscape Ecology Principles in Landscape Architecture and Land-Use Planning, Harvad University Graduate School of Design Island Press ISBN 1-55963-514-2

Fawcett, R. Historic Scotland (2001) Guidance on Principles: The Conservation of Architectural Ancient Monuments in Scotland, Historic Scotland

Feilden, B. (2004) Conservation of Historic Buildings, Architectural Press ISBN 0-7506-5863-0

Felmingham, M. & Graham R. (1972) Ruins, The Hamlyn Publishing Group Limited ISBN 0-600-433349-8

Fitter Richard, Fitter Alastair, Farrer Ann (1984) Grasses, Sedges, Rushes and Ferns of Britain and Northern Europe, Collins ISBN 0-00-219136-9

Gilbert, O. (1992/1996) Rooted in stone, the natural flora of urban walls, English Nature ISBN 1 85716 044 4

Gilbert Oliver (2004) Lichens, naturally Scottish, Scottish Natural Heritage ISBN 1-85397-373-4

Grant, Gary (2006) Green Roofs and Facades, BRE Press, ISBN 978-1-86081-940-7

Harman M. (1997) An Isle Called Hirte: A History and Culture of St. Kilda to 1930, Maclean Press ISBN 1-899272-08-9

Hazelius J. A. (1856) Lärobok i befästnings-konsten, J. Hörberg, Stockholm

Henk 't Hart (2000) Sedums of Europe: Stonecrops and Wallpeppers, A.A. Balkema Publishers ISBN 90-5809-594-0

Historic Scotland (1997) Biological Growths on Sandstone Buildings: Control and Treatment, ISBN 1-900168-40-5

Historic Scotland (2002) Passed to the Future: Historic Scotland's Policy for the Sustainable Management of the Historic Environment

Historic Scotland, (1998) Memorandum of Guidance on Listed Buildings and Conservation Areas

Historic Scotland and Scottish Natural Heritage (May 1995), A Statement of Intent Between Historic Scotland and Scottish Natural Heritage

Hubbard C. (1980) Grasses, The Chaucer Press Ltd ,ISBN 0-1402 0295-1

Håkansson G. (1902) Hufvuddragen af krigsbyggnadskonsten, P. A. Norstedt & Söner

Jackson J. (1980) The Necessity for Ruins, The University of Massachusetts Press ISBN 0-87023-292-4

Johnston Jacklyn and Newton John, Building Green - a Guide to Using Plants on Roofs, Walls and Pavements, The London Ecology Unit ISBN 1-871045-18-5

Jokilehto J. (2004) A History of Architectural Conservation, Elsevier Butterwork-Heinemann
ISBN 0-750655119

Kulturmiljövård (1997) Ruiner Vol. 3/1997 Sweden ISSN 1100-4800

Kaijser G. (1917) Lärobok i krigsbyggnadskonst, P. A. Norstedt & Söner

Land Use Consultants (1987) An Inventory of Gardens and Designed Landscapes in Scotland, Countryside Commission for Scotland, ISBN 0 902226 91 6

Macauley, R., (1953), Pleasure of Ruins, Weidenfeld & Nicolson, London

Miljoministeriet (1991) Ruiner- bevaring af forfald / Midtvejsstatus for Ruinkampagnen,
ISBN 87-503-9031-7

Miljoministeriet (1993) Danmarks Ruiner 12 - Asserbo ruin bevaringsarbejdet 1990-1992,
ISBN 87-601-3808-4

Oliver P. (2003) Dwellings, The Vernacular House World Wide, Phaidon ISBN 0 71484202 8

Osborne Mike (2004) Defending Britain: Twentieth-Century Military Structures In The Landscape, Tempus ISBN 0-7524-3134-x

Quine David (2000) St Kilda: Colin Baxter Island Guides, Colin Baxter Photography Ltd
ISBN 1-84107-008-4

Pearson G. T. (1992) Conservation of Clay and Chalk Buildings, Donhead ISBN 1873394004

Powys A. R. (1981) Repair of Ancient Buildings, The Society for Protection of Ancient Buildings ISBN 0 903090 91 0

Rainsford-Hannay F. Colonel (1999) Dry Stone Walling, South West Scotland Branch of the Dry Stone Walling Association ISBN 0950262307

Raistrick A. & Gilbert O. (1963) Malham Tarn House: Its Building and Materials, Their Weathering and Colonization by Plants

