Developing an ecosystems approach – dry stone walls

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Summary

This report presents results from a return-on-investment (ROI) model developed to explore ways in which historic environment values can be incorporated into the four categories of ecosystem services. The model is based on identifying and monetising the benefit flows from ecosystem services provided by dry stone walls in the Peak District National Park (PDNP). The overall project aims involved: development of a methodology for recording the public and environmental benefits (goods and services) flowing from dry stone walls in the PDNP; identification of those benefits in a way that is compatible with the language associated with 'ecosystem services' and 'natural capital'; attribution of value (economic and non-economic) to those benefits (services); and, to recommend other heritage assets for which this approach would be suitable.

Dry stone walls are an integral part of the landscape and cultural heritage of the PDNP and other upland areas of England, marking routeways, territorial, occupancy and tenurial boundaries, separating rough grazing from meadows, pastures and arable land and enabling the management and movement of people and livestock. As the still-dominant form of enclosure in the PDNP dry stone walls are part of the 'scenery' appreciated by residents and visitors, and also providing wildlife habitats and corridors. A report on landscape change in the National Parks of England and Wales, published in 1991 by the Countryside Commission, estimated that in the PDNP there were 8,756 kilometres (km) of dry stone walls, 1,710 km of hedges and 472 km of fences. Although the PDNP has experienced greater loss of field boundaries than any other National Park, it still has the third highest density of dry stone walls in any of the National Parks - at an average of 7.6 km^2.

This report demonstrates that the existing stock of dry stone walls exhibits great variation in the following ways: their age, which surveys have demonstrated can date back to over 2,000 years, but which is predominantly of late 18th and 19th century date; their function, which is mostly to shelter and manage livestock and crops; local economic impacts, including the strength of the local walling industry; and, their contribution to local landscape character, due to the pattern, density and survival of dry stone walls in the landscape. Maintenance issues and costs also vary according to their original construction, local geology and topography including soils, and the economics and nature of modern farming. Three case study areas were selected, one from each of the National Character Areas (NCAs) in the PDNP, these are:

- Flash, in the South West Peak area;
- Ughill Hill, in the Dark Peak;
- Tideswell and Litton, in the White Peak.

Each area is broadly representative of the key characteristics of the NCA in which they are located.

Benefits flowing from dry stone walls arise from the current level and quality of the stock (the asset), and from the functions they currently serve that enhance social welfare. These include their contribution to:

- biodiversity;
- agricultural management and understanding of historic and present land management;
- the character of landscapes and local distinctiveness;
- how landscapes are experienced and perceived by people;
- sense of place and well-being.

Value also flows from an understanding of the historic functions of dry stone walls, many of which are still relevant today.

The approach to valuing the benefit streams flowing from dry stone walls is based on a simple ROI model using financial approximations ('proxy measures') to estimate values of the benefit flows. Within the model the functions of dry stone walls were allocated to the four main ecosystem services categories (provisioning, supporting, regulating, cultural). Annual costs of wall restoration and maintenance, and annual benefits produced were modelled over a 50-year time horizon. Annual costs and benefits were discounted back to present value (using a 3.5% discount rate) and summed to provide total present values for costs and benefits of dry stone walls over the period.

The model is based on measuring the ecosystem services flowing from dry stone walls in the case study areas. Each service flow is measured using indicators tailored to the type of service delivered and the 'level' of each service flow is then modified by assessment of its condition. Assessment of condition requires ground surveys to observe the current state of dry stone walls. Condition is also related to current functions of dry stone walls; walls that are functional are likely to have more resources invested in maintenance and restoration and are likely to be more robust, than those that no longer perform an economic function. A financial approximation (a 'proxy') is assigned to each service flow and multiplied by the number of beneficiaries to provide an annualised value for each service flow. Proxies are based on market prices of similar goods and services to those delivered through the ecosystem service being valued. Annual values are then project over 50 years and discounted back to present value (using a 3.5% discount rate).

The pattern of benefit-to-cost ratios (BCRs) matched expectations based on field assessments of the linear extent, function, and condition of the walls in each area. In other words, areas with greater density of dry stone walls and walls in better condition and higher levels of functionality had higher BCRs. The Tideswell area provided the highest benefit flows in relation to restoration and maintenance costs (9.96 to 1) over the 50-year time horizon; the ratio for the Ughill area was 4.54 to 1, while the lowest value of benefit flows was the Flash area with a ratio of 1.05 to 1. The total present value of ecosystem service benefits over the 50-year time horizon ranged from £36.72 million for the Tideswell area, down to £4.53 million for the Ughill area, and £1.15 million for the Flash area. The model outputs reflect the differences between the three areas, which vary in function, condition, and heritage value of dry stone walls across the PDNP.

Aggregating up from the case study areas to the entire PDNP area the model indicated that the present value of dry stone walls over the 50-year time horizon (i.e. annual benefit flows minus the annual costs of restoration and maintenance) is £668.71 million. The ratio of benefits to investment for the PDNP area was 4.91 to 1 (i.e. for every £1 of investment in dry stone walls the value of the benefits is £4.91). Across the PDNP cultural services contributed 53.8% of the total value of benefits, supporting services (e.g. provision of habitat and contributions to biodiversity) contributed 31.4%, provisioning services (i.e. largely agricultural benefits) contributed 14.4%, and Regulating services contributed less than 1%.

The method developed in this study is applicable to all forms of field enclosures and linear features in the rural landscape, and which have been mapped in individual Historic Landscape Characterisation projects. It is also applicable (with some modification) to non-linear heritage assets, including consideration of:

- Woodland, the historic character and potential for change of which has recently been assessed by a project funded by Historic England.
- Buildings and sites under the Agriculture and Subsistence heading in the Historic England Thesaurus of Monuments Types, in particular:
    - Traditional farmsteads and field barns, which have been the subject of extensive historic characterisation and some mapping projects that have recorded their historic character and survival.
    - The earthworks of historic land use and settlement - for example, ridge and furrow, water meadows, shrunken and deserted settlements.
    - Industrial sites in rural areas.
    - Historic parks and gardens.
    - Defence sites, from prehistoric and historic earthworks to airfield, ordnance and training sites.

Several issues were identified for further exploration, including: the scale at which the ecosystem services are measured; access to digital mapping data; aggregation of values, and, assumptions underlying the model. The study selected relatively small case study areas (7.5 km^2) but even within these areas walls exhibited a significant amount of variability in function, condition, and heritage value. Geographic information system analysis of historic characterisation data would provide a more effective means of ensuring the variability in walls across an area is captured. Scale of application also has implications for data capture: at small scales, for example, it can be difficult to access basic data on number of residents and visitors to an area. In relation to model development, and in addition to stressing the need for access to digital mapping data, we suggest consideration of longer time periods and sensitivity testing of different discount rates to explore how the model outputs vary when longer time frames are considered. Finally, this project has highlighted the paucity of work on dry stone walls; analysis of current understanding, and its relevance to ecosystem services within the PDNP and further afield, is included in the appendices to this report.

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1 INTRODUCTION

1.1 Background to the project

Historic England has begun to look at how the heritage sector might engage with the ecosystem services approach to assess the benefits that cultural heritage can provide to people's health, wellbeing and prosperity.[1] Ecosystem services first emerged in the 1980s but its current iteration stems from the Millennium Ecosystem Assessment that was commissioned by the United Nations in 2001 and published in 2005. Subsequently the UK Government commissioned its own National Ecosystem Assessment (NEA), the first reports from which were published in 2011, reports from the most recent phase of work were published in 2014. While these approaches are becoming increasingly influential in environmental policy and land management decision, Historic England recognises that the historic environment is currently poorly represented in ecosystem services and natural capital accounting methods.[2]

There are clear challenges and opportunities here. The breadth and language of ecosystem services is challenging for professionals working in the natural and historic environment, particularly for those working in heritage who have developed expertise in protecting, assessing and providing advice on specific buildings, monuments and areas, and for those whose work on the natural environment would benefit from a better understanding of the interaction of human and natural factors in shaping landscapes. On the other hand, the integration of historic environment functions and processes into an ecosystem services framework will offer increased opportunities to:

- Consider the benefits offered by historic landscapes, places and assets for inclusion in future land management strategies, including incentives to farmers in agri-environment schemes and regulation for some types of land management and development activities.
- Deliver national and local planning policy including its emphasis on weighing environmental, social and economic factors.
- Understand 'local distinctiveness' and the character of the whole historic environment, defined in The National Planning Policy Framework (NPPF) as resulting from 'the interaction between people and places through time'.[3]
- Apply understanding of the inter-relationship between culture and nature to the delivery of integrated approaches to land management.

This report describes the process of developing a methodology to apply an ecosystem services approach to valuing the benefits from dry stone walls, a significant cultural heritage asset in many of the upland areas of England. The

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[1] Fluck and Holyoak (2017) Ecosystem Services, Natural Capital and the Historic Environment. Historic England Research Report Series 19/2017

[2] Fluck and Holyoak (2017)

[3] And as also stressed in the Farrell Review of Architecture and the Built Environment, www.farrellreview.co.uk

landscape, cultural and natural value of dry stone walls is widely recognised and appreciated, but to date there has not been a systematic exploration of their utility for defining either economic or non-economic benefits.[4] Dry stone walls are an integral part of the landscape and cultural heritage of the Peak District National Park (PDNP) and other upland areas of Britain, now including the Lake District National Park World Heritage Site. These principally agrarian landscapes are vital for community well-being and for attracting domestic and foreign tourists to rural areas, as outlined in the 2013 study for National Parks England.[5] In undertaking this work, the Countryside and Community Research Institute (CCRI), based at the University of Gloucestershire, is building on previous heritage and rural development valuation work, which includes, for example: quantification of the contribution of pre-2008 'barns and walls' schemes to local economies in the Lake District and Yorkshire Dales, and scoping the potential for determining the social and economic benefits of heritage in the National Parks of England and Wales.[6]

1.2 Aims and objectives of the project

1.2.1 Project Aims

Currently there is limited understanding of the role of historic environmental assets in ecosystem services and natural capital approaches, and the monetary and non-monitory benefits they can provide to society. The issue of heritage valuation is insufficiently conceptualised and there is a dearth of empirical research. The impact the project is seeking to have is to improve the incorporation of historic environment assets into ecosystem services and natural capital approaches both in terms of conceptualisation and practical implementation.

The aims of this project are to demonstrate how the monetary and non-monetary value of the historic environment can be incorporated into the four categories of ecosystem services. This project will look at one landscape feature that is clearly humanly constructed – dry stone walls - and will set out the public benefits that result from this in language that is compatible with the ecosystem services framework. The project will develop a methodology that can identify the benefits and attribute values associated with the dry stone walls of the PDNP that is compatible with the ecosystem services approach. The project will also identify and recommend other heritage assets whose benefits can be identified and valued using the methodology.

The project aims are to:

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[4] See for example: Courtney *et al.* (2007) A Socio-economic study of grant-funded traditional dry stone wall and farm building restoration in the Yorkshire Dales National Park; House of Parliament Select Committee on Environment, Transport and Regional Affairs (1998) Thirteenth Report: The Protection of Field Boundaries, 3 November 1998; Land Use Consultants (2007) Defining Stone Walls of Historic and Landscape Importance. Final Report produced for Defra and partners. April 2007. For a recent UK synthesis see Winchester (2016) Dry Stone Walls: History and Heritage. Amberley Press: Stroud.

[5] National Parks, National Assets, www.nationalparksengland.org.uk

[6] Courtney *et al.* (2008) Scoping Study on the Socio-Economic Benefits of Heritage in the National Parks. Final Report for English Heritage and Cadw. Project Report. CCRI, University of Gloucestershire

- Develop a methodology for recording the public and environmental benefits (goods and services) flowing from dry stone walls in the PDNP.
- Identify those benefits in a way that is compatible with the language associated with 'ecosystem services' and 'natural capital'.
- Attribute value (economic and non-economic) to those benefits (services).
- Recommend other heritage assets for which this approach would be suitable.

The focus of the project is on the monetary valuation of ecosystem services. Ecosystem services provided by dry stone walls are captured and valued as benefit flows over time to specific individuals and/or sectors of society. No attempt has been made in this small developmental study to address the 'inherent' value associated with the current stock of dry stone walls in the PDNP, which would require a different approach, and raise questions about the suitability of monetary valuation techniques as an approach.

1.2.2 Project objectives

To achieve these aims the project has 4 objectives:

1. Develop a Methodology: Develop a methodology that identifies the benefits and attributes the values associated with the dry stone walls of the PDNP in a way which is compatible with the ecosystem services approach, using clear understanding of their historic function, character and significance.
2. Apply the Methodology: Apply the methodology by:
    - identifying the benefits of and gathering empirical evidence on the value of dry stone walls in the PDNP,
    - testing that the outputs (benefits and values) can be identified and communicated in a language compatible with the ecosystem services and natural capital approach.
3. Revise the Methodology: Revise the methodology in the light of lessons learned and identify and recommend other heritage assets whose benefits can be identified and valued using the methodology.
4. Reporting and Dissemination: Clearly communicate the results of this project to stakeholders, setting out needs, opportunities, and both the challenges and benefits of future application.

1.3 Report structure

The remainder of this report is divided into six sections. Section 2 provides details of the research methodology. Section 3 introduces current understanding of the historic character and development of dry stone walls, which is further set out in the appendices, prior to an assessment of their heritage value. Section 4 presents a summary of the historic character of dry stone walls in 3 case study areas. In Section 5 the methodology is applied to the case study areas and the PDNP. The empirical results are analysed and discussed. The final section (6) presents the conclusions of the research, considers the applicability of the method for other heritage assets and identifies issues for future research.

2 METHODOLOGY

2.1 Introduction

This section sets out the methodology for identifying the 'services' provided by dry stone walls in the PDNP in a way that is compatible with the language associated with ecosystem services and natural capital. The methodology builds on existing techniques for valuing the benefits of market and non-market goods and services.

Dry stone walls are conceptualised as part of a larger socio-ecological system in the Peak District that generates a range of services, the value of which may or may not be directly recognised by system managers, residents, visitors and other elements of society. The method essentially brings together valuation approaches currently utilised within ecosystem services to provide monetary values for 'benefit streams' generated over time by the 'capital stock' of the existing systems of dry stone walls within the national park area of the Peak District. The method does not attempt to provide inherent values of the current stock of dry stone walls, it focuses on valuing the stream of benefits that flow from the existence (in the case of ecological benefits), and the utilisation (e.g. in the case of livestock management) of the existing stock of dry stone walls, in their current condition.

2.1.1 Dry stone walls and other linear heritage assets: valuation methodology

Figure 1 illustrates the overall approach and shows that there are five main elements or 'steps' to the method. The aim of Steps 1 and 2 is to develop an understanding of dry stone wall functions in the PDNP based on an assessment of the role played by dry stone walls in different parts of the area, and the condition of the 'capital stock' in terms of its extent, condition and current utilisation. The ecosystem services model developed here is designed to support decision makers through providing measures of changes in value of the flows of services provided by dry stone walls that would result from alterations in external drivers which might alter the condition and/or linear extent of dry stone walls. Steps 1 and 2 occur in tandem utilising expertise of the project team, a rapid evidence review and stakeholder discussions. A field trip and 2 stakeholder workshops were undertaken to help clarify the nature of the functions of dry stone walls in the PDNP.

In an ideal situation Step 2 would include a valuation exercise to assess the total value of the current 'stock' of wall in a defined area. However, the limited resources available and the focus on measuring the value of ecosystem service 'flows' precluded such an approach. At the outset of the study there was some consideration of alternative approaches to valuation of the current stock. Several alternatives were considered, including: utilisation of a replacement-cost measure, which was discarded due to its inability to capture the cultural heritage value of dry stone walls; and, a 'time-depth' approach was explored based on a positive discounting approach, which appears to offer potential, though a full analysis was not undertaken as part of this study.

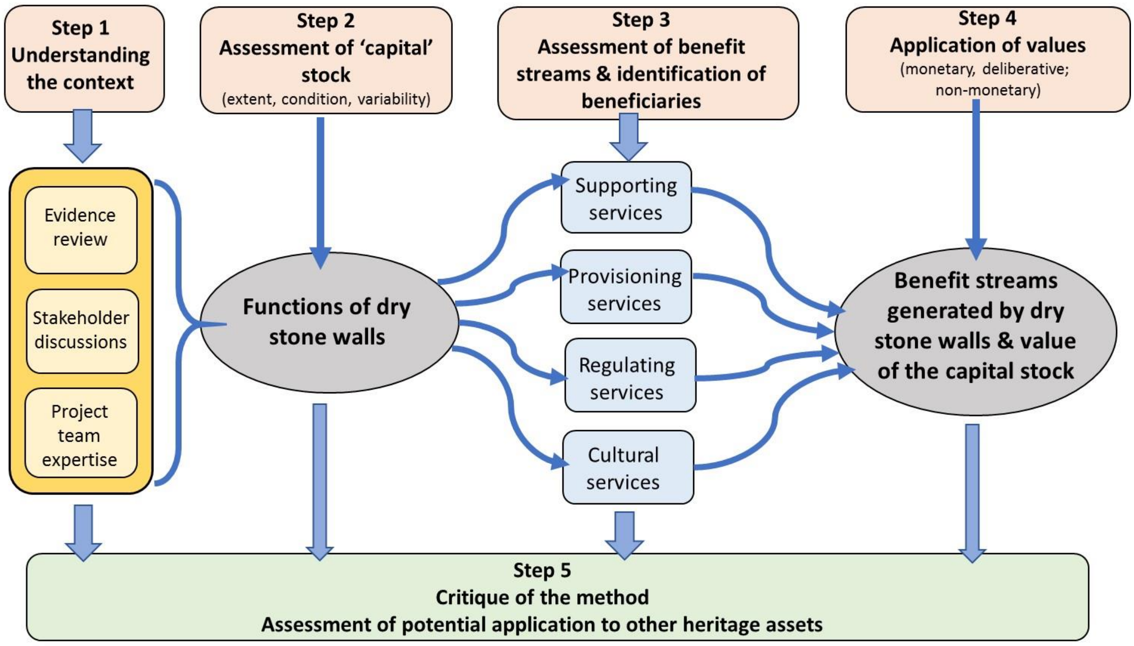

Figure 1: The methodological approach

Step 3 explores the functions of dry stone walls from an ecosystem services perspective. Ecosystem services are a means of conceptualising a resource or set of resources in terms of the benefits it contributes to different parts of an ecological and social system. In order to identify the magnitude and values of benefit streams (Step 4) it is important to understand how dry stone walls function in the larger socio-ecological and economic system, and who or what benefits. Literature review has revealed limited information on monetary values of dry stone walls, which supports a Return-on-Investment (ROI) type of approach.

2.1.2 Developing the methodology

Step 3 involves a careful and detailed analysis of the functions of dry stone walls in terms of how they contribute 'services' to the socio-ecological and economic system of interest. Services are grouped under the key service flows of the ecosystem services model (i.e. supporting, provisioning, regulating and cultural). Service flows can then be explored in terms of 'benefit streams' which allows the project team to identify who or what benefits, enabling the attribution of values to each benefit stream.

The tables in Appendices A and B summarise an expanded framework of the functions of dry stone walls and identified benefit streams. However, the service 'flows' depend on the current stock of the asset (in this case the pattern and extent of stone walls within a defined area), its condition (e.g. good, poor, derelict; see Figure 19), and the extent to which it continues to support relevant desired functions. The method therefore needs to assess:

- The current functions and condition of the 'stock' of the asset (dry stone walls).
- The ecosystem service 'flows' arising from the stock and the how those flows are translated into valued benefits by different stakeholders.

Dry stone walls are defined in this study as walls currently existing (in any condition) within the PDNP (see Appendix C for further details on their constructional form and historic development). Dry stone walls are those constructed from (usually) local sources of stone, where no cementing materials (such as mortar) has been utilised (see Figures 14 and 15). Detailed research has found that some date from the Romano-British period (see Appendix D for Roystone Grange case study). Most dry stone walls have basic features in common with each other: they are built up from a foundation layer of large stones, decreasing in size and tapering to a layer of capstones, and with a fill or 'hearting' of small stones between outer faces of stonework which can be linked crosswise by through-stones. They have primarily developed for the purposes of land management, in order to separate and better manage land for stock and crops (see Section 3.2). Some no longer perform any agricultural function. Walls that are present as features in the landscape (even if only identifiable as banks, or marks on the ground), are taken into account; even remnants of dry stone walls may continue to provide historical, cultural, and/or ecological value, and are therefore included in this study. Walls that are no longer visible, or exist under the current surface features, are not included in this study.

2.1.3 Assessing the stock of the asset

The existing stock of dry stone walls exhibits great variation in their:

- date of construction, which detailed survey has demonstrated can date back to over 2,000 years but which is predominantly of late 18th and 19th century date;
- function, which is mostly to shelter and manage the rotation of cropping and livestock;
- maintenance issues and costs, due to their original construction, local geology and topography including soils and the economics and nature of modern farming;
- local economic impacts, including the strength of the local walling industry;
- contribution to local landscape character, due to the pattern, density and survival of dry stone walls in the landscape.

This project has highlighted the poor evidence base for walls, and ways in which Historic Characterisation can address this.[7]

Where does value come from?

Value arises from the ecosystem service flows generated by the dry stone walls, modified by the current level and quality of the stock, arising from the functions that

[7] See Appendix C for consideration of this issue.

they served in the past (see Section 3.1) and perceived functions currently providing benefit streams that enhance social welfare. These include the benefits that dry stone walls, offer in terms of their contribution to:

- biodiversity;
- agricultural management and understanding of historic and present land management;
- the character of landscapes and local distinctiveness;
- how landscapes are experienced and perceived by people;
- sense of place and well-being;
- understanding of the historic functions of dry stone walls.

2.1.4 Valuing the annual flow of services

Walls provide a range of functions within the landscape, ranging from supporting livestock management to providing wildlife habitat and a sense of place to residents of the area. These functions can be identified, along with those who benefit, and categorised according to the concepts of ecosystem services, i.e. the notion that aspects of the environment provide a range of supporting services that benefit society and the environment on which it depends. The functions are envisaged as services (see Figure 1), the extent to which they are utilised and valued changes over time. All functions can be incorporated within one of the four major types of ecosystem service. The text in Appendix B offers a preliminary outline of the major benefit flows which will be valued through market values where appropriate.

2.1.5 The adopted approach

The adopted approach is a modified cost-benefit analysis (CBA) based on a ROI using financial approximations (also referred to in this report as 'proxy measures') to estimate values of non-market benefit flows. Resource and time constraints mean a full-scale CBA approach based on empirical data cannot be developed. The study uses a ROI approach based on the New Economics Foundation framework (New Economics Foundation, 2007; Cabinet Office, 2009) for assessing social return on investment (SROI). The underlying approach is a form of CBA whereby 'flows' or 'streams' of costs and benefits are valued over a specific time period, and compared on a present value basis (using discounting) to provide a ratio of overall costs to overall benefits over the period of interest. The framework utilises a surrogate methodology for assigning market values to ecosystem services that do not have market prices. Hedonic pricing (Office for National Statistics, 2018) and travel cost methods are perhaps more familiar techniques for using surrogates in order to determine environmental monetary values (e.g. for landscape, outdoor recreation, clean air and water).

The tables in Appendix A identify functions of dry stone walls in the PNDP, allocated into the four main ecosystem services categories. Costs and benefits were modelled over a 50-year time horizon, capturing the value of benefit flows from identified ecosystem services and the full range of re-construction and maintenance costs.

3 ASSESSING THE BENEFITS OF DRY STONE WALLS

3.1 Introducing the Peak District and its dry stone walls

Dry stone walls are an integral part of the landscape and cultural heritage of the PDNP and other upland areas of England, marking routeways, territorial, occupancy and tenurial boundaries, separating rough grazing from meadows, pastures and arable land, and enabling the management and movement of people and livestock. Their historic functions (see Section 3.2) underpin their form and presence in today's landscape, and the benefits they offer to society (see Appendix B). Initial work in this project sketched out the relationship between their historic character and landscape. As the still-dominant form of enclosure in the PDNP (see Figure 2), dry stone walls are part of the 'scenery' appreciated by thousands of residents and millions of visitors and provide wildlife habitats and corridors, having developed over millennia to serve a variety of agricultural and other functions. These principally agrarian landscapes are vital for community well-being and for attracting domestic and foreign tourists to rural areas.

A report on landscape change in the National Parks of England and Wales, published in 1991 by the Countryside Commission, estimated that in the PDNP there were 8,756 km of dry stone walls, 1,710 km of hedges and 472 km of fences. Although the PDNP has experienced greater loss of field boundaries than any other National Park, it still has the third highest density of dry stone walls in any of the National Parks - at an average of 7.6 km^2 (Countryside Commission 1991).

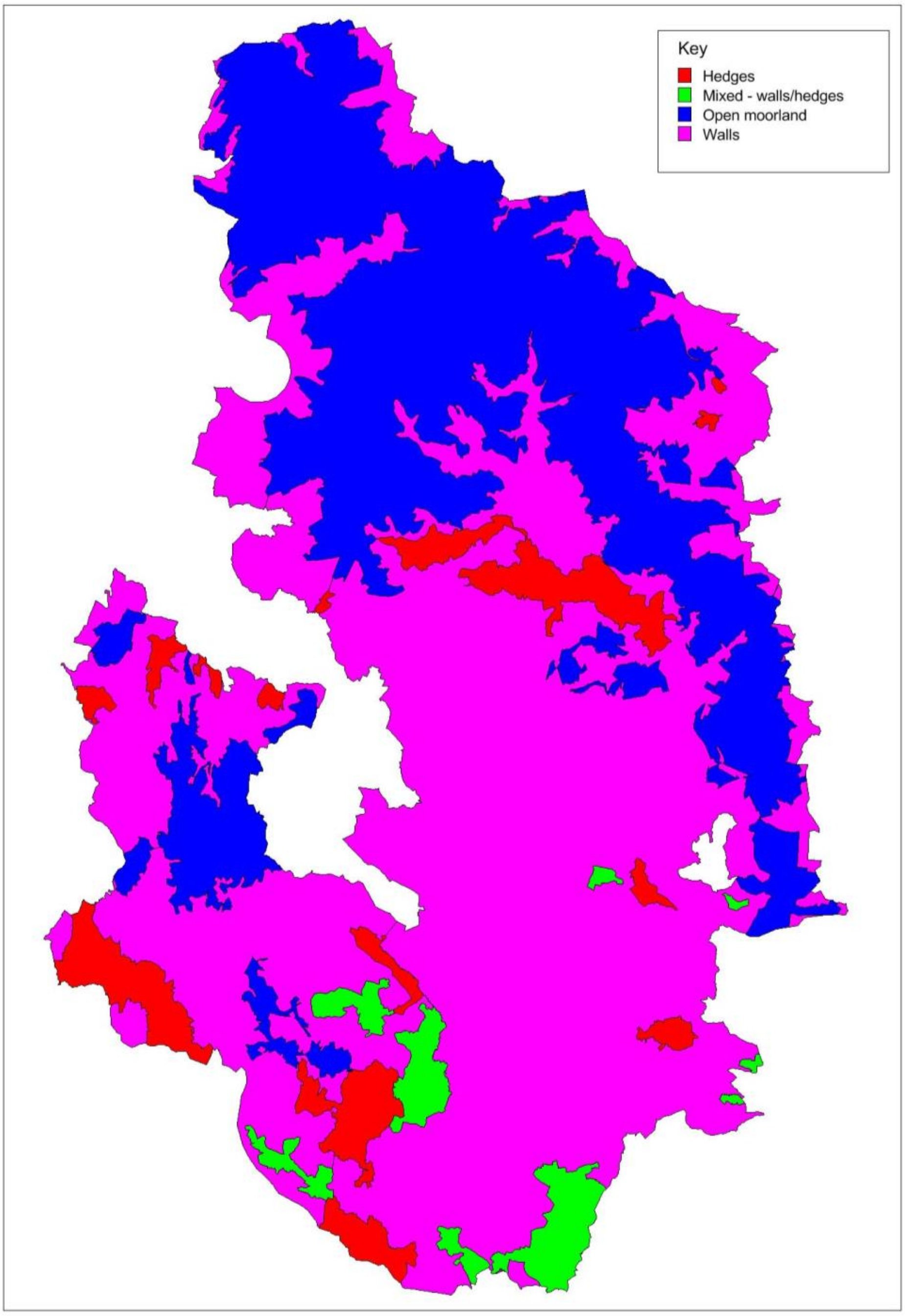

Figure 2: Map illustrating extent of areas dominated by dry stone walls (pink), hedges, and open moorland. Based on Peak District Historic Landscape Characterisation data, courtesy of Peak District National Park

The historic character and development of dry stone walls is summarised in Appendix C. Many years of field work at Roystone Grange in the White Peak (see Appendix D) has demonstrated that dry stone walls with orthostats can date from the Romano-British period, and that dry stone walls built from quarried and dressed stone are the most standardized in their appearance and most likely date from the late 18th century. Any survey of local variations based on the techniques developed at Roystone Grange would take decades of work and be alive to subtle variations at a local level. More useful in assessing the historic character of the stock, and consideration of its potential benefits, would be consideration of how the density and pattern of dry stone walls in the landscape result from their historic functions in broad terms, and specifically how they have marked routeways, territorial, occupancy and tenurial boundaries, separated rough grazing from meadows, pastures and arable land and enabled the management and movement of people and livestock.[8] These functions are principally but not exclusively agricultural in nature, although lead mining - of particular importance in the Roman period and into the 17th and 18th centuries - and other industrial activities were often combined with small-scale farming (Barnatt 1996).

It is clearly important to see if local variations in the patterning of dry stone walls can be identified at a broad scale. The Peak District broadly subdivides into three areas which align with the National Character Areas (NCAs), first mapped and described through the Countryside Commission's *Countryside Character Initiative* and recently updated:[9] the central, Carboniferous limestone of the White Peak plateau (NCA 52), the Coal Measure gritstones of the Dark Peak (NCA 53) and, the South West Peak (NCA 54) area. These NCAs are dominated by three of the National Ecosystem Assessment's landscape typologies - Mountain Moorland and Heath, now concentrated in the Dark Peak and to a lesser extent the South West Peak, Enclosed Farmland, and Semi-Natural Grassland.[10]

The Historic Landscape Characterisation (HLC) of the PDNP, published in 2003 (Barnatt 2003), mapped the time-depth of the present landscape including the patterning of dry stone walls which are concentrated in Enclosed Land.[11] It then informed development of the Peak District Landscape Strategy and Action Plan (LSAP), published in 2009.[12] The NCAs were used in the LSAP to identify Regional Character Areas which were then subdivided into Landscape Character Types (Figure 3), all setting out their physical, ecological and human influences. The mapping of traditional farmsteads and field barns, and analysis of their survival, recorded date and historic layout in the framework of the NCAs and HLC, has deepened understanding of the time-depth and local variation in enclosed and also

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[8] For a recent UK summary of the role that dry stone walls played in upland economies and culture see Winchester (2016) Dry Stone Walls: History and Heritage. Stroud: Amberley Press. For a summary of the Peak District see Barnatt and Smith (2004) The Peak District. Windgather Press: Macclesfield.
[9] https://www.gov.uk/government/publications/national-character-area-profiles-data-for-local-decision-making
[10] http://uknea.unep-wcmc.org/EcosystemAssessmentConcepts/EcosystemFunctioning/tabid/100/Default.aspx
[11] For further details see Appendix F and Figure 20.
[12] http://www.peakdistrict.gov.uk/looking-after/strategies-and-policies/landscape-strategy

unenclosed land from the medieval period: this was published in 2017 as part of the Peak District Historic Farmsteads Guidance project.[13] It has demonstrated a close link between the recorded date and historic character of farmsteads, and the enclosed fieldscapes within which they developed (Figure 4).

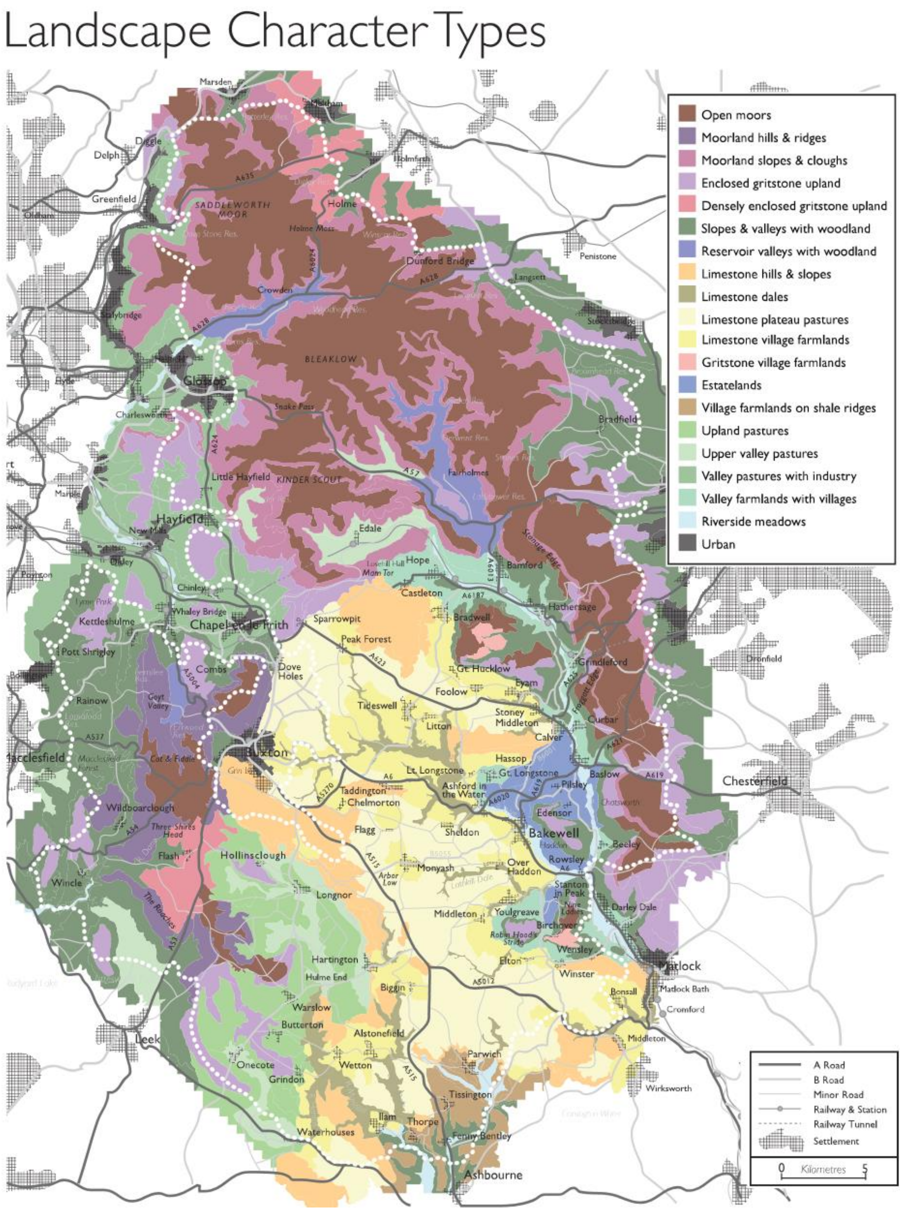

Figure 3: The Landscape Character Assessment published as part of the Peak District Landscape Strategy and Action Plan. The white dotted lines mark the boundaries of the NCAs. © Peak District National Park

[13] http://www.peakdistrict.gov.uk/looking-after/living-and-working/farmers-land-managers/historic-farmsteads-guidance

Figure 4: Dry stone walls are integral part of patterns of historic enclosure and the settings to vernacular buildings in the Peak District. Images from the Peak District Farmstead and Landscape Project (Edwards and Lake, 2015). The maps (see Figure 17 for a more detailed map) show the colours used for HLC - blue for Pre-1650 enclosure (also termed Ancient Enclosure), yellow for Post-1650 enclosure, pink for Enclosures of Uncertain Date and brown for Unenclosed land. The top left map shows the close correlation between Pre-1650 enclosures and to a lesser extent Enclosures of Uncertain Date against the distribution of farmhouses and working buildings recorded as having buildings of pre-1700 date. These only represent 9% of farmsteads recorded from c. 1900 Ordnance Survey maps. Whilst the top left map shows very few farmsteads in the pink landscapes of the South West Peak, Farmstead Mapping has revealed concentration of dispersed plans in these areas which are often indicative of an early date (top right). In contrast formal courtyard farms, often with Georgian facades facing routeways, are concentrated in the landscapes of Post-1650 (mostly post-1780) enclosure - particularly in the White Peak (as here)

One additional point worth noting here is that this study has not addressed different construction methods and techniques. One key reason for this is the fact that the study of dry stone walls, at a local and national level, is in its infancy. We are well aware that construction techniques vary across time and place, and may be influenced by factors such as geology (the type and characteristics of the stone locally available), local craft techniques (which may vary from builder to builder), and the original function the wall would perform. Construction techniques can contribute to understanding of the time-depth and historical development of an area, but we have not explored any potential impact on value of dry stone walls of the existence of a particular type of construction. These factors may offer scope for future refinements of the valuation method.

3.2 Assessing the value of dry stone walls

This project has developed and refined techniques for assessing the value of dry stone walls through an ecosystem services approach. This involved identifying the ecosystem services flowing from dry stone walls, analysing the nature of the flows and who benefits, then applying monetary values to those flows of benefits. The present pattern and density of dry stone walls in the landscape results from how they were intended to enable the management or regulation of land on a communal and individual basis and the production of food, wool and other products for local communities and export. The principal past and present functions of dry stone walls in the Peak District are the following:

- Manage different types and ages of livestock.
- Act as permeable barriers to shelter livestock and crops.
- Organise livestock close to settlements and farmsteads or in areas of open grazing, typically in small and inter-connected paddocks or in circular pounds.
- Mark out individually-managed blocks of land, as distinct from the communal management of unenclosed land and strips within in-bye land.
- Enable blocks of land to be managed efficiently and productively for pasture and cropping.
- Take stones cleared off land for grazing and cropping.
- Mark out estate and other territorial boundaries - parishes, manors and parkland.
- Prevent livestock from encroaching into woodland, limekilns and industrial sites including lead rakes.