Ritchie, J.N.G(1998) Brochs Of Scotland, Second Edition, Shire Publications Ltd ISBN 0-7478-0389-7

Ryd, Y. (1999) Torvkåtor, intervjuer med gamla kåtabyggare, rapport 1999:4 AJTTE 1999/050

Schenk, G. (2003) Gardening on Pavement, Tables and Hard Surfaces, Timber Press ISBN 0-88192-593-4

Segal Samuel (1969) Ecological Notes on Wall Vegetation, Uitgeverij Dr. W. Junk N.V., Den Haag 1969

Society for the Protection of Ancient Buildings, (1903) Notes on the Repair of Ancient Buildings, SPAB, Batsford

Stanford, C. (2001) Dore Abbey, SPAB news, Vol 22, No 4

Söderblom, P. (1992) Sedumtak, lätta gröna tak av sedumväxter ARKUS ISSN 0284-7809

Söderblom P. (1999) Sedumtak i Sverige, utvecklingen 1991 till 1998 ARKUS ISBN 91-973626-0-3

Ståhl, L. (1829) Handbok i fältbefästningskonsten för officerare vid alla vapen, Artilleri-Läroverkets förlag, Stockholm

Thompson, M. (1981) Ruins: Their Preservation and Display, British Museum Publications Ltd.

ISBN 0-71418034-3

Tilling, R (2004) Curtains of Stone: Conservation of the Black Castle of Moulin, SSCR Journal Vol. 15

Tolley, R. (2000) Transactions Vol25: Wigmore Castle, Herefordshire, The Repairs of a Major Monument: An Alternative Approach, Association for Studies in the Conservation of Historic Buildings
ISBN 0142-5803

Vegetationsteknik, Systemlösningar och produkter (2005) Veg Tech

Viles, Groves & Wood, (2002) Soft Wall Capping Experiments, English Heritage Research Transactions, Vol 2: Stone, pp 59-74.

Walker, K.J, Manchester S.J, Mountford J.O, Stevens P.A, Pywell R.F (2001) Methodologies for restoring and re-creating seminatural lowland grassland: a review and quantitative model, Centre for Ecology & Hydrology

Wedman, S. (1994) St Nicolaus Kyrkoruin, Arbets: och materialbeskrivning, Swedish National Heritage Board Archives Dnr 203-689-1994

Wills Henry (1985) Pillboxes: A Study of UK Defences 1940, Leo Cooper in association with Secker & Warburg ISBN 0-436-57360-1

Woodward, C. (2001) In Ruins, Chatto & Windus ISBN 0-7011-6896-X

Walker, B. & McGregor, C. (1996) Technical Advice Note 6: Earth Structures and Construction in Scotland: A Guide to the Recognition and Conservation of Earth Technology in Scottish Buildings
ISBN 1-900168-22-7

Walker, B. (2003)Technical Advice Notes 23: Scottish Turf Construction, Historic Scotland ISBN 1900168-85-5

Welsch, Roger (1991) Sod Walls: The Story of The Nebraska Sod House, J & L Lee Co.
ISBN 0-934904-27-8

Wilson, R. (2005) Natural Growth, Architectural Journal, 14th April 2005

APPENDIX A:
GUIDANCE ON GOOD PRACTICE

There is a wide range of techniques that might be appropriate and successful in the varying situations in which soft cappings can be used. This guidance is therefore not prescriptive, but intended to establish an appropriate methodology for good design. Where appropriate, case specific expert guidance should be sought.

1. Evaluating Existing Vegetation

An initial survey of a masonry structure should identify the extent, distribution and species diversity of vegetation. If the site is within an area designated for its natural heritage, or if the vegetation is long-established, or unusual plants are indicated by an initial survey, specialist botanical surveyors should undertake a more detailed assessment. SNH and local environmental groups may have valuable local knowledge and be able to assist.

Species should be assessed individually for their ecological value and their effect on the performance on the structure. An assessment should also be made of vegetation in the vicinity, especially what grows on other structures or rocky outcrops, with any potentially damaging species present being identified.

Botanical surveys are best undertaken in summer, when species identification is easiest.

2. Assessing the Host Structure

The condition of the masonry structure should be assessed and a detailed understanding of the decay mechanisms developed. The role of existing vegetation, and/or the potential affect of a new soft capping, on the host structure should be evaluated.

It should be recognised that such assessments may be complex, as the effects of plants on decay mechanisms may be positive or negative in different ways in different locations, as well as varying seasonally. Where appropriate, guidance should be sought from specialists with appropriate experience.

3. Defining the Aesthetic Intention

The role of vegetation in the character of the structure and its setting should be assessed, with a clear, holistic strategy determined. This may require client or public consultation. The intended visual character of any mural vegetation, whether existing or proposed, should be clearly agreed with all who have an interest.

4. Designing the Capping

The Case Study section of this report could act as a guide to the technical appropriateness of different soft capping techniques for an individual site's climatic conditions, botanical context and aesthetic intention.

It is important to understand a site's microclimatic context. The Met Office's public information (www.metoffice.gov.uk/climate/uk) is a good starting point, but this can be augmented by local knowledge and the physical evidence of current and past decay mechanisms.

If a site is dry, a deep soil with clay content, but still root-accessible, may help retain moisture. Good quality turf and a robust edge detail will be important in inhibiting edge dieback.

On windy sites, it is very important to protect cut edges, to avoid dieback. Doubling up the turf by retuning it under the edge is a good approach. Doubling turf is generally good practice in sites with stress conditions, or where only poor quality turf is available.

Where required, protection from wind and bird damage should be given by hessian or coir mesh. A 50mm mesh size is usually suitable. The mesh should be lapped under the base of the cap, and /or restrained by biodegradable pegs, fixed in at an angle.

In difficult climatic conditions, or where the work has to be undertaken in summer, or without aftercare, and some failure is therefore anticipated, cappings can be sown with suitable grass seed to improve long-term viability.

Defining layers will rarely be appropriate, unless the substrate is biodegradable, for example, a turf wall.

Damp proof courses or membranes will rarely prove necessary or successful beneath soft cappings, with the exception of large flat surfaces. Where impermeable membranes are used, a thick capping, min. 300mm, should be applied on top and care taken to establish a robust edge.

5. Sourcing Suitable Plants

It is usually preferable to source plants from near the site. Where turf is to be cut, this is best taken from conditions that imitate those on the structure, for example, in places of thin soils over rock. Long-established grazed turf will have a good root structure, but heavily fertilised land should be avoided.

Where capping vegetation is to be re-used, any undesirable species should be carefully removed.

Where suitable turf is not available in the vicinity, it is preferable to use natural material rather than commercially grown turf. Where herbs, sedums, moss or other plants are to be used, these can often be sourced as plug plants, grown outside from native wild seeds or cuttings. They can also be sourced in the wild in small quantities, but advice should be sought on appropriate locations.

Where the caps are to be sown with seed, this should be gathered locally or sourced as wild, native seed.

Where seed or plants are to be commercially supplied or gathered in the wild, this should be programmed appropriately.

6. Managing Installation

Unless the work is in mainland Argyll, soft capping work should not be carried out in summer, without provision for watering aftercare. Spring and autumn are generally appropriate, with September the optimum month.

Where original capping vegetation is to be re-used, this should be carefully stored to prevent damage or deterioration.

Care should be taken to avoid creating over-sheltered conditions for new cappings, by the location of scaffolding or protection for other works.

The top vegetation layer should be well pressed down into the underlying soil or upside down turf layers, to facilitate rooting in. The underlying layer should not be too dry or smooth textured.

Care should be taken to protect vulnerable plants, such as sedum, from damage after installation. Light watering may be appropriate, depending on local conditions, but care should be taken to avoid creating unnaturally benign conditions.

7. Maintenance

If possible failure is anticipated, the cappings should be inspected periodically in the first years until they stabilise, to determine whether intervention is merited and record whether failing cappings might present a hazard.

Thereafter the condition of soft cappings should be included in routine periodic inspections of the condition of structures. Such inspections should record colonisation by any potentially damaging species. The risk of this should be clear from the sites botanical context. It should be noted that summer is usually the easiest time to identify such species.

GLOSSARY

Coverband: Large fat stones placed across the top of the wall, as a base for cope stones

CS: Case Study, contained in Volume 2

dieback: Dieing back of vegetation from its edges

ring beam: A continuous structural member at the head of a wall to provide continuous restraint against movement, commonly formed in reinforced concrete

shielings: Vernacular seasonally occupied dwellings, commonly associated with summer hill pasture

stolon: A plant that takes root along its length to form a new plant

thermal flux: Range of temperature experienced by a material

thermal blanketing: Thermally insulating effect

NOTES

NOTES