These functions are principally but not exclusively agricultural in nature, although lead mining - of particular importance in the Roman period and into the 17th and 18th centuries - and other industrial activities were often combined with small-scale farming (Barnatt 1996).

An interest of the project was to identify the full range of services flowing from dry stone walls. This includes the cultural and historical values that flow from remnants of dry stone walls, or even archaeological remains (as long as they are visible in the landscape). In the absence of any detailed fieldwork we have used HLC as a framework to consider the dates of dry stone walls based on their pattern in the landscape, using historic maps where possible. We have not incorporated old land surfaces preserved below existing features or surface layers. Although such archaeological features may have cultural value the focus of this study was to assess ecosystem services flowing from the existing stock of dry stone walls. Incorporating sub-surface remains would require significantly more resources to determine the services provided, and how those services should be valued, especially where knowledge of their existence is extremely limited. The historic function and context of dry stone walls has also informed consideration of the extent to which different types of historic enclosure patterns are linked to actual and potential Time Depth, reflecting past as well as present uses and perceptions of the value of dry stone walls in the landscape (see Appendix E).

A key reason for selecting an ecosystem services approach was to enable the different service flows (i.e. supporting, provisioning, regulating, cultural) to be identified and valued independently of each other. It was clear at the outset that any technique must be sufficiently flexible to work at different scales, and that limited resources demanded a 'top-down approach' that could be tested by assessment of value and condition of individual walls through fieldwork. A 'bottom-up' approach risked getting bogged down in detail, would require reconciling different methodologies, and would be difficult to scale up to, for example, Landscape Character Areas (LCA), NCAs and Agricultural Landscape Types (ALT). Discussion at two workshops conducted as part of the study also brought other issues to the fore:

- The need to be clear that the focus of this study was to identify and then value the 'service flows' provided by dry stone walls. The impact of changes in the condition of dry stone walls can then be explored in terms of alterations to service flows and values.
- That ecosystem services offers a framework for identifying the flow of all benefits from dry stone walls and other linear features, and how these derive from the legibility, pattern, and context of dry stone walls in the landscape (see Appendix B).
- That any method for scoring the heritage values of dry stone walls needs to be capable of being replicated in other areas. In terms of the cultural services value this demands a clear articulation of local variations in the historic character of dry stone walls - in particular the extent to which they: are present in the landscape, reflect past patterns of land use on account of their patterning and, relate to heritage assets and broader patterns in the historic landscape.

3.3 Developing a means of measuring the cultural heritage services provided by dry stone walls

A key focus of the work was to develop a methodology for assessing the cultural heritage value of dry stone walls which incorporates current function and condition of dry stone walls, their age, relationship to other landscape features, the 'story' they tell' about settlement and historical development of an area, and how easy it is to interpret that story. The methodology needed to be able to take into account enhanced values from the presence of multiple features from different time periods, as well as provide a coherent valuation system for features appearing from specific time periods. The outcome is an approach that incorporates three facets of heritage into a single scoring system: legibility, time-depth, and inter-relationships of dry stone walls in the landscape (See Figure 5 below). These considerations have been foremost in setting out the criteria for assessing the heritage value of dry stone walls and are described in more detail below. The heritage value of dry stone walls is also influenced by function and condition. Where dry stone walls continue to perform the functions for which they were built, they are likely to be in better condition (e.g. livestock management, marking property boundaries). Dry stone walls in poor condition (e.g. with large gaps, collapsed sections) will provide lower levels of many ecosystem services (such as species habitat, livestock management, sense of place and wellbeing) and this is reflected in the model through an indicator which assesses condition. Assessment of condition does not mitigate against older dry stone walls since condition is related to functional use, and not to age of walls or historical significance.

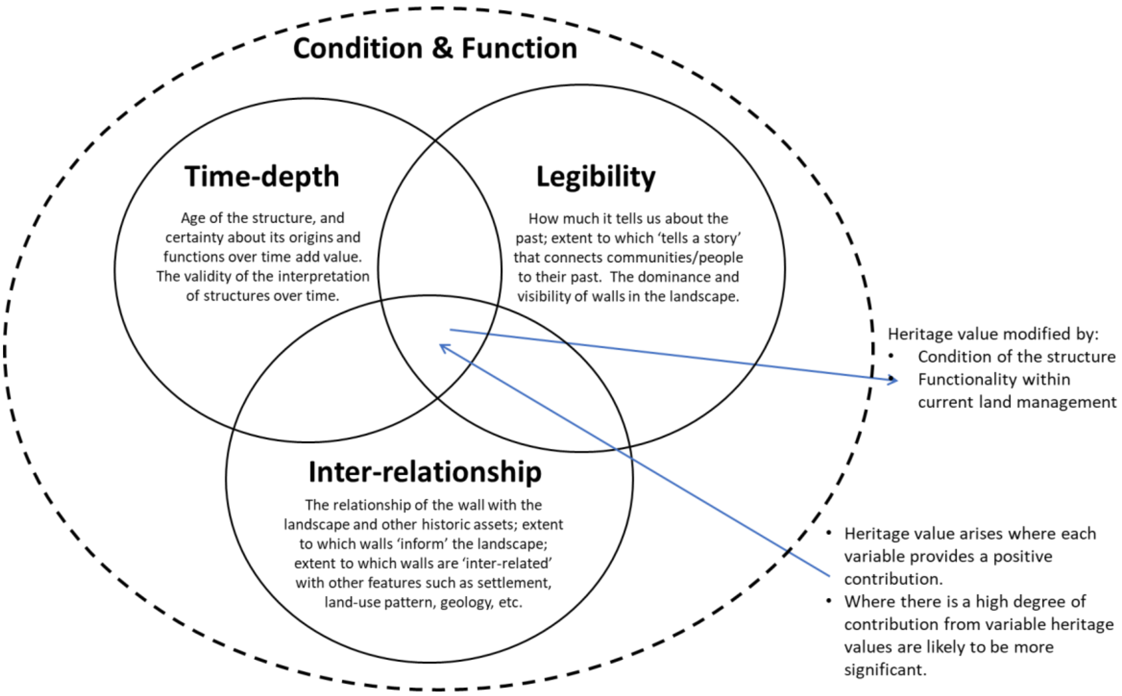

Figure 5: Factors contributing to heritage value of dry stone walls

3.3.1 Scoring for heritage value

The system developed for scoring the heritage value of dry stone walls was not designed for the assessment of individual walls. Ecosystem services are not easily assessed from single units of a feature in the landscape, but from how that landscape is put together and functions as a holistic unit. The approach works best at a scale from the NCA level down to the level of LCA units, parishes, farm holdings and groups of fields. Such areas, containing dry stone walls embedded into a managed landscape, are assessed and scored in terms of legibility, time depth, and interrelationships with other heritage assets: the rationale for this is illustrated and set out in further detail in Appendix F.

Legibility (visual and functional)

Addresses the question: to what extent are dry stone walls, as linear features; dominant, present or relict features, and so contribute to our experience of landscape? Scoring reflects the extent to which walls as linear features are present within, contribute to and help form landscape character, and thus contribute to the broadest range of ecosystem services.

- Very high: Walls make a dominant contribution to landscape character, due to their state of preservation, their density and their prominence due to landform.
- High: Walls make a strong contribution to landscape character, due to their state of preservation, their density and their prominence due to landform.
- Medium: Walls make a visible but in part fragmented and declining contribution to local character and distinctiveness, due to areas of collapsed and lost walls.
- Low: Relict 'wall landscape' where the walls, as a result of widespread collapse, appear as relict features and thus - although making a strong contribution to sense of place in representing a brief episode in land management - are less legible as heritage assets and make a much weaker contribution to the broadest range of ecosystem services.
- Very low: Walls make a barely discernible contribution to landscape.

Time depth

Addresses the question: what is the probable age of dry stone walling in an area? The scoring relates to how long, given the pattern of walling, walls have been part of the landscape, acknowledging that earlier coherent systems of dry stone walls have the highest significance because of their rarity.

- Very high: Patterns of dry stone walls retain clear evidence of medieval or earlier land use, which in the Peak District includes Romano-British and possibly even earlier walls. This comprises:
    - Ancient Enclosure (Pre-1650) of different types - where walls retain patterns of medieval strip fields, are rectangular (usually in the context of high-status sites and medieval stock farms) or irregular.
    - Relict medieval and prehistoric walls in unenclosed land, particularly important in the Peak District being those in the Eastern Moors which are associated with later walls linking them and subdividing formerly extensive areas.

- **High:** Area dominated by high potential for 18th century and earlier walls resulting from ancient or later piecemeal enclosure. In the Peak District this comprises Pre-1650 enclosure and Enclosures of Uncertain Date, fieldwork having shown that the latter can retain high potential for 17th century or earlier walls (or walls rebuilt on footings of this date) within groups of fields often subject to later enlargement and modification.
- **Medium:** Area dominated by Post-1650 enclosure, as shown on historic maps and mostly resulting from post-1750 enclosure and sometimes retaining traces of earlier boundaries. Also walls within areas of Unenclosed Land, which might be bounded by earlier walls but are mostly sparse and post-1750.
- **Low:** Sparse survival of dry stone walls in top two categories, due to post-1900 (mostly post-1950) enlargement of fields, which is indicated in HLC categories and can also be determined by comparison of the present pattern with that shown on 2nd edition Ordnance Survey maps.
- **Very low:** Sparse survival in areas dominated by Post-1650 enclosure, due to post-1900 (mostly post-1950) enlargement of fields. Fragmentary survival of Enclosed Land with dry stone walls in the area.

Inter-relationships

Addresses the question: to what extent do the dry stone walls in an area, as a result of their coherence and relationship with other recorded heritage assets, help 'tell the story' of landscapes and places and enrich 'sense of history and place'? Where walls from multiple periods exist, or can be traced, a higher score for inter-relationships is likely to result, thus the value of dry stone walls from multiple time periods will be reflected in a higher overall cultural heritage score. Scoring reflects the extent to which functioning and connecting networks of dry stone walls offer an historic setting to a diversity of heritage assets which have developed in a close functional (integral) relationship to them, including:

- Settlement, farmsteads and field barns and interconnecting routeways.
- Historic boundaries (to parishes/townships/counties, parkland, estates).
- Earlier land use features (e.g. ridge and furrow, lynchets) which have influenced the alignment of dry stone walls.

Dry stone walls may also relate to other heritage assets which are not so integral to their development but which also enrich our understanding of how landscapes have developed - e.g. the relationship of late moorland enclosures to long-abandoned settlements and field systems; industrial sites and routeways (including tramroads and railway lines); the earthworks of medieval land use and settlement (often crossed by survey-planned post-1650 enclosure) and earlier (including prehistoric) earthworks including ritual/burial sites, settlements and field systems.

- **Very high:** Areas dominated by Ancient Enclosure whose walls are an integral and coherent part of a settlement pattern inherited from the medieval period - 19th century or earlier farmsteads, field barns, routeways and other historic buildings which are an integral part of the settlement pattern; other heritage assets may also be present.

- **High:** All areas of historic enclosure where walls relate to settlement patterns and buildings whose historic character is well-retained and an integral part of how they have developed - 19th century and earlier farmsteads, field barns, routeways and other historic buildings; other heritage assets may also be present.
- **Medium:** Area of Post-1650 enclosure dominated by 19th century features - routeways, farmsteads and field barns, which may also include other heritage assets.
- **Low:** Areas with very few recorded heritage assets where walls do not have such a clear story to tell.
- **Very low:** Inter-relationships of dry stone walls to heritage assets very difficult or impossible to appreciate due to lack of identified examples or extent of post-1900 development.

4 AREA VARIATIONS AND CASE STUDIES

4.1 Introduction

One case study area was selected from each of the NCAs. This section presents a summary of the historic character of dry stone walls in each of these areas, including an overview of the heritage potential of areas within them using the Landscape Character Assessment, prior to assessment of the heritage value of each case study area (Appendix G).

4.2 Case study areas

The case study areas selected for detailed study are:

- Flash, South West Peak (SK 033679)
- Ughill Hill, Dark Peak (SK 291909)
- Tideswell and Litton, White Peak (SK 157759).

Each are broadly representative of the key characteristics of the NCAs in which they sit, with corresponding differences in the distribution of designations and in the patterning of HLC and LCAs (Figures 6 - 8).

Heritage designations are sparse in the selected case study areas (Figure 6). In the South West Peak being confined to the church and churchyard monuments at Flash (which is also a conservation area) in the Dark Peak being confined to the 17th century Ughill Hall to the north-east and milestones on the turnpike road which crosses the area to the south; and those in the White Peak area are confined to the medieval nucleated settlements of Tideswell and Litton, each of which are conservation areas. Conversely, and with the notable exception of the Site of Special Scientific Interest (SSSI) of species-rich grassland set within a steep-sided area of

Daleside Enclosure just south of Tideswell in the White Peak, area designations aimed at retaining and enhancing nature conservation are far more extensive in the South West and Dark Peak areas.

HLC permits a more seamless understanding of the potential Time Depth of dry stone walls in each area (Figure 7):

- The South West Peak area is dominated by Enclosure of Unknown Date, the key indicator of early enclosures within this area being the scatter of farmsteads with small-scale courtyard and dispersed plans - although with no recorded 18th century or earlier buildings. Moorland, associated with medieval and later coal mine workings, and former moorland, dominate the northern part of the area.
- The Dark Peak area is dominated by moorland and former moorland, with some Post-1650 Enclosure and associated farmsteads (all mostly of early-mid 19th century date) with the recorded 17th century farmstead site at Ughill being set within one of the earlier (pre-18th century) Enclosures of Unknown Date.
- The White Peak area is split between post-1650 enclosures and associated farmsteads (none with pre-19th century recorded buildings) and the Ancient Enclosure of fossilised strip fields around the medieval settlements of Litton and Tideswell.

The Peak District LCA (Figure 3) similarly enables enable initial identification of time depth, but not so easily or readily as with the HLC (Figure 4). The White Peak area broadly matches the analysis presented in the HLC, with a strong distinction between the Limestone Village Farmlands and the Limestone Plateau Pastures to the north and a strip of unenclosed Daleside Pastures (Medium Potential) to the south. There is not such an exact match in the South West Peak area, which makes a broad distinction between the northern part of the area - Open Moors to the north-west (Low Potential) and the Moorland Hills and Ridges - and the southern part of the area - Densely Enclosed Gritstone Upland, Upland Pastures and Upper Valley pastures (High Potential). The Dark Peak area has Open Moor (Low Potential) subdividing Moorland Slopes and Cloughs (Medium Potential) with mostly post-1750 farmsteads from older enclosures and farmsteads in the Upper Valley Pastures.

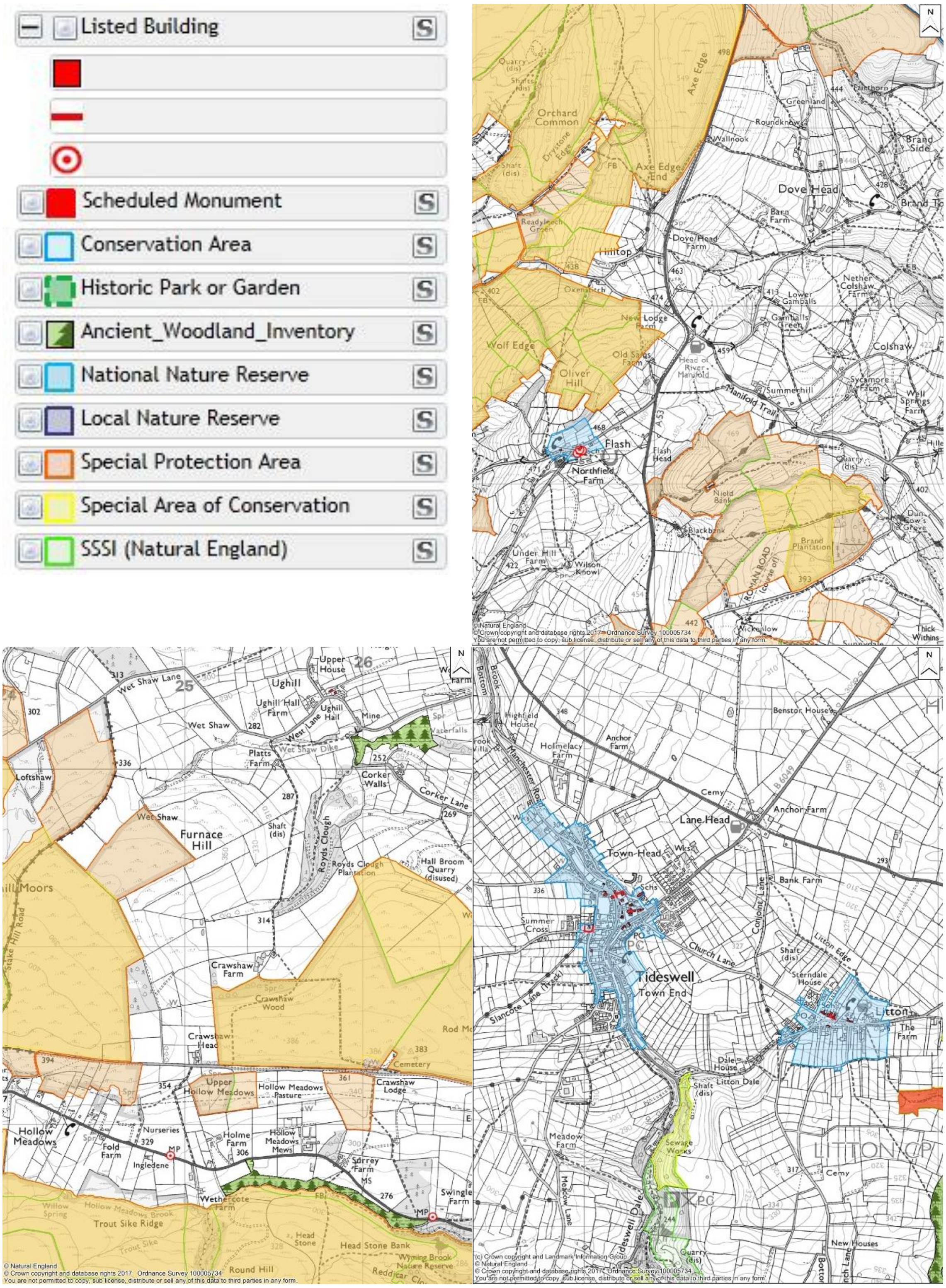

Figure 6: Designations in case study areas. South West Peak (top right), Dark Peak (bottom left) and White Peak (bottom right)

Figure 7: Historic Landscape Character in the case study areas. South West Peak (top right), Dark Peak (bottom left) and White Peak (bottom right)

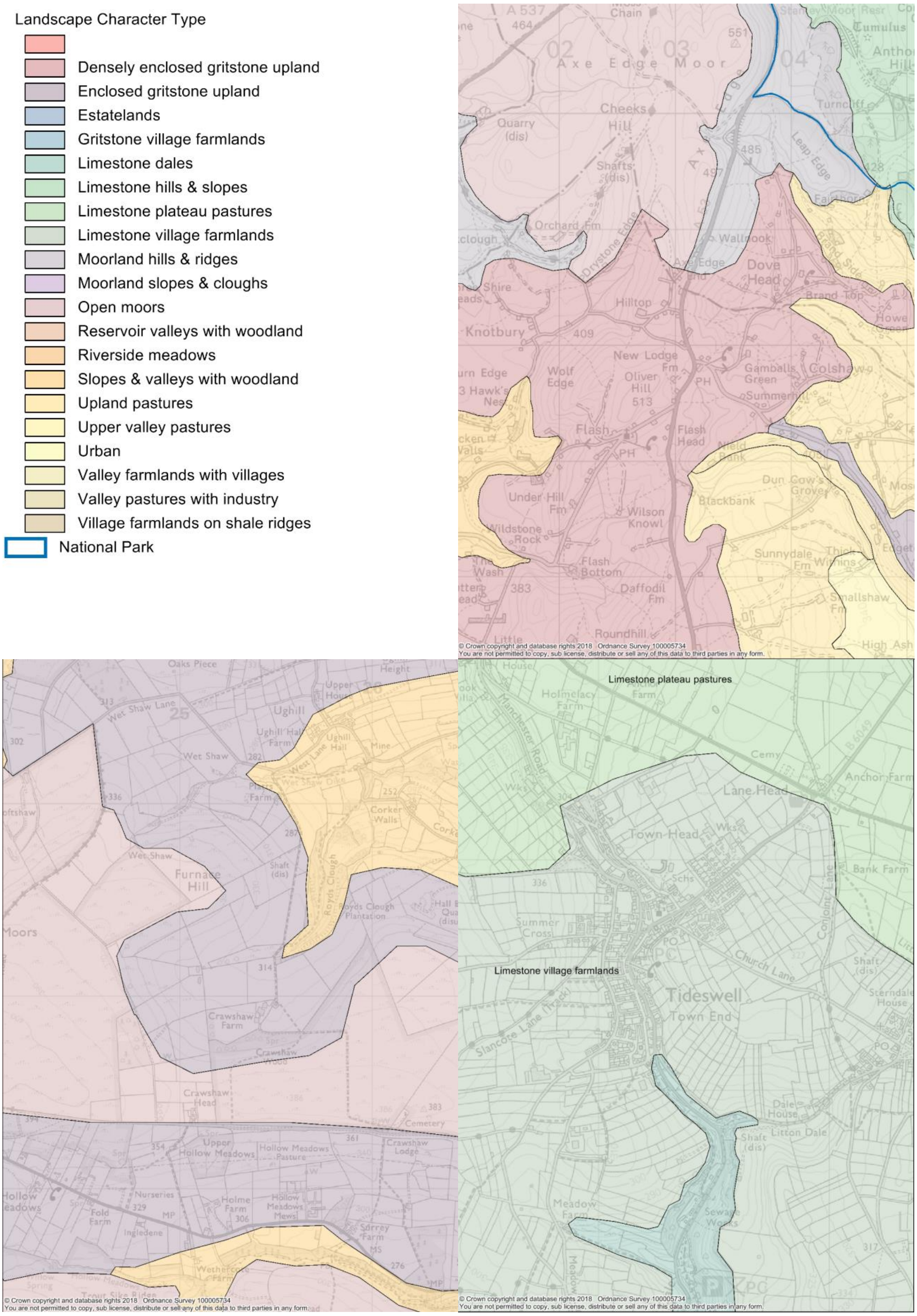

Figure 8: Landscape Character Types in the case study areas. South West Peak (top right), Dark Peak (bottom left) and White Peak (bottom right)

4.3 Flash, South West Peak (SK 033679)

Enclosures of Uncertain Date dominate this area, and the form of the field boundaries in the area of Post-1650 Enclosure around Dove Head to the north hints at earlier origins. There are two small areas of identifiable Ancient Irregular Enclosure of medieval or earlier date to the north east. There is no recorded evidence of fabric pre-dating 1750 in any of the area's farmsteads, although most of them - including cattle farms or vaccaries belonging to outlying estates - occupy sites that have almost certainly been in continuous occupation since at least the 13th century and were sited in field enclosures established by the same period. This is reflected in the predominance of linear farmsteads, where cattle were housed in the same range as the farming family, and the survival into the late 19th century of dispersed-plan farmsteads characterised by stock pounds. The area is traversed by a Roman road. The Leek-Buxton road was realigned to run through Flash by 1749. Its church - around which button making developed in this period - was built in 1744 and rebuilt in 1901, and a Wesleyan chapel of 1821 testifies to the importance of Nonconformism to its farming community.

The moorland (Open Wastes and Common on the HLC key) including Axe Edge and Orchard Common is traversed by some very late dry stone walls, including some set around quarries, pits and shafts. Both were areas of small-scale but extensive coal mining combined with farming, with probable origins in the medieval period and intensifying on a more commercial scale from the 16th-17th century. Much has reverted to scrub.

Figure 9: Flash. View looking east from moorland in the north of the case study area

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4.4 Ughill, Dark Peak (SK 291909)

This area is scattered with kernels of Enclosure of Uncertain Date, one of which relates to the medieval site at Ughill Manor, surrounded by Enclosed Moorland and post-1650 enclosure. The substantial Regular Courtyard farmsteads at Ughill Hall, Platts Farm, Corker Walls and Surrey Farm clearly made use of kernels of continually manured and farmed 'infield' in a sea of open grazing. Crawshaw Farm and Crawshaw Head, newly established in post-1650 Parliamentary Enclosure, were similarly large in scale and in contrast to the predominant small-scale areas of enclosure by private agreement across the south of the map.

Sinuous routeways form an integral part of the Enclosures of Uncertain Date, which in combination with the evidence for earlier buildings again suggests earlier origins. Crossing the map to the south is a late 18th century turnpike road, marked by listed milestones, which prompted the development of allotments and buildings to either side.

Figure 10: Ughill. View looking south towards moorland.

4.5 Tideswell and Litton, White Peak (SK 157759)

This is a classic White Peak landscape, with enclosures immediately around the villages being derived from the medieval strip fields that once surrounded Tideswell and Litton. Listed buildings on medieval plots are concentrated in each of the Tideswell and Litton conservation areas, only the latter including the distinctive and tight-knit patterns of dry stone walls around them as a contextual landscape. To the south of Tideswell is an area of Daleside Enclosures, valley-side pastures, used as such from the medieval period, which were partly enclosed post-1650. The Enclosures of Uncertain Date to the north may represent enclosures pre-dating the post-1650 enclosure which dominates this area and is characterised by a low density of small-scale farmsteads.

Lead mining and sheep farming characterised this area from the medieval period. Tideswell was granted a market in 1251 and at its core is one of the finest 14th - century churches in the area - the 'Cathedral of the Peak'. To the south-east is part of the scheduled mining complex consisting of Arbourseats Veins and Sough, Wardlow Sough, Nay Green Mine and washing ponds, Hading Vein and Seedlow Rake, dating from the 18th and 19th centuries but with earlier origins. Beyond the area to the north is Tideslow Rake, part of one of the major lead rakes traversing the Peak District landscape. This rake is documented as being worked in 1195. The low density of field barns hints at sheep farming being the main driver of enclosure here.

Figure 11: Tideswell and Litton. Views across enclosed medieval strip fields (left) and early 19th century regular enclosures (right).

5 APPLYING THE METHODOLOGY

5.1 Heritage accounting framework: dry stone walls model

Within the constraints of data availability set by the project, an accounting model was developed to explore the monetary value of ecosystem service flows arising from dry stone walls in the PDNP. The model was applied to three different LCAs within the PDNP but resource constraints limited testing across a wider range of landscapes. Dry stone walls have been conceptualised within an ecosystem services framework. Literature review and stakeholder discussion identified key functions of dry stone walls within the PDNP (see Appendix A and H). Each function was then characterised as a flow of benefits over time, and the beneficiaries identified using an Excel spreadsheet. The model takes a basic ROI approach identifying maintenance and restoration costs as well as benefit flows based on a 50-year time cycle. Costs and benefits are discounted using recommended discount rates as found in the Treasury Green Book.[14]

Figure 12 below illustrates the generalised layout of the model. The three distinct case study areas described in Section 4 (each one approximately 7.5 km^2) were selected in order to capture the variability in function, condition, and development pattern of dry stone walls across the PDNP. Understanding of the historic characteristics of dry stone walls in each case study area, based on rapid survey and reference to available data, were fed into separate runs of the model, along with data on farming activity, historical development pattern, landscape features, and biodiversity contribution of dry stone walls within a local context. The ecosystem service functions provided by dry stone walls (Functions) were converted into benefit flows (e.g. livestock shelter, sense of history, ecological resilience), which were then assigned monetary valuation utilising financial surrogates or ‘approximations’.

[14] HM Treasury (2018) The Green Book: Central Government Guidance on Appraisal and Evaluation. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

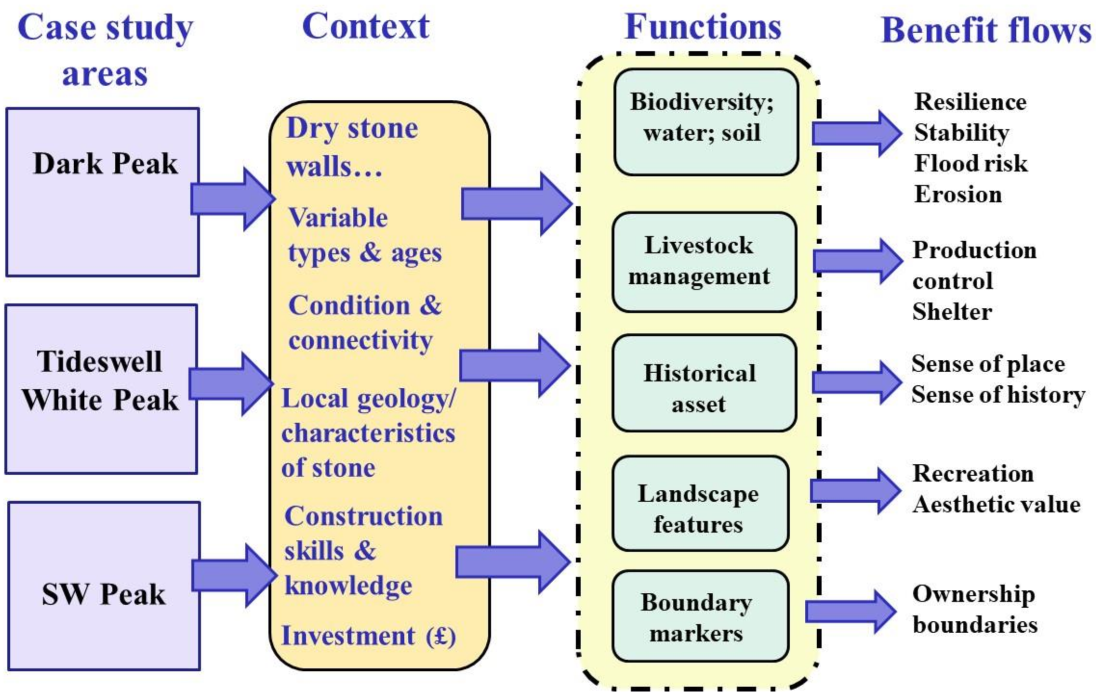

Figure 12: Overview of the conceptual framework

The basic structure of the accounting model is illustrated in Figure 13. All service flows are measured on the basis of the total annual provision within a defined area, based on the total length of dry stone walls in the area:

- Once the service flows from dry stone walls have been identified and allocated to one of the four ecosystems service categories (top left hand corner of the diagram), the next step is to identify the type and number of beneficiary. This will vary for each service 'flow' depending on the nature of the service and the level of utilisation. A provisioning service, for example, that enables farmers to manage livestock, may only be utilised by certain livestock farmers, who are the prime beneficiaries. A cultural service, such as the historic value of dry stone walls, might be 'utilised' by all residents and visitors to an area. Calculating the total level of service flows utilised requires information on the type and number of each beneficiary for each service flow.
- The level of each identified service flow is measured by an 'indicator' which is a means of assessing the 'scale of delivery' and tailored to each service flow. Thus a 'flood control' service might be assessed through a scale that determines the potential for walls in an area to impeded overland flow of water and reduce flood impacts, whereas a cultural heritage value of dry stone walls might be based on an integrated scoring system taking into account historic value. Relevant indicators must be constructed for the outcomes from each identified service flow.
- The level of ecosystem service delivered is modified through a measure of condition of dry stone walls in an area (taking into account the number and extent of gaps and collapsed wall).

- Ecosystem service flows delivered are based on the total length of dry stone walls in the area of interest. Thus, the greater the linear distance the higher the level of a particular service delivered.
- Financial proxies (approximate values) are identified using market data where possible. Where no market prices exist (e.g. value of a landscape) then non-market values are applied. Proxie values are selected that mimic as closely as possible the type of service delivered. Thus, a provisioning service such as 'shelter for livestock' provided by dry stone walls can be valued by identifying the cost of purchasing and erecting animal shelters for the same number of animals that are present on an average farm. All proxy values are expressed in the model on the basis of value (£) per kilometre of wall.
- Multiplying the proxy value per kilometre of wall by the level of services delivered in an area provides an annualised current value for the total length of wall in a defined area.
- The annualised current value is modified through depreciation and discounting. The depreciation of dry stone walls over time is calculated over the 50-year programme cycle to account for deterioration due to weather, animal, and other sources of damage. Depreciation is set at 0 for the first 10 years and then slowly increase to a maximum 40% after 40 years. The depreciated values are then modified using a 3.5% discount factor and each annual value over 50 years is summed to arrive at the total present value for each service flow.
- Total present values (PVs) for each service flow are summed to arrive at the total value of ecosystem service flows over the 50-year period, which can then be compared to the total current value of the costs of maintenance and restoration over the same period.

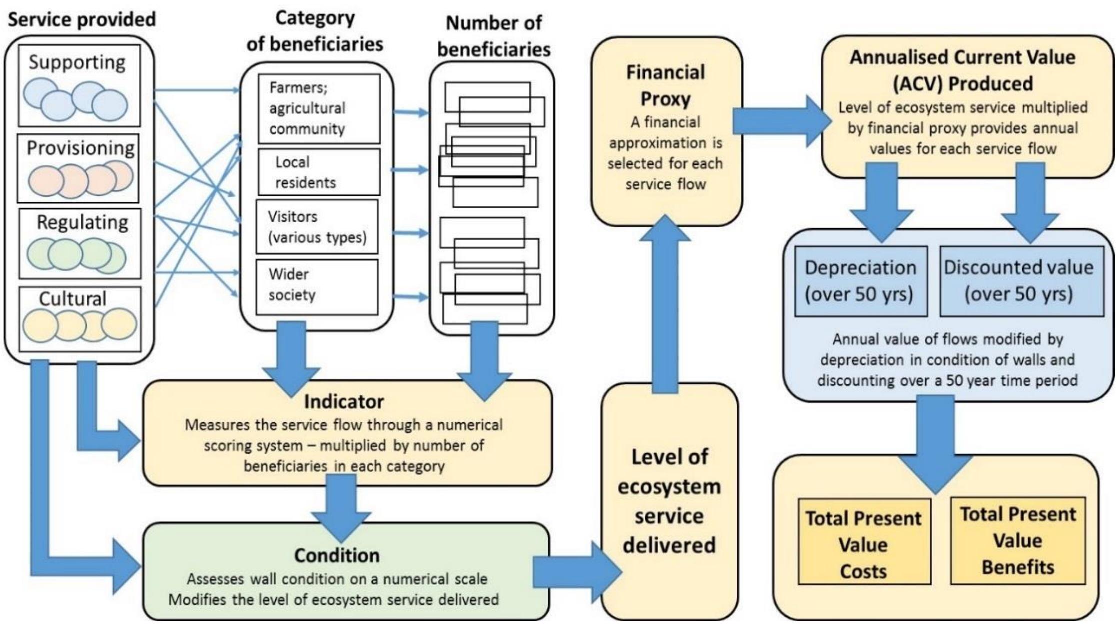

Figure 13: Structure diagram of the return on investment (ROI) model

5.2 Model operation

The model is a basic form of CBA which examines streams of costs (in the form of restoration, maintenance and repair costs) and benefits over a multi-year period (currently the time frame utilised is 50 years). Figure 13 illustrates the overall model structure.

The operational steps are as follows:

Step 1: Identify ecosystem services originating from dry stone walls under each of the four categories of ecosystem service.

Ecosystem services generated by walls

Step 2: For each service identified determine the nature of benefits flowing, and who benefits:

- The form of the benefits flowing from each service.
- The magnitude of each flow of benefits.
- The number and type of beneficiary (e.g. farmers, visitors, community residents, etc.).

Flows of benefits arising from each service

Number and type of beneficiaries

Step 3: Determine how each benefit flow will be measured (e.g. a benefit such as livestock management might be measured in terms of sheep protected per kilometre of wall; sense of place might be measured by kilometre of dry stone walls in a defined area and an indicator reflecting strength of the association between walls, the landscape, and well-being of community residents). Indicators are identified for each ecosystem service which produces a flow of benefits. Additional indicators can be used to modify the flow of benefits from a particular service depending on its quality, magnitude, or strength. Thus, an indicator can assess condition of dry stone walls and modify the benefit flows generated from services by decreasing or increasing the size of the indicator. A wall in poor condition would be given a low indicator score, thus lowering the level of benefits flowing from a particular service. Different indicators can be allocated to the same area/section of dry stone walls for each service provided if necessary, to account for variability of benefit flows resulting from a particular condition. Walls in poor condition with many gaps, for example, may have a low condition indicator score in relation to benefit flows relating to livestock management, a medium level score in relation to ecological services (as the walls still provides habitat for certain species), yet maintain a high score for cultural heritage due to its historical significance in the area.

Indicators for each flow of benefits

Step 4: Valuation of benefits. The services that produce benefit flows for identified sectors of society are valued using surrogates, or 'financial approximations', which match the magnitude of a benefit received with a market-based estimation of its worth. Since benefits such as 'sense of place' do not have market values, some form of approximation is required. Financial approximations are intended to 'reflect the value' of a benefit acquired, rather than be regarded as a fixed measure of monetary worth. The aim is to identify the price that is actually paid in market transactions for similar categories of benefits (i.e. what people actually pay to acquire a similar benefit). The CBA accounting framework recognises this may not reflect the actual worth of a flow of benefits to an individual, it is only an approximation based on ability to pay a market price (which not everyone may be able to afford). The advantage is that it allows us to represent flows of unpriced social and environmental benefits in terms of monetary value, which can then be compared to each other, and to construction, restoration, maintenance, and repair costs.

The model outcomes are clearly sensitive to the choice of financial approximations, so discussion is required, and agreement on the values selected. One clear benefit of the model is that different financial approximations can be applied to explore the sensitivity of the model outcomes to changes in one or more financial approximation.

Financial approximations for each benefit flow & category of beneficiary

Step 5: Financial approximations are multiplied by both the number of beneficiaries (there may be several categories of beneficiary for each benefit flow), and by the indicator selected for the benefits flowing from each different service provided.

Benefit flow 'A' = Financial approximation X Number of beneficiaries X Indicator Value

Benefit flow 'B' = Financial approximation X Number of beneficiaries X Indicator Value

⋮

Benefit flow 'n' = Financial approximation X Number of beneficiaries X Indicator Value

Step 6: Discounting over time. Standard discounting approaches (HM Treasury Green Book) are then applied over the relevant time frame for both costs and benefits. The model currently uses the Treasury Guidance to select 3.5% as the discount rate. For each year of the time period the benefits are assessed and then discounted back to present value. Discounted values for each year across the time period (currently 50 years) are summed to provide results in terms of total present value of future flows of costs and benefits, which can then be compared.

The final output from the model is therefore not a measure of the value of dry stone walls at a single point in time, but a measure of the value of the benefits flowing to society from the services provided, over a 50-year time period, along with a measure of the costs of maintaining a constant flow of those benefits over that period.

Tables 1 and 2 below are a simplified illustration for the key elements of the model (only cultural services are shown, although the same approach was taken for all service categories). Each identified 'flow' of services is represented on a separate line, which enables service flows to be valued individually and in categories (i.e. provisioning, supporting, regulation, cultural). The model has been designed to account for variable size of the selected 'character area' (i.e. the area of interest for analysis). The model operates as follows:

- Each service flow is assessed through some form of indicator which measures the quantity or 'level' of service delivered. Indicators vary with each identified service flow depending on the type of service and the nature of the beneficiaries. In the dry stone wall model, the majority of indicators are measured on 1 – 5 scales which are then scored by stakeholders with specific expertise. For example, the level of livestock management services delivered by a particular set of dry stone walls in a landscape might be assessed by livestock farmers, while the contribution to ecological biodiversity in an area might be assessed by local ecologists.[15]

[15] Note: as the project is a small-scale project to develop a valuation model the results presented in this paper arise from assessments made by the project team following stakeholder discussions (e.g. with farmers, dry stone

- The 'level' of each service flow is then modified by assessment of its condition. Condition is the key variable and assessed on a 1 – 5 scale (where 1 = very poor condition with significant gaps and collapsed sections; 5 = complete walls with little evidence of missing stones or gaps). Condition assessment requires ground surveys in order to observe the current state of dry stone walls. For the purposes of this study, in relatively small areas, ground assessments were made by project team members based on driving around the case study sites to obtain a general indication of state of the walls. In practice a condition survey would be required (perhaps based on geographic information system (GIS)-supported sampling) in order to arrive at an average condition score for a defined area. It would not be possible to undertake a condition survey without some form of 'ground-truthing' since care must be taken to differentiate between a more permanent deterioration in wall condition and temporary gaps. Wall collapse can occur, for example, from a period of bad weather, and a hard winter might result in a larger than usual number of gaps in walls, which are then often restored during the spring and early summer. Timing of any condition assessment is therefore critical.
- Condition is also related to current functions of dry stone walls; walls that are functional (in the sense that they continue to perform the function for which they were originally built) are likely to have more resources invested in maintenance and restoration and are likely to be more robust, than those that no longer perform an economic function. Walls may also be modified with varying amounts of wire fencing and/or netting to manage and reduce damage from livestock.
- Table 2 is a continuation of the model structure assigning monetary value to each ecosystem service flow. A financial approximation (a 'proxy') is assigned to each service flow (see Appendix H for more detail). Wherever possible proxies are based on market prices of similar goods and services to those delivered through the ecosystem service being valued. Thus, for example, in order to assess the value of livestock shelter provided by dry stone walls the price of purchasing animal shelters is utilised. The match is not perfect as a purchased livestock shelter would have to be in a fixed position and owing to construction would have a limited lifetime (compared to a wall). These factors are also taken into consideration in the determination of expenditure required to provide an alternative to the shelter function, and hence value, provided by dry stone walls. Where no market prices exist for specific ecosystem services provided (e.g. the value of biodiversity, or the aesthetic value of landscape) then non-market valuation studies are used as a guide to determine the value of the benefits flows.
- Financial proxies are multiplied by the level of services provided for the total length of dry stone walls in the defined area of interest to derive an annual monetary value for the flow of each defined benefit in the model.

wallers, landscape ecologists, park managers, and planners in the PNDP). In practice a certain amount of empirical data would be collected from a wider range of stakeholders.

- The remainder of the model accounts for depreciation in the condition of dry stone walls over a 50-year time horizon and discounts the stream of annual benefits back to present value (using a 3.5% discount rate).

Table 1: Part 1: Structure of the accounting model for dry stone walls

Service category	**Wall length**	**No. & type of beneficiary**	**Service(s) & Function(s) delivered**	**Indicator**	**Condition**
Cultural	Km in the case study area	Variable by case study area	Variable within case study areas	Based on characteristics of services delivered	Variable by wall
Supporting					
Provisioning					
Regulating					

Table 2: Part 2: Structure of the accounting model for dry stone walls

Service category	**Financial proxy**	**Current value generated (per year)**	**Depreciation over 50 yrs**	**Value generated per yr**	**Total value**	**Present value of benefit stream**
Cultural	Varies with service	Based on linear extent of wall & number benefitting	Variable 0.03 – 0.4	1 – 50 yrs	Over 50 yr cycle	Discounted to present
Supporting						
Provisioning						
Regulating						
Total discounted benefits (over 50 yrs) **Total discounted maintenance costs** **Benefit – Cost ratio**						**£ benefits** **£ costs** **Ratio**

5.3 Model outputs

The output from the model includes the following:

- Present value of the discounted maintenance and restoration costs over a 50-year time horizon.
- Present value of the discounted ecosystem service benefit flows over a 50-year time horizon.
- A benefit to cost ratio based on the present value of the 50-year streams of costs and benefits.
- Identification of the contribution of each category of ecosystem services to the total present value of the stream of discounted benefits.
- Identification of the contribution of each individual ecosystem service flow to the total present value of the stream of discounted benefits.

Ecosystem service values were calculated in two ways: first, by developing a model based on values assigned to the PDNP as a whole; and secondly, through aggregating values based on case studies which were selected to reflect the variability in density, function, and condition of dry stone walls across the wider National Park. Case study areas were relatively small (around 7.5 km^2), and selected to represent specific characteristics as set out in Section 4: it is important to note that resources for GIS data were not available, the intention being to explore methods. Even within these areas there was some variability in condition, function, and utilisation of dry stone walls. Dominant characteristics of case study areas were utilised to assess level of service flows and condition. The accounting model is currently based on a 50-year time horizon and PVs of ecosystem service flows are discounted using a 3.5% discount rate.[16] Sensitivity testing on the discount rate and time horizon have not yet been carried out.

Table 3 provides the summary model output data for the three case study areas and for the modelling of the PDNP as a whole. The pattern of Benefit-cost ratios (BCRs) matches the expectations based on field assessment of the walls in each area. The Tideswell area stands out as providing the highest return in benefit flows in relation to restoration and maintenance costs (9.96 to 1) over the 50-year time horizon. The Tideswell case study area has a greater density of dry stone walls than the other two areas, overall in good condition, and having a much larger impact on the landscape. In addition, the cultural heritage indicator score is high due to strong values of time depth, inter-relationship with other historical assets, and legibility. Other factors influencing the high level of benefit flows are the larger residential population and a larger number of visitors[17] compared to the other two case study areas. The model is assessing value of service flows to different stakeholders and is thus sensitive to the number of beneficiaries identified for each service flow. This is reflected in the relatively high overall level of benefits generated from the ecosystem services provided by dry stone walls in the area. A foundation of the model is that all service flows provide value to some individual or group of persons, and the larger the number of persons benefitting, the larger the value of the service (relative of course to the size of the financial proxy being utilised).

[16] HM Treasury (2018) estimated

[17] Note: annual visitor numbers were as no data exists for the three defined case study areas.

Table 3: Summary output data from the accounting model (dry stone walls)

Defined Area	Total Present Value of ecosystem service benefit flows (£) (50-yr time horizon)	Total Present Value of maintenance costs (£) (50-yr time horizon)	Benefit-Cost Ratio (£)
Ughill Case Study Area (Dark Peak)	£4,538,915	£999,428	4.54
Tideswell Case Study Area (White Peak)	£36,722,574	£3,688,365	9.96
Flash Case Study Area (SW Peak)	£1,155,123	£1,102,310	1.05
PDNP Overall	£192,114,930	£113,660,444	1.69
PDNP value: aggregated up from case study areas	£668,710,418	£136,056,590	4.91

The Flash area in the South West Peak has the lowest BCR at 1.05 to 1. The area is characterised by a shorter overall length of wall, walls in poorer condition with significant gaps and areas of collapse. This legibility is combined with greater uncertainty with regard to time-depth, the key inter-relationships with other heritage assets elements in the landscape being a dispersed settlement pattern of farmsteads with recorded for the first time on 19th century maps. The result is a less coherent story in terms of cultural and historical activity that now delivers ecosystem benefits and flow. Whilst this is a significant factor in consideration of options to invest in walling, it raises the issue of accepting dereliction as a significant contributor to sense of place that can be managed and interpreted in a positive way – the declining condition of dry stone walls adding to a strong sense of the marginal and hard-fought character of upland farming in this exposed location. The value of a ROI model such as that described here is that it can be modified to take into account a wide range of outcomes, including outcomes arising from declining condition of dry stone walls. Outcomes, however, must be specified through a process of developing a 'programme logic' at the start of the model-building in order to be included, and indicators developed to measure such identified outcomes.

The Ughill area in the Dark Peak is somewhere between the two extremes with approximately the same linear length of wall as in the Flash area, but in better condition, and a more legible pattern of development, however, both residents and visitors are low in number.

The final two rows of Table 3 provide values from two alternative approaches to assessing value of dry stone walls across the entire PDNP. The approaches are described below.

5.3.1 Approach 1: Assessing values of ecosystem services across the entire PDNP area

The basic accounting model was revised to utilise national park area data for:

- Length of dry stone walls.
- Visitor numbers.
- Farm holdings.
- Agricultural area.
- Population and number of households.

Visitor numbers are high (estimated at over 9 million in 2015) though the model only included the proportion of visitors identifying scenery and cultural heritage as an important reason for visiting.[18] In addition visitor data were disaggregated to take account of day and overnight visitors. Present value of the total benefits generated over the 50-year time horizon are in the order of £192.1 million, and restoration and maintenance costs £113.6 million, creating a BCR of 1.69 to 1.

There are difficulties in operating the accounting model at this scale, in particular the failure to capture spatial variability in condition and cultural heritage value of the walls, which results in generalised scoring across large areas. The low BCR of 1.69 perhaps reflects a 'below average' score utilised to assess the current condition of dry stone walls within the Park boundary, and functional values estimated by farmers. Even though the PDNP is highly variable in terms of the current condition, use and contribution to landscape character of dry stone walls and their historic character and relationship to settlement patterns and heritage assets, a single score had to be applied across the whole area. The overall value obtained is thus quite sensitive to the selected scores as measured by the cultural heritage scale and condition scores. The main weakness in undertaking the analysis at this scale is the inability of the scoring process to capture local variability resulting in a dominance of the characteristics that are most prevalent across an area.

The alternative approach, to aggregate up from the case study areas to the whole National Park level, provides a significantly higher overall value of ecosystem service benefit flows and BCR outcome, as it enables some of the variability from the case study areas be captured. The next section describes this process and the model outputs.

[18] The Visitor Survey identified 0.05 of visitors indicating cultural heritage, and 0.57 of visitors indicating scenery, as a reason for their visit.

5.3.2 Approach 2: Aggregating from the case study areas to the Peak District National Park Level

Using the variability in the case study areas to estimate ecosystem service flows and benefits streams across the entire PDNP area presents some difficulties due to lack of detailed information on the pattern and length of dry stone walls, and on condition and function. As a result, the data presented here can only be considered as an approximation of values based on expert judgement of the spatial extent and representativeness of each case study area across the larger national park area.

In the absence of GIS data, it is difficult to present anything more than a professional judgement concerning the 'representativeness' of the case study areas. Although each case study areas can be subdivided using time-depth, it is best to consider the representativeness of each case study area as a whole and caveat this through additional information.

The maps from the farmsteads mapping report (Figure 4) powerfully demonstrate the links between HLC-types (Time Depth) and farmstead date and types (Historic Context/ Inter-Relationships). The analysis and model outputs would have higher validity if the information on which these maps are based were available in some form (as data sets or some form of GIS), along with current information on wall condition. The maps show, in terms of approximate proportions:

- Pre-1650 enclosure (also termed Ancient Enclosure) comprises:
    - Medieval Strip-Fields - light blue (12%).
    - Rectangular and/or Irregular Fields - dark blue (3%).
- Post-1650 enclosure - yellow (21%).
- Enclosures of uncertain date - pink (25%).
- Unenclosed land - brown (35%).
- Woodland and scrub - green (3%).
- Parkland - red (1%).

Figure 2 is also helpful in providing an overview of areas dominated by hedges, walls and open moorland. Using this information together and based on the characteristics of the three case study areas we can make the following assumptions regarding the extent to which the case study areas are characteristic of the larger national park area.

In terms of how each area is representative of the historic character (as a combination of Time-Depth, heritage context, and inter-relationships) of the PDNP as a whole:

- The White Peak case study area is representative of 27% of the Park (and most of the White Peak), the small area of Daleside Enclosures (in green) being representative of a very small proportion of Unenclosed Land (1% of the whole).

- The South West Peak area is representative of 23% of the Park, as – besides areas of Open Moorland (see below) - it is dominated by Enclosures of Uncertain Date, Post-1650 enclosure (probably of moorland post-1750) and Ancient Irregular enclosure in the northern third of the map.
- The Dark Peak area is representative of 15% of the Park, as – besides areas of Open Moorland (see below) -it is dominated by Post-1650 enclosure (probably of moorland post-1750) and with pockets of Enclosures of Uncertain Date where the earliest enclosures probably lie.
- Open moorland, including some areas of very late and large/ redundant sheep pastures enclosures, is representative of 35% of the Park.

Model outputs
Using these calculations, the accounting model was revised to estimate the value of ecosystem services over the entire PDNP. The outputs are contained in Tables 3 and 5, which summarise the outputs from the model.

The final row of Table 3 ('PDNP value: aggregated up from case study areas') illustrates the value of the ecosystem service benefit flows over a 50-year time horizon. The discounted flow of benefits is in the order of £668.7 million compared to restoration and maintenance costs of £136 million, providing a BCR of 4.91 to 1. The difference in value from the overall PDNP value (found in the row above in Table 3) derives from the fact that variability, and the high rates of return from cultural heritage values in the White Peak area, have a proportionally greater influence on overall benefit estimates.

The model requires some refinement, particularly with regard to the assumptions made about the following issues:

- Number of farmers, farm labourers, and farm holdings.
- Proportion of dry stone walls utilised by farm holdings (and their condition).
- Length of dry stone walls in the case study areas.
- Condition of dry stone walls across the PDNP.
- Visitor numbers to different parts of the PDNP.

There is currently limited scope for refinement due to data gaps and lack of information that would enable relevant calculations to be made.

5.4 Contribution of the categories of ecosystem service flows to total value

Table 4 provides an overview of the proportion of benefits contributed by the four categories of ecosystem services. The Tideswell case study area, where 65% of total benefits come from cultural services, illustrates the significance of cultural and historical value arising from dry stone walls in an area where they make a significant impact on the landscape, ('create' the landscape) and the time-depth, inter-relationships with other historic assets, and legibility are all high. The proportion from 'provisioning' services (i.e. agriculture) is also considerably lower than the other two areas. This is not surprising given the limited agricultural activity (in terms of commercial farm holdings) and predominance of tourism in the case study area.

At the other end of the spectrum both Flash and Ughill case study areas have similar profiles with a relatively small proportion (21 – 26%) of total value contributed by the cultural heritage value. In some ways the areas are similar (upland, sparsely populated, low visitor numbers), although a key difference is the condition of dry stone walls with the Flash area having walls in poorer condition, and lower contribution from provisioning services. For the PDNP Overall model, just over half of benefits come from cultural services but only 14.9% from Provisioning services (i.e. mostly agricultural benefit flows).

Table 4: Contribution of each ecosystem service category to the Total Present Value (%) by defined area

Ecosystem Service Category:	Contribution to Total PV (%)			
	Ughill area (Dark Peak)	Tideswell area (White Peak)	Flash area (SW Peak)	PDNP Overall
Cultural	21.9	65.0	25.8	53.6
Supporting	37.9	16.3	45.6	29.5
Provisioning	40.1	18.7	28.2	14.9
Regulating	0.1	0.0	0.4	2.0
Total	100	100	100	100

Table 5: Contribution of each ecosystem service category to the Total Present Value (%): Values derived by aggregating up from case study areas

Ecosystem Service Category:	Contribution to Total PV (%)			
	Ughill area (Dark Peak)	Tideswell area (White Peak)	Flash area (SW Peak)	PDNP Overall
Cultural	51.5	61.2	48.7	53.82
Supporting	33.8	27.9	32.5	31.42
Provisioning	14.1	10.6	18.5	14.38
Regulating	0.5	0.4	0.3	0.38
Total	100	100	100	100

It is interesting to compare the results from Tables 4 and 5. Table 4 contains the outputs from the basic case study models, while Table 5 contains the data from the case study models aggregated up to PDNP level. The most noticeable changes are:

- Large increases in the proportion of benefits flowing from cultural services for the Dark Peak and South West Peak areas.
- Reductions in the proportion of benefits flowing from Provisioning services.
- Regulating services are virtually unchanged, while Supporting service values alter across the case study areas.

The large number of visitors undoubtedly influence the overall values derived from cultural heritage, and the magnitude of visitor numbers (and benefit flows generated) have the effect of overwhelming other valued service provision (e.g. provisioning services flowing from agricultural activity). Refinement of the models with respect to the locational focus of visitor activity, and more comprehensive farm data might modify the proportional flows of benefits to some extent. Revised models might reflect the importance of dry stone walls to the agricultural sector, but with such large visitor numbers, the benefit flows from cultural services will continue to predominate when comparing the overall ecosystem service values of dry stone walls.

5.5 Discussion points

The accounting model is a pilot to test the feasibility of taking an ecosystem services approach to valuing the cultural heritage value of features such as dry stone walls.

5.5.1 Current weaknesses in the model

Gaps in the data
As with any modelling approach, a number of assumptions have been made regarding variables where data was not available (or available at the correct scale). These include:

- Length of dry stone walls by case study area has been derived from OS map-based sampling within case-study areas.
- Condition of dry stone walls by site/case study area. Condition was assessed through expert judgement of local stakeholders and field visits. Ideally some form of sample surveying would be required utilising a template for data collection; GIS with ground-truthing might provide an alternative way forward.
- Estimates have been made of the following:
    - Number of farm holdings/farmers in the case study areas.
    - Agricultural land in the case study areas.
    - Resident population in the case study areas.
    - Number of visitors in the case study areas.
    - Proportion of dry stone walls contributing to biodiversity through provision of shelter/habitat.

- o Proportion of dry stone walls contributing to shelter for livestock (which is more important for farms in upland areas).

Much of the data identified above is available at the PDNP level but not for the smaller case study areas selected on the basis of coherent wall patterns.

Current functionality and condition
Condition of dry stone walls is closely related to functionality. Where walls no longer perform the function for which they were constructed their condition tends to deteriorate. However, it can difficult to differentiate between long-term deterioration of dry stone walls where the functions are no longer valued, and temporary reductions in condition due to severe weather which might cause unduly large numbers of gaps and collapse of dry stone walls. Determination of condition thus requires some knowledge of agricultural activity in an area and expert judgement. That judgement must then feed into a process of understanding the impact of condition and function of dry stone walls on inter-relationship across a landscape and changes in legibility ('the story that can be told').

Scale
For the purposes of this study four models were developed: one covered the whole National Park, and three examined dry stone walls in distinct character areas each 7.5 km^2. At both scales there were issues that require attention. At the National Park level there was good quality data on residents, visitor numbers, and agricultural activity. Using indicators to measure variables such as the contribution of dry stone walls to agricultural activity, to biodiversity value, and to cultural heritage value was much less satisfactory, however, requiring averaging scores across areas with very different characteristics and conditions. At the large scale much of the variability within the area is lost, and the end result is a set of indicator values all in the mid-range of the scales developed for measuring differences. Local variation is entirely lost, and changes in condition at local levels are not adequately captured. In the PDNP, for example, characteristics vary enormously from upland areas where walls are degraded and condition declining, to lowland areas with higher levels of investment and high density of dry stone walls in good condition, though functions may be more aesthetic than agricultural. Running an accounting model at the PDNP scale cannot adequately describe function and condition of dry stone walls accurately across such a large area; and condition values start to become meaningless as they are only based on a very generic overview (in the absence of actual empirical data).

At the other end of the scale, selection of small areas to capture the variability in patterns, time-depth, and inter-relationships of dry stone walls within the landscape comes with its own problems. It is easier to assess function of dry stone walls, and relatively easy to determine length and condition (although the latter requires fieldwork); it is also relatively straightforward to assign scores to time-depth, inter-relationships, and legibility using expert judgement. But even within the 7.5 km^2 areas selected for the models in this study there was significant variability in two of the areas, which had to be accounted for in scoring cultural heritage value. Other difficulties arise in getting suitable data on residents, agricultural activity, and visitors, but the small scale does allow capture of variability, uniqueness, and condition, which can then be scaled-up across larger areas with some basic field studies (and possibly utilisation of GIS resources) and detailed knowledge of the larger area.

It is important to capture the variability in dry stone walls and understand the proportion of a larger area that might contain one or another pattern. In this way even small areas, which might be quite unique, can be captured and included in the assessment, rather than overlooked. Data collection costs are likely to be higher, but the outcome will be a more accurate reflection of the situation on the ground.

Aggregating values

Determination of beneficiaries is linked to the issue of scale identified above. When small areas are assessed (selected, for example, on the basis of coherent patterns of dry stone wall construction), the number of direct beneficiaries (e.g. number of farms in the case study areas), and the consequent value of benefit flows might be quite low. This study has not considered the value of benefit flows, such as improved biodiversity or cultural heritage value, of dry stone walls to wider society (i.e. outside of the community of users directly benefitting). The argument can be made that the population of England benefits indirectly through provision of wildlife habitat and heritage as improvements in these services lead to a general increase in social welfare, especially where unique, rare, or vital ecosystem services are provided. However, selection of the appropriate means to aggregate benefit flows to those who do not directly benefit is not straightforward.

Ecosystem services are based on identifying the activities and resources within socio-economic and ecological systems that are of value to humans, it is an anthropocentric value approach. Use of the term 'services' implies this - these are services that human populations find beneficial. We may, as part of this approach, explore ecological services that benefit ecological systems, but the ultimate aim is to understand the ecological system as a whole and how we can maximise output of the services that provide social, cultural and economic benefit to humans. The ecosystem service approach does not consider inherent rights of species to exist, the value of cultural artefact independently of the community that created or treasures it, or the value of system operations independent of their utility to humans.

The strength of the approach is that it identifies multiple benefit flows emanating from historical assets, which can be valued and discounted over time. As such it is an ideal approach that fits into the CBA techniques that underpin many decisions over public investment and social welfare. This study was never intended to be an exploration of non-market or other (non-monetary) forms of valuation. If there is a desire to develop arguments for cultural heritage value independent of any benefit to humans, then some deeper philosophical arguments need to be made. These arguments need to be based on rights of species/artefacts to exist independent of human utilisation (inherent rights), and potentially on the rights of future generations. Alternative (to monetary) forms of value are required to make such judgements.

The model developed here is based on valuing the flow of benefits arising from ecosystem services based on the current stock of dry stone walls within a defined area. Value, in the form of monetised flows of benefits (minus costs), is thus based on those who experience those benefits directly. The advantage of the approach is that is enables stakeholders to explore how marginal changes in the extent and/or condition of the stock of the asset alters the value of the service flows over time. This study has not concerned itself with measuring the inherent value of the current stock of dry stone walls (the natural capital), which requires a different valuation approach.

One approach is to select a proportional figure to represent indirect benefits to the larger population (e.g. perhaps based on some notion of option or bequest value derived from previous studies that identify the proportion of the population expressing a desire to preserve such value). Any such approach will significantly increase the benefits flowing from functions provided by dry stone walls. The current accounting models provide a conservative assessment of value, there is scope to explore alternative approaches to aggregating value to the larger population, which may be useful for considering marginal changes brought about by policy decisions or other forces driving change, but this will require more detailed analysis.

5.5.2 Strengths

Flexibility
The accounting model developed is a straightforward 'return on investment' approach, which compares values of a range of benefit flows to expenditure on restoration and maintenance over a specific period of time (in this case 50 years). The model takes the current stock of dry stone walls as a given and does not try to value the stock; it only values the benefits that flow from that level of stock, and the costs of maintaining the stock at the current level.

The model is flexible in that it can accomplish the following:

- Be applied across variable time scales (the current model is set at 50 years, but this can be shortened or lengthened, which may alter the benefit-to-investment ratio).
- Be applied across variable spatial scales (the model can be applied at a range of spatial scales, although if the area is too small some benefit flows will decrease, due to the inability to identify beneficiaries (e.g. residents, or visitors to an area; the value derived from the combination of dry stone walls of different ages and functions which combine together to give a sense of place).
- Incorporate changes in function/condition of dry stone walls, and reflect changes in agricultural activity on walls and the range of ecosystem services generated; reveal the impacts of changes in driving forces (e.g. agricultural policy, market conditions).

Transparency
The model is transparent. The data incorporated into the model is clearly visible, along with the selection of financial proxies and the calculations used to derive value.

Enables comparisons
The models can be varied in a number of ways to enable comparisons and exploration of changes in key variables. The mode:

- Allows for comparison across time scales.
- Allows for comparison between areas.
- Enables the user to explore the impact of changes in key variables (e.g. length of wall, condition, functionality).

Exploration of ecosystem service values by beneficiary type
Values of ecosystem services can be explored for each individual service identified, for categories of ecosystem service (i.e. cultural, provisioning, supporting, regulating), and for different types of beneficiary.

A scenario-based approach as an alternative to case studies
A case study approach was selected in order to capture some of the variability across the PDNP. Time and resources limited the number of case studies, but three areas were selected in order to test the sensitivity of the model to variability in key characteristics of the walled landscape. The approach demonstrated some of the strengths and weakness of the model, in particular the high degree of variability in the walled landscape even within relatively small geographic areas. This suggests that the method might need to be applied at a fine grained landscape level, rather than across large areas. It also suggests that if valuation over large areas is of interest then some form of sampling is required, which could be determined in the following way:

- Initial survey to gain deep understanding of variability.
- Categorisation of 'micro-landscape' areas.
- Sampling of micro-landscapes from each defined category across the area of interest.
- Aggregation of values across large areas based on weighting of mean values obtained from sampling of different categories of 'micro-landscape'.

The alternative option is some form of benefit transfer approach based on a set of readily identifiable characteristics of an area, or 'scenarios'. The disadvantage with the scenario-based approach is its inability to capture the variability that exists on the ground. A small number of scenarios could illustrate differences based on agreed characteristics but would not be a valid means of undertaking benefits transfer from one place to another. Benefits transfer may be conceptualised as the 'Amazon' or 'department store catalogue' approach to environmental valuation where environmental goods and services are allocated a specific individual value that can then be transferred and applied anywhere, irrespective of local context. The catalogue approach provides a description of a good (a table, a lamp, an acre of wetland) and a price. It tells you nothing about the quality of that product, the source of the materials, how they were put together, or the resilience and durability of the product. And, just as with many catalogue purchased products, you find it never quite matches expectations, it's not quite the right shade, the quality does not live up to expectations, it looks fine in the photo, but the reality does not match the image. What the 'Amazon/catalogue' approach misses out, is that the value of many environmental services comes from their place-based characteristics and the integration of ecological and socio-economic factors. What we are valuing in the study described in this report, are unique socio-economic and ecological systems. Each locality is unique. It is the mix of services and the different inter-relationships that have evolved between humans and their environment, in a specific place, that creates value (economically, socially, culturally and ecologically), and determines how and why specific features in the landscape are utilised, their condition, and their future resilience. This cannot be captured by benefit transfer processes, which (at best) tend to just homogenise value based on some basic characteristics derived form a small sample of places.

6 CONCLUSIONS

6.1 Introduction

This project aimed to demonstrate how the functions and values of dry stone walls, in particular the cultural heritage values, can be incorporated into an ecosystem services framework. The project has developed a methodology that can identify the functions of dry stone walls, the beneficiaries, and attribute values that are compatible with the ecosystem services approach. The method focuses on identifying and measuring the flow of ecosystem services over time arising from the current level of natural capital (the stock), and changes in value of the flow of benefits resulting from marginal changes in the condition and extent of the stock.

The project team have developed an environmental value accounting model that identifies the benefits and attributes the values associated with the dry stone walls of the PDNP. The model is based on an ecosystem services approach that integrates their historic function, character and significance with a range of agricultural, environmental, and social functions to analyse the range of values generated by dry stone walls. The historic value of dry stone walls in the case study areas was assessed through the integration of three scored characteristics (time depth, inter-relationships, legibility). This initial and largely desk-based identification of the extent to which the historic pattern of dry stone walls in an area 'tell the story' was aimed at enhancing understanding of the annual flow of benefits generated by the asset. It was not aimed at identification of the intrinsic heritage significance and value of dry stone walls as defined in the NPPF and Historic England's Conservation Principles.[19]

[19] Both are under review at the time of writing.

Individual dry stone walls were not valued directly in this study, the methodology assesses the value of the pattern of dry stone walls within a defined geographic area (currently based on a 7.5 km^2 area). The model utilises a ROI approach to provide a ratio of benefits generated by identified ecosystem services in relation to restoration and maintenance costs. PVs of the flow of costs and benefits are calculated and compared over a 50-year time horizon (using a standard 3.5% discount rate). Model outputs were generated for three case study areas and for the PDNP overall utilising two slightly different approaches to aggregating the values over the PDNP, and case study areas were selected to represent key differences in the historical landscape of the National Park.

Discounted values generated by dry stone walls over the 50-year period for the PDNP as a whole, from the two modelling approaches developed range from £192.1 to £668.7 million and benefit-to-investment ratios range from 1.69 to 4.91 (i.e. an investment of £1 generates a return of £4.91 in valued benefits). The large difference in Total PV is related to the fact that the larger total value is derived from the model that takes into account variability across the PDNP highlighted by the case study areas. The models also indicated the breakdown of value by category of ecosystem service across the PDNP:

- Slightly more than half of total present value was generated from cultural services (i.e. the historic, aesthetic and recreational value).
- Just under one third came from supporting services (e.g. provision of habitat, contribution to biodiversity).
- Approximately one sixth (15%) was generated through provisioning services (largely livestock management).
- Less than 2% could be attributed to regulating functions (e.g. erosion control, flood control).

6.2 Lessons learned: Strengths and weaknesses of the approach

The methodological strengths relate to the flexibility of the model in adapting to a wide range of functions provided by dry stone walls. The model provides values for a wide range of benefit flows ranging from nutrient cycling and biodiversity enhancement to flood control functions, livestock shelter and social wellbeing for residents and visitors. The model can be varied in several ways to enable comparisons and exploration of changes in key variables, such as length and condition of dry stone walls, number of beneficiaries, and the range of functions performed. The annualised value of benefit flows provides capacity to conduct analysis of the impacts of policy change and market drivers, such as decline in livestock farming, or increase in tourism. The model is transparent in that variable influencing values, and assumptions underlying the calculations, are clearly expressed.

The main weaknesses of the approach arise from the following:

- determination of the most suitable scale for analysis;
- the availability of data at the correct level (relatively small-scale areas);

- the level of expertise required to make judgements on heritage value and condition; and,
- the more familiar issues associated with cost-benefit analyses (such as discounting over time) and monetary valuation of non-market goods and services.

The issue of scale is one requiring wider testing of the approach as this study was focused on methodological development and limited in its capacity for testing. Further sensitivity testing of the model is required to explore the most suitable scale for data collection, sampling approaches, use of GIS and other remotely sensed data, and model operation. The current study focused on application of the model at the relatively small scale (7.5 km^2) to capture variability in walled landscapes within the Peak District. The study revealed that even within such relatively small areas considerable variability in wall function, condition, and relationship to the landscape can occur. This suggests the need for a more comprehensive sampling approach based on a high level of understanding of the local context to capture the variability present. The model was also applied at the National Park level in order to utilise more readily available data (for example on wall length, number and type of farms, and visitor numbers), which demonstrated an inability to effectively capture the full value of service flows and benefits arising from the stock of dry stone walls in the area, reinforcing the need to undertake analysis at much small scale.

The second issue regarding data quality and availability is related to that of scale. Along with information on linear extent, functional utility, and condition of the walls themselves, the model requires data on the magnitude of benefits flowing from the range of services identified, the numbers of beneficiaries, and the extent to which they benefit from a particular ecosystem service. Little of this data is available at the relatively small scales at which the model was applied, and the variability in service flows across an area require a good level of understanding of the pattern of dry stone walls in that area, and an ability to assess their cultural significance and condition. This study utilised expert knowledge of the Peak District to select case study areas for analysis, and for determination of heritage values, wall condition and functional utility. Data on the magnitude and significance of service flows were obtained from farmer interviews and discussion with other stakeholders. Identifying the number of beneficiaries in the case study areas required interpolation from data collected at large scales (e.g. local authority and National Park levels) and some assumptions regarding some categories of beneficiary (e.g. number of visitors to the case study areas), demonstrating the need for improved sampling methods, both to reduce costs and capture the variability in the walled landscape.

A strength of the current approach was the multi-disciplinary expertise available in the project team to monetise the service flows and to support judgements on heritage value and condition of dry stone walls. The level of local knowledge was high leading to a good understanding of the factors contributing to the heritage value of dry stone walls and the variability existing at local and larger scales. The valuation model depends on three key factors: first, the ability to identify the range of service flows and the benefits they deliver; second, the ability to determine the condition, and cultural heritage value of dry stone walls; and third the capacity to select appropriate financial approximations to impute value to the range of services delivered. Development and application of the model has identified the range of services that dry stone walls are able to deliver, and resulted in a method for scoring cultural heritage value of dry stone walls. Identifying beneficiaries is relatively straightforward, although questions remain as to who constitutes a beneficiary from dry stone walls that are providing a range of ecosystem services, some of which might benefit society beyond the local area. The current study limited beneficiaries to those directly coming into contact (e.g. local residents, visitors) with a walled landscape. There may be arguments for incorporating a wider set of beneficiaries into the calculations, but this will require further research to determine how they benefit, and possibly the addition of non-market value estimates (e.g. existence and option values) into the model. Finally, description of the function, condition, and heritage value of dry stone walls are all context specific requiring a good level of understanding of dry stone walls in relation to the local historic settlement and development pattern. Further work is required to develop techniques that enable more rapid assessment of these aspects.

The model is a form of cost-benefit technique whereby streams of future costs and benefits are discounted back to present value for comparison. CBA is not without its faults, a key issue being the differential impact of the discount rate on costs/benefits occurring early in time compared to those occurring much later in time. The Treasury Green Book provides guidance on conducting cost benefit studies and suggests a standard discount rate of 3.5% but there may be good reasons to diverge from this standard (for example to give more weight to benefits occurring far in the future). Exploration of the sensitivity of the model outcomes to changes in the discount rate is an area requiring further exploration.

The model, like other CBA approaches, puts monetary values on all goods and services, whether or not they have market prices. A strength of the model is the utilisation of 'financial approximations' to determine monetary value; the aim is to find goods and services that closely approximate those being valued. Where they exist goods and services with market prices are utilised. Where the benefits from ecosystem services (e.g. habitat and biodiversity, sense of place, well-being, aesthetic benefits) are not duplicated in the market place, it can be more difficult to find suitable approximations based on market price, requiring utilisation of estimates based on non-market valuation techniques (e.g. derived from hedonic pricing, contingent valuation, and travel cost techniques). Despite their widespread use these approaches remain controversial in terms of their validity (for example, income dependency of values, those who cannot pay are left out, and the hypothetical nature of the values obtained from contingent valuation type studies). Transparency of the financial approximations used is a positive aspect of the model. Demonstrating clearly the link between the service being valued and the means by which it is valued opens up potential for discussion and improvement of the model.

6.3 Applicability of the method for other heritage assets and areas

The advantage of the approach is in its flexibility. If the interest lies in an ecosystem services approach to valuing cultural heritage then the method described here enables the relevant services to be identified, described in terms of benefit flows, and valued in terms of the potential improvements to welfare of those beneficiaries. Many aspects of the historic environment contribute a range of ecosystem services, and assuming that the beneficiaries can be identified, then those services can be valued. For example, the model is currently being applied to linear features in the landscape, and to buildings and structures, and potentially could be applied to any physical aspect of the historic environment that generates a range of service flows. The disadvantage to the approach is that where actual or potential beneficiaries are few in number, consequent values allocated to the ecosystem services will be low (although this also depends on the magnitude of the value of the service flow to each individual).

What the approach does not do, is provide a value for the existing stock of a historical asset, especially where that stock is limited in availability (i.e. rarity), and/or irreplaceable. The approach is not aimed at deriving 'inherent values' of historical assets; what it does is measure the flow of benefits emanating from the stock of an asset. As a result, it does not give any indication of the irreplaceability of the stock, or its overall contribution to social welfare. A monetary approach may not be the most appropriate in the valuation of the stock of an irreplaceable cultural or historical asset. A monetary value could be assigned, based on factors such as replacement cost, value over the time period since it was created, with multipliers to reflect rarity and/or age but the techniques economists utilise in non-market valuation are better suited to analysing marginal change in values rather than capital value.

The method developed in this study is applicable to all forms of field enclosures and linear features in the rural landscape, and which have been mapped in individual HLC projects. It is also applicable (with some modification) to non-linear heritage assets, including consideration of:

- Woodland, the historic character and potential for change of which has recently been assessed by a project funded by Historic England.
- Buildings and sites under the Agriculture and Subsistence heading in the Historic England Thesaurus of Monuments Types, in particular:
    - Traditional farmsteads and field barns, which have been the subject of extensive historic characterisation and some mapping projects that have recorded their historic character and survival.
    - The earthworks of historic land use and settlement - for example, ridge and furrow, water meadows, shrunken and deserted settlements.
- Industrial sites in rural areas.
- Historic parks and gardens.
- Defence sites, from prehistoric and historic earthworks to airfield, ordnance and training sites.

The technique put forward in this report has great potential for being applied to other enclosed landscapes with dry stone walls, hedgerows and other boundary features. HLC offers a seamless 'synoptic map' for estimating the potential time depth of dry stone walls that can be tested through ground survey. Similarly, Historic Environment Record (HER) data such as Farmsteads Mapping (only conducted in some parts of England) and analysis of the archaeological remains of settlement, ridge and furrow and other relict land uses has great potential in displaying the date and distribution of buildings and archaeological features that make such an important contribution to our understanding of the date and landscape context of dry stone walls – and the stories they can tell. Experience on a parallel project in the Lower Severn Vale, however, has indicated that the richness of HER data makes anything other than selective analysis or the use of proxy data (such as obtained from the farmsteads and field barns in the Peak District) prohibitively expensive. The roll-out and replicability of data such as Farmsteads Mapping and the use of National Landscape Characterisation is considered here to be of vital importance in developing a cost-effective means of integrating the historic environment into ecosystem services and other agendas.

6.4 Research Issues

There is a need for balanced appraisal of wider social, economic and environmental factors. This should include an understanding of the historic character, significance and sensitivity to change of the assets and their landscape settings, with particular emphasis on demonstrating their value as heritage, which may be modified by the present and future pattern of use. This form of appraisal could be used to inform future development and contribute to a strategic approach to prioritising significant landscapes, for example, walls that are sited in areas of low farm income or more densely populated areas, but which are important to local economies and communities through the value that they hold both for tourism and local residents. The present study has demonstrated the potential for incorporating cultural heritage valuation within an ecosystem service-based approach which allows for comparison of values across categories of beneficiary and across different service flows, as well as highlighting the wider range of benefits contributed by a historic asset such as dry stone walls. The model that has been developed is a first step in the direction of a more comprehensive valuation approach, and as such requires further development and testing. Some of the key areas for further research and development are described below.

6.4.1 Scale

One issue for investigation is the extent to which the most suitable scale might vary across different landscapes. Areas must be large enough to identify historical patterns and value, but not so large that markedly different patterns, ages, or style of dry stone wall get mixed together. The idea is to apply the model at a scale based on readily identifiable 'walled landscape characteristics', and then to aggregate the service flows from these smaller assessed units across larger areas, in order to more accurately capture the variability in value of service flows. We suggest the approach – appropriately caveated - can be easily applied at a range of scales from national level (NCA, ALT and the types identified in the NEA) to individual holdings.

In our study, the Peak District HLC, with its use of 17th century maps to mark Time Depth, emerged as a useful baseline for identifying the potential of individual areas, (resources for the GIS interpretation and analysis of data were not available for this project). Used in combination with datasets such as Farmsteads Mapping and Characterisation it was more useful than the National Park Authority's Landscape Character Assessment: the latter however, can be used to offer an initial interpretation of the potential heritage value of areas and types. Differing approaches mean that there is some uncertainty with regard to the applicability of HLC at a local scale, although the methodology adopted for the National HLC Project could be used at a national scale. A sampling technique is required that enables capture of relevant 'wall variables' (e.g. function, condition, time-depth, legibility, inter-relationships) across an area. Sampling must be able to capture the variability in a defined area of interests and provide the information that enables aggregation of findings up to larger scales. What should be avoided is any approach that tries to create a 'catalogue' of values for walls of specific age and condition (irrespective of the local context in which they are situated) that can then be plugged into some simplistic accounting spreadsheet. One possible way forward would be to use consistently-captured data sources such as Farmsteads Mapping, and develop simple character statements so that the scoring system can be applied locally. The method needs to be applied in some other areas of the country, using GIS to test its applicability and devise a sampling strategy that will capture the variability in a landscape.

6.4.2 Data capture

The study demonstrated the capability for deriving the required data to run the model but also indicated the need for more comprehensive sampling and data collection protocols in order to make the method more readily applicable. Access to GIS information would make the task of assessing wall length, and possibly condition, easier, although ground surveys to assess both functionality and condition would still be required. The alternative of undertaking assessments over large areas would not capture the variability in ecosystem service flows arising from these assets. Interpolation strategies to make more accurate determinations of local beneficiary numbers, and creation of standardised field sampling approaches based on existing historic landscape information could be developed to produce a more refined data collection approach based on small-area sampling to capture local variability in the services delivered by the walled landscape. Development of sampling protocols and standardised field survey templates are an area ripe for development that would reduce data collection costs. Exploring the most effective ways to integrate high levels of expertise (e.g. ecological, historical) are part of this process. The current study demonstrated the need for deep understanding of historic development in order to interpret assets in their local context. Such expertise is inevitably in short supply. Understanding the most suitable way to utilise and integrate such expertise into the valuation methodology requires further exploration.

6.4.3 Model improvement

The model itself is a prototype ROI design based on identification of ecosystem services. Financial proxies selected are based on those used in recent valuation studies, selected because of agreement on their reliability and validity. However, there may be scope for improving the selection of proxies in relation to some of the benefit flows not previously valued. Some sensitivity testing of the model would identify the financial proxies with significant impact on the overall model outcomes enabling exploration of potential alternatives.

A second issue relates to the period of time over which the model operates. Initially this has been set at 50 years, although many of the walls have been in existence for far longer, and if well-constructed can last up to 200 years before needing significant rebuilding. Given the high costs of construction of dry stone walls (in relation to other forms of barrier such as fencing) a useful exercise would be to explore the relationship between costs and benefits over longer time periods (perhaps over 100 or even 200 years). Any exploration of costs and benefits over long time periods runs up against the effects of discounting whereby costs and benefits occurring far in the future can appear insignificant in present value terms. Such an analysis would also need to explore the effects of different discount rates and consider the arguments for what might be appropriate in a model measuring the value of ecosystem services over time. Given the importance of time in valuing heritage assets this would be a worthwhile exercise that could underpin and strengthen the quality of evidence provided by a valuation models such as the one developed in this study.

Set out below (Table 6) is some preliminary thinking on a research agenda and strategy for developing methodologies and techniques for valuing dry stone walls. The table highlights the main areas of research required to improve and develop valuation methodologies for heritage assets.

Table 6: Research Agenda and Strategy

Focus	Issue	Key questions	Strategic actions
Historic assessment	Extent to which broad HLC typologies match past phases of enclosure/ types of stock/ functions of boundaries/ agricultural regimes.	How can the broad typologies be narrowed down?	• Undertake more detailed analysis of HER data in relationship to field boundaries, building on the work initially undertaken for the Peak District Farmsteads and Landscape Project.
	Age of dry stone walls and utility of documentary evidence. Validity of alternatives to documentary evidence for estimating age of dry stone walls. Costs and need for additional evidence.	How old are dry stone walls? How can archaeological and documentary investigation deepen our understanding of broad-brush and cost-effective historic characterisation mapping?	• Foster postgraduate research projects in different parts of the country (one example is the MoU between the PDNPA and the University of Sheffield). • Prepare a user-friendly guide to levels of significance. • Investigate the potential for crowd-sourced funding (e.g. for recording of dry stone walls by digital photography).
Modelling /economic	Impacts on model outcomes arising from changes in the time period and discount rate selected.	How do valuations change over longer time periods? How sensitive are benefit and cost valuations to different discount rates?	• Undertake sensitivity testing of the walls model both in the Peak District and elsewhere
	Determination of scale for model application.	What is the most suitable scale at which to apply the model? What are the consequent challenges and opportunities in relation to data collection?	• Test the model in a range of different landscape contexts • Develop protocols for sampling and data collection • Explore how disciplinary expertise can be integrated into valuation studies in a cost-effective manner
	Determination of a sampling regime. Understanding who benefits.	To what extent do walled landscapes alter in their level of local variability across the country? What is the ideal way to undertake sampling to capture local variation within defined areas?	• Test the model in a range of different landscape contexts • Develop protocols for sampling and data collection • Explore the scope for extending beneficiaries to the wider population
Drivers of change	Impact of climate change upon dry stone walls, together with the adaptation and mitigation measures	What are the pressures/incentives on farm businesses to retain/remove field boundaries including walls?	• Investigate the potential impact of climate change upon the agrarian landscape.
	Impact of Brexit and changes in agri-environment schemes upon dry stone walls	What are the pressures/incentives on farm businesses to retain/remove field boundaries including walls?	• Assess how recent changes in the farming economy have impacted upon the use, form, function and appearance of dry stone walls.

7 APPENDIX A: ECOSYSTEM SERVICE FUNCTIONS UTILISED IN THE MODEL, BY CATEGORY OF ECOSYSTEM SERVICE

Supporting

	Asset/service	Function	• Stakeholder type	Indicator	Measure	Financial proxy
Supporting	Primary production (e.g. lichens; nutrient cycling);	Breakdown of stone to release nutrients; food source for higher plants. Provision of habitat for lichens, mosses, and other plants	• Society overall • Landowners; farmers; • local community • higher level species	Rate of weathering by geological type. Proportion of dry stone walls with extensive growth of moss and lichen (depends on age of wall, exposure, aspect)	Average km of wall per farm type	Value from enhanced biodiversity
	Formation of species habitat	Flora - long-term habitat creation (e.g. plant habitats; enhanced biodiversity); Walls can be important habitats for pollinator species	• Society overall • Landowners; farmers; • local community • local ecological system	Provision of shelter and habitat for range of local species	Km of wall	Value from enhanced biodiversity
	Formation of species habitat	Fauna - long-term habitat creation (e.g. for insects, reptiles, small mammals, birds, other species); enhanced biodiversity;	• Society overall • Landowners; farmers; • local community • local ecological system	Provision of shelter and habitat for range of local species	Km of wall	Value from enhanced biodiversity
	Wildlife corridors	potential to support animal movements; Enables or inhibits movement (possible migration of species along sheltered linear corridors) Greater resilience to climate change	• Society overall • Landowners; farmers; • local community • local ecological system	Number of species with potential to spread through provision of 'transition' corridors	Km of wall provided with spaces that allow ease of movement.	Value from enhanced biodiversity Value from improved climate change resilience

Provisioning

	Asset/service	Function	Stakeholder type	Indicator	Measure	Financial proxy
Provisioning	Livestock management;	Separation of arable crops from livestock;	• Number of arable farmers (farmers with crops needing protection) • Mixed arable and livestock farms	Reduction in crop damage.	Estimated efficiency savings from provision of dry stone walls	Cost of alternative fencing
	Livestock management	Separation of animal types and by gender	• Livestock farmers	Efficiency of livestock production through ability to separate animals	Estimated efficiency savings from provision of dry stone walls	Cost of alternative fencing
	Shelter	Provision of shelter in poor weather for livestock;	• Livestock farmers • Sheep • Cattle • Other	In situ shelter – enables livestock to be left outside in poor weather	Estimated efficiency savings from provision of dry stone walls	Cost of providing alternative shelter
	Shelter	Shelter for crops against wind:	• Arable farmers • Farmers producing fodder crops	Enables enhance productivity of otherwise marginal land, or production of higher value crops	Estimated productivity gains	Value of production differential between sheltered and non-sheltered fields
	Shelter	Provision of shelter for seeds, plants, fauna against wind. Creation of micro-climate	• Biodiversity (flora/fauna) - Be aware of double counting!	Supports high nature value farmland	Estimated areal extent (km^2) of sheltered field margins	Value of enhanced biodiversity

Regulating

	Asset/service	Function	Stakeholder type	Indicator	Measure	Financial proxy
Regulating	Boundary marker	Identification of land ownership boundaries. Provision of certainty over land ownership. Reduction in need for land surveys at point of sale of property. Fencing against the common Markers for historical ownership and landscape management	• Land owners • • Local community (to a lesser extent)	Proportion of total wall used as property boundary. Proportion of total wall forming boundary between commons and improved land.	Average km of wall per property	Cost of a property boundary survey
	Soil erosion (location specific)	Provision of shelter for soil against wind erosion;	• Arable farmers • Farmers producing fodder crops	Estimated decrease in soil erosion and soil creep Estimated proportion of wall preventing soil erosion in the landscape/type of farm	Estimated hectares (ha) protected per farm type	Cost of purchase and transport of soil (per tonne)
	Soil quality	Enclosure by dry stone walls has played a role in retaining long-term pasture alternating with arable use and hay production. Enables manuring, of the in-bye land closest to farmsteads and in fields without farms and field barns.	• Farmers producing fodder crops	Enhanced crop production Support for livestock production (lowers feed costs)	Estimated area protected (ha) per farm type	Value of tonne of soil
	Water flow (location specific)	Slows down overland flow during high intensity rainfall periods. Limited in extent – depends on orientation of wall in relation to slope and bare soil.	• Arable farmers • Mixed farms where bare soil exposed for cropping.	Estimated proportion of wall with potential for preventing water erosion in the landscape/type of farm	Average km of wall per farm type providing the service	Value of tonne of soil

Cultural

	Asset/service	Function	• Stakeholder type	Indicator	Measure	Financial proxy
Cultural	Landscape and aesthetic;	Sense of place Wellbeing Sense of history	• Local residents •	Improved sense of wellbeing from living in an 'Iconic landscape'	Wellbeing improvement measure	
	Landscape and aesthetic;	Utilisation of existing stone	• Land owners • Local residents • visitors	Reduced environmental impacts from alternative forms of fencing	Cost of quarried stone avoided	(£ per m^2)
	Tourism	Valued landscape attracts visitors	• Visitors	Improved sense of wellbeing from visiting an 'Iconic landscape'	local economy impact	Average spend per visit modified by proportion of tourists placing value on landscape
	Traditional skills	Traditional skills for construction, repair, maintenance; skills are in short supply; creates local jobs	• Skilled dry stone wallers • Casual labour • Local communities	Maintenance of traditional skills in building with local stone	Av. income from walling work/person/ year	£ per year (based on average 750m^2 wall per year)

8 APPENDIX B: PRELIMINARY ASSESSMENT OF THE BENEFITS OFFERED BY DRY STONE WALLS

8.1 Introduction

This reflects early work for this project and sets out the link between the historic character of dry stone walls, their impact on land management and thus the range of potential ecosystem services.

8.2 Supporting Services

8.2.1 Soil formation

Historic patterns of land use, indicated by the historic character and pattern of dry stone walls in the landscape, have affected soil formation. The structure of soils in enclosed land, for example, has been and continues to be affected by manuring and the application of lime, intensifying and expanding into formerly unenclosed land from the late 18th century.

Beneficiaries: farmers, farm economies, wider society

8.3 Regulating Services

8.3.1 Climate and carbon storage regulation

Walls represent a massive investment over millennia, and of embedded energy. Their close association with stock management for long-term pasture has played a role in carbon storage, pasture being well-known to store more carbon than arable unless it is overgrazed.

Benefit streams: slowing down/halting landscape degradation, maintaining carbon capture/reducing carbon loss, maintaining grazing, habitats, heritage assets and landscape generally.

Beneficiaries: environmental footprint of post and wire fencing not known but rebuilding walls with original stone conserves embedded energy with no (or significantly reduced) environmental impact from importing new stone – acquisition, transport etc. so, benefits farmers, farm economies, wider society.

8.3.2 Erosion regulation

Walls can play a role in mitigating erosion from wind and rain if they act as permeable barriers slowing down wind over longer distances than as impermeable barriers.

Benefit streams: slowing down/halting landscape degradation, maintaining carbon capture/reducing carbon loss, maintaining grazing, habitats, heritage assets.

Beneficiaries: soils, farmers, farm economies, water companies, plant communities, habitats, heritage

8.3.3 Water flow and flood regulation

Walls are capable of filtering and slowing down flows of water, especially if they are sited along contours where soils have built up along one side.

Benefit streams: Slowing down of run-off; maintaining water balance in local areas

Beneficiaries: farmers, farm economies, water companies, local (and further afield) residents/properties, plant communities, wetlands, wider society (climate change issue managing water), water companies (wider economy).

8.3.4 Soil quality regulation

Soil quality and biodiversity is crucial to soil health and future food/ nutrition security. Enclosure by dry stone walls has played a critical role in helping to shelter, manage and retain long-term pasture alternating with arable use and hay production. It has enabled manuring, especially in in-bye land closest to farmsteads and in fields with outfarms and field barns.

Benefit streams: slowing down/halting landscape degradation and water run-off, maintaining carbon capture/reducing carbon loss, maintaining grazing, habitats, heritage assets.

Beneficiaries: farmers, farm economies, plant communities, habitats including wildlife corridors, wider society

8.3.5 Disease and pest regulation

Dry stone walls are known to harbour insects and invertebrates that predate on pests.

8.3.6 Pollination regulation

Walls can be important habitats for a range of species, particularly relevant in this respect being pollinator species. See for example the advice by Bug Life in wall mason bees in calcareous grasslands.[20]

[20] https://www.buglife.org.uk/advice-and-publications/advice-on-managing-bap-habitats/upland-calcareous-grassland

8.4 Provisioning Services

8.4.1 Food production

The role walls have played in food production - as permeable shelters for stock, hay, corn and other crops, stock and crop management including creating micro climate protecting young stock and crops.

8.4.2 Genetic diversity

Genetic diversity has declined as farming and other activities have intensified. Walls can be significant in their own right as habitats and corridors for amphibians, bees, butterflies, birds, insects etc. Flower-rich meadows are now very rare and concentrated in Daleside Enclosures and in other areas unaffected by post-1950 improvement where pastures have been harvested for hay or grazed once grass has grown; walls bordering woodland and water courses seem to be particularly rich in lichens and mosses.

Beneficiaries: farmers, farm economies, plant communities, habitats including wildlife corridors, role in facilitating species movement, wider society

8.4.3 Supply of raw materials

Potential to use materials for repair of other walls and buildings.

Beneficiaries: farmers, farm economies, wider society

8.5 Cultural Services

Walls fossilise patterns of communal as well as economic farming – societal issues, reflecting past social organisation, activities and development.

Benefit streams: Valued landscape; sense of order; contribution to sense of place and sense of history; supports tourism, recreational and community activities (communities of place and interest)

Beneficiaries: local residents; visitors, farmers, farm economies, plants and young stock, habitats, wildlife corridors

8.5.1 Traditional skills

Traditional skills for repair/maintenance; such skills are in short supply; where they do exist, they represent local jobs, with enhanced input into the local economy (as per Lake District barns study)

Benefit streams: contributes to local economy, valued landscape; sense of order; contribution to sense of place and sense of history; supports tourism, recreational and community activities (communities of place and interest)

Beneficiaries: farmers, farm economies, local tradespeople, local economy, visitors, wildlife, wider society

8.5.2 Sense of place

Walls in their diversity of local materials, dates and craft techniques are fundamental to local distinctiveness and the 'landscape offer' for tourists (local, national and international), as well as being home for residents. Local character and the heritage assets within the local landscape – including field walls – are the raw material from which the stories can be spun that enthral people and draw people to the Peak District, thus benefitting local employment, farm diversification and accommodation provision, providing either or both extra jobs and safeguarding existing jobs and lifestyles e.g. farming.

Benefit streams: Valued landscape; sense of order; contribution to sense of place and sense of history; supports tourism, recreational and community activities (communities of place and interest) and the local and national economy.

Beneficiaries: farmers, farm economies, visitors, local people, local economy, local distinctiveness, wider society (through maintenance of local/regional character differences, taxation, etc.).

8.5.3 Sense of history

Walls provide the context for understanding the historic development of the landscape. Wall furniture – sheep troughs, stiles, dew ponds etc. - and trees contribute to this story. Footpaths also, as they often represent the ways in which people in the past accessed their fields and/or neighbouring settlements, mines and quarries. That social and economic/community history now contributes to the health agenda, as well as the footpaths that visitors and locals walk along and benefit from.

Benefit streams: Valued landscape; sense of order; contribution to sense of place, sense of history; supports tourism, recreational and community activities (communities of place and interest) and the local and national economy

Beneficiaries: visitors, local residents, local economy, wider society.

8.5.4 Recreation and tourism services

Walls comprise the distinctive framework to the Peak District landscape and how it is experienced by visitors and residents.

Benefit streams: Valued landscape; sense of order; contribution to sense of place, sense of history; supports tourism, recreational and community activities (communities of place and interest) and the local and national economy

Beneficiaries: visitors, local people, local economy

8.5.5 Educational resource

Walls provide a rich and largely untapped resource, linked to the foregoing points and also the research agenda considered in the conclusions to this report.

9 APPENDIX C: DRY STONE WALLS IN THE PEAK DISTRICT: HISTORIC CHARACTER, DRIVERS FOR CHANGE AND DESIGNATION

9.1 Historic development

There are extensive remains of dry stone walling dating from the prehistoric period throughout the British Isles and Europe, used to enclose fields, settlements and other historic sites and in the construction of buildings. Examples include the Céide Field enclosures dating from around 3000 BC in County Mayo, western Ireland, Graeco-Roman terraces across the Aegean and from the 15th-16th centuries in south-western Germany.[21] In areas where stone was readily available - typically stones from cleared land and sometimes in combination with earth banks – walls were used in the creation of extensive fieldscapes such as the reaves of Dartmoor, the hedgebanks of Cornwall's West Penwith and the Iron Age farmed landscapes overwritten by Hadrian's Wall. There are useful overviews of how walls have developed in different areas, published by the British Trust for Conservation Volunteers, the Gwyneth Archaeological Trust and Land Use Consultants with AC Archaeology (2007) which includes a framework for the assessment of dry stone walls.[22] The most comprehensive recent study is by Angus Winchester (2016), building on his considerable knowledge of the development of upland landscapes.[23] The overall impression, however, is of a subject that has received very little academic attention from archaeological, landscape or architectural perspectives.[24]

The patterns of dry stone walls in the landscape relate to very broad developments in how communities, individual farmers and estates wished to farm, manage and expand the area of enclosed land since at least the Bronze Age. Of fundamental importance in the Peak District, as in other upland areas, is the contrast between the networks of dry stone walls, mostly dating from the 16th century, in the enclosed land around farmsteads and settlements and the mostly relict walls located in unenclosed wastes and commons on the gritstone moors and on the thinner soils of the White Peak. These wastes and commons have, since at least the medieval period and in some areas at least from the late Bronze Age (around 1000 BC), been used for grazing livestock and for extracting fuel, building materials and minerals. Most boundaries in these areas date from short-lived attempts at enclosure in the late 18th and 19th centuries. Unenclosed moorland dominates the Dark Peak and occupies a significant area of the South West Peak, fringed by pre-1650 (mostly irregular) enclosure and post-1650 enclosure of moorland.

[21] McAfee (2011); Price and Nixon (2005); Petit et al (2012)
[22] British Trust for Conservation Volunteers (1977) 6-26; Gwyneth Archaeological Trust (2001), (2002a and 2002b); Land Use Consultants with AC Archaeology (2007)
[23] Winchester (2016 and 2000)
[24] e.g. Oles (2015), Vasudevan et al (2008)

Enclosed farmland in the Peak District, as in other upland areas, has ebbed and flowed in tandem with the use of unenclosed wastes and commons. Across England, the patterning of dry stone walls and other boundaries reflects differing historic patterns of settlement, the historic development of enclosure as a system of land management, changes in estate policy and tenancies and the response of farmers and estates working with local soils and conditions to changes in population, urbanisation and access to markets and fluctuating commodity prices. The dominant driver behind enclosure, apart from the development of land management farmed from villages, hamlets or isolated farmsteads, was the need to separate mixed grazing and small-scale arable (mostly oats for both human consumption and as fodder) in the valleys and on richer soils of the limestone plateau. Cattle provided dairy products for home consumption and young stock for fattening on lowland farms, whilst sheep provided wool, meat and milk. Sheep had emerged as a particularly important part of the Peak economy in the medieval period. Tithe map evidence from the 1840s shows that there were few arable fields on the Millstone Grits, and that the best pastures were concentrated on the Carboniferous limestones of the White Peak. By the 19th century cattle rearing and dairying, to supply the growing industrial centres and important markets to the west and east, had grown in importance. In addition to the grazing of sheep, the heather moorlands were also managed for grouse shooting from the early 19th century.

The summary below synthesises the state of current knowledge, resulting from decades of fieldwork in the Peak, Historic Landscape and Farmstead Characterisation and consideration of the sources outlined above.

9.1.1 Pre-1650 including prehistoric

- There is evidence dating from the Bronze Age across the lower shelves of the Dark Peak for field banks and clearance cairns and associated settlement evidence – house sites, burial cairns, ceremonial sites. There is also evidence - as low banks and lynchets - of Romano-British settlement in the White Peak. Thus far there is no evidence for the planned and irregular Bronze Age and Iron Age enclosures using dry stone cores or walls found in Dartmoor, West Penwith or around Hadrian's Wall.
- The patterning of dry stone walls reflects a major distinction between areas farmed on a communal, co-operative or individual basis, probably established by the 11th century in most areas. Large fields subdivided into strips dominated the farmed landscapes around the villages which emerged at water sources in the White Peak and in the broad valleys which intersect the gritstone moors elsewhere. These were internally open, the strips being separated by low earth banks from valley pastures and open land. These patterns of enclosure contrast with the ovoid and irregular outlines of fields enclosed in the medieval period in areas of dispersed settlement in the Dark Peak and South West Peak, often close to farmsteads and hamlets and sometimes appearing as islands of enclosures in a sea of open land.

- The development by the 12th-13th centuries of ring-fenced estate farms with their own large sub-rectangular enclosed fields. Ecclesiastical and secular estates worked large cattle and sheep farms (termed granges) which often later formed the foci of farming settlements and estate centres as they continued to develop in the 14th-16th centuries.
- The shrinkage of settlement and the decline in arable farming in the 14th century, due to the combined effects of famine, climatic deterioration and disease including the Black Death of 1348. Communal and estate management declined in importance and increasing specialisation in pastoral husbandry required more field enclosures for different ages and types of stock.

9.1.2 Post-1650

- Dry stone walls and other boundaries were made to enclose and subdivide medieval strip fields and bring former wastes and commons into agricultural use, sometimes through survey-planned enclosure. Early examples of the latter include the enclosure of part of the Castleton Commons around Dirtlow Rake in 1691. Some farms moved to new farmsteads.
- The Enclosure Movement is strongly associated with the (often survey-planned) enclosure of wastes and commons to increase the productivity of pastures (especially for sheep) and more rarely the cultivation of crops, through the more systematic containment of livestock and their manure, and the construction of large numbers of field lime kilns.
- Most in-bye land in the Peak had been enclosed by 1750 and continued to be improved by tenants and estates especially on soils whose productivity could be greatly enhanced by more systematic manuring and rotations; fields continued to be reorganised and enclosed (again with straight-walled boundaries) as farms rationalised their holdings and amalgamated fields.
- Small-scale enclosure continued in areas where by-employment in coal mining, the lead industry and weaving sustained smallholdings and small farms - for example around Bonsall and Winster in the White Peak, and on the eastern fringe of the Dark Peak.
- The combined effects of rising wage rates, decline in the rural workforce and agricultural depression from the 1870s, although locally variable, led to decline in the maintenance of dry stone walls. Post-and-wire fences were an increasingly common sight from the end of the 19th century.

9.2 Dry stone wall construction and detail

Most dry stone walls have basic features in common with each other: they are built up from a foundation layer of large stones, decreasing in size and tapering to a layer of capstones, and with a fill or 'hearting' of small stones between outer faces of stonework linked crosswise by through-stones.

The development of dry stone walls in the Peak District has - based on detailed survey at Roystone Grange (see Appendix D) in the White Peak and elsewhere[25] - been broadly linked to three main types or phases of constructional form:

- Walls comprising substantial boulders or orthostats set out as single or double rows, these large stones resulting from an initial phase of clearance and often forming the base on which later phases of building/rebuilding took place. These include walls resulting from prehistoric-to-medieval land clearance, and occasionally later clearance of stones from wastes and commons to enable their agricultural use.
- Walls with tapered profiles built from irregular stones of different sizes which have been gathered from surrounding fields. Some of these stones may have smoothed sides resulting from glacial or other erosive action, others may have been hammered into suitable shapes. These are commonly medieval to 17th century, although they can be later.
- Walls built from quarried and dressed stone - identifiable by their rough edges resulting from basic quarrying/knapping techniques - which are more regular in their size and often display more standardisation in how they have been coursed and tapered. Through-stones for lateral bonding are a common feature. These were commonly built from the middle of the 18th century by professional craftsmen to standard lengths (so-called 'chains') which enabled payments for piece-work.

Details associated with all types of dry stone walls include:

- Slots and holes for loose rails on gate posts, millstone grit being easier to carve and therefore the most common, even in areas where it does not naturally occur.
- Socket stones and 'creaks' for harr hung gates.
- Stiles - step stiles and through or 'squeezer' stiles.
- Openings, locally termed 'smoots' or 'smouts', to permit the movement of rabbits and badgers (which may otherwise burrow under walls), streams and other bodies of water and sheep; larger examples of the latter, also called 'sheep creeps', might be fitted with gates, commonly top-hung to prevent sheep moving back through them.
- Recesses for bee skeps.
- Wall heads built from alternating courses of horizontal ties to strengthen the ends of dry stone walls and tie them together.

The dismantling of dry stone walls may also reveal finds such as clay pipes and bottles which can aid dating. Walls display an enormous variety within each of these categories, most obviously on account of the type of stone available locally and local craft techniques.[26] In the Peak District, the sandstones from the Millstone Grits dominate the Dark Peak (NCA 51) and the South West Peak (NCA 53). The limestone walls of the White Peak (NCA 52) (Figure 14) are dominated by

[25] Wildgoose (1991)
[26] For national overviews see Winchester (2016) and Land Use Consultants with AC Archaeology (2007)

Carboniferous Limestone but include the more-rounded dolomitised limestone to the south east. There are also notable examples of individual walling techniques, such as the double walls at Friden and Newhaven, the different styles of 'Irish walls' built by Irish workers at Stanton and Cotton in the South West Peak, estate boundary walls to Hassop Hall and Hardwick Hall and in some cases 'consumption walls' made from cleared stones and boulders. Walling from the Millstone Grit (Figure 15) is typically straighter and thinner than those built from the more angular Carboniferous Limestone of the White Peak. The latter requires the occasional use of a hammer to shape stone, leaving the copings to be made of larger blocks. The copings in Millstone Grit areas are commonly trimmed, and late 18th and 19th century walls commonly use through-stones and projecting top-stones to further deter stock - a feature extending northwards into the Pennines.

View of Chelmorton, showing the late 18th century and early 19th century regular enclosures in the foreground, and the medieval village with its surrounding strip fields still legible in the denser and linear pattern of dry stone walls.

Straight joint indicating the phasing of dry stone walls in an area of former wastes and commons enclosed in the early-mid 19th century enclosure

Figure 14: Limestone walls in the White Peak © John Powell

(left) showing the arrangement for inserting horizontal poles as barriers in lieu of a gate. Opening to allow passage of sheep (termed a sheep creep) in 200-year-old wall (right) constructed of rounded gritstone boulders, derived from the adjacent water course.

High-quality early-mid 19^{th} century roadside wall (left), and stock-proof gritstone wall (right), topped with two strands of wire. In the distance can be seen the boundary between the improved grassland fields and their well-maintained walls and the moorland grazing above with its derelict dry stone walls.

Figure 15: Gritstone walls in Edale, Dark Peak © John Powell

Appendix D offers an overview of the Roystone Grange area, including analysis of the fabric and patterns of dry stone walls in relationship to HLC. Construction characteristics provide part of the cultural 'story' that dry stone walls can tell within a defined area such as the Peak District but have not been directly included within the valuation model. The different styles of construction inform the analyst about the landscape, provide evidential support for historical development, and contribute to the character of dry stone walls within a landscape. To build a wall in a style that is 'out of character' with the dominant construction style would result in loss of some of the cultural heritage embodied in dry stone walls. Capturing stylistic differences in valuation terms was determined to be too complex and difficult for the current study, requiring extensive empirical data collection and detailed knowledge regarding different styles of construction. Construction style, however, can be indirectly incorporated into the valuation model through assessment of condition or 'inter-relationship' (i.e. the ability to 'tell a story' of cultural development in a landscape). If a wall is built or repaired in a style sufficiently different from the original such that the cultural tradition represented by the wall is lost, then that change (and loss of heritage) can be identified through the attribution of lower scores in the valuation model for either 'condition' or 'inter-relationship'.

9.3 The drivers for change

Farmers in upland areas of England, as well as managing landscapes with high amenity, ecological and archaeological value, face considerable challenges, as demonstrated by a now considerable body of research:[27]

- They have relatively little productive capacity and low capital endowment.
- Farm businesses are relatively small-scale, with low average incomes and low workers' wages. They are under considerable pressure to minimise labour costs, both in the farmyard and for efficient grassland management.
- Changes in farm structure - growth of some farms, the abandonment of some of the more marginal land and the development of a more diverse mix of family businesses, farms run by hobby and lifestyle farmers, and farms whose owners rely upon multiple sources of income.
- Farmers are particularly vulnerable to changes in livestock prices, which have obvious consequences for farm profitability.
- An above-average proportion of farmers are aged over 60 and over a quarter of farms have no recorded successor, and nearly the same proportion of businesses do not expect to survive for the next five years. This is probably an underestimate.
- There is an increase in smallholdings and lifestyle farms e.g. horsiculture in some areas.

27 Gaskell, *et al.* (2010)

- In some of the remoter areas of Britain there has been call for farming to be abandoned altogether and the land to be rewilded to create new habitats of replaced by forestry.

For many years there have been both economic and social pressures on commercial upland farmers and they have frequently responded by enlarging their farms and extensifying production. These challenges, combined with changing farm practice, present a range of different but related drivers for change in the management of dry stone walls:

- Walls are particularly vulnerable to enlargement of holdings, the increase in the size of dairy farms being a strong driver especially in the White Peak: changing farming regimes or practices can result in rationalisation which in turn can impact on dry stone walls and their patterning, extent and condition.
- Particular farming regimes may require fewer field walls – it is not unusual to find dairy farms with only their holding boundary walls maintained and grazing within those bounds controlled not by dry stone walls but by electric fences.
- Intensive use of pastures - the decline of traditional hay meadows/ pastures and increase in bale silage and the size of farm machinery often require easier access and is more efficient in larger working areas.
- While well-built walls will, reportedly, last for 100 years,[28] the introduction of larger varieties of stock (sheep and cattle) means that even well-built walls come under increased pressure and require increased maintenance.
- Maintenance can be expensive compared with post and net fencing in the short-term. There is no analysis of the environmental footprint of post and wire fencing against the longer-lived dry stone walling. CBA is therefore difficult.
- The increased costs of maintaining walls, especially those at the furthest distance from farmsteads, despite the use of 4x4s, quad bikes and similar vehicles which seems to have reduced the difficulties of getting to the more-remote parts of the holdings.
- Restrictions on the supply of stone from available quarries, including local field quarries.
- Linked to this, there is an obvious incentive to take stone from redundant walls to repair other walls on a holding, or to sell it for repairs on other holdings, as walling stone is not that easy to come by. Famers land managers who claim various rural payments under the Common Agricultural Policy have to follow a set of cross compliance rules which set standards for 'Good Agricultural and Environmental Conditions (GAECs). GAEC 7a: Boundaries protects dry stone walls and farmers and land managers are not allowed to remove stone from their walls unless they receive derogation for the widening of gateways, repairing other walls on the holding or enhance the

[28] As suggested by the Dry Stone Walling Association: http://www.dswa.org.uk/about-the-dswa.asp

environment, improve public or agricultural access, or for reasons relating to livestock or crop production.[29]

- Changing regulations (e.g. animal welfare, public health) can also impact on field systems and associated features such as dew ponds.

9.3.1 Agri-environment schemes

Upland areas are particularly sensitive to changes in agri-environment schemes. Current and past schemes have played an important role in funding the maintenance and restoration of dry stone walls, while cross-compliance rules also ensure that there is a measure of protection. The future of these schemes after 2020 will depend upon post-Brexit domestic priorities. These (currently unclear) priorities may pose challenges, but also create opportunities, for the incorporation and integration of heritage and historic environment features within new environmental land management schemes. Expectations of enhanced protection through legislation are unlikely in the near future as the legislative time-table will be filled with higher priority issues following any exit from the European Union.

9.3.2 The supply of skilled labour

In addition to the agri-environment schemes, there are a range of Heritage Lottery Fund Initiatives that have brought benefits to dry stone walls and the skills base that is so vital in sustaining them .[30] Work for private clients, for example in the context of new housing development and 'barn conversions' have also gathered pace in recent decades, to some extent compensating for the decline in traditional forms of wall maintenance and construction on farmland. The Dry Stone Walling Association of Great Britain[31] exists to promote a greater knowledge and understanding of dry stone walling and to encourage the repair and maintenance of dry stone walls across the country. It operates a nationally-accredited certification scheme, run in conjunction with Lantra Awards, with four levels of certification. DSWA branches offer a range of short courses, mostly for beginners, with some opportunities for advanced training. Consultation in the context of this project has highlighted the need to gain a better strategic grasp of the issue of supply, demand and skills, and relate this to the historic character and survival of dry stone walls in different areas.

9.4 Designation

Very few dry stone walls have any form of statutory protection as designated heritage assets. The exceptions are walls which are listed as part of the designation of listed buildings and walls within their curtilage; Scheduled Monuments including, for example, the fragments of prehistoric walling at Carl Wark and the

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29 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/668684/Cross_Compliance_2018_guide_v1.0.pdf

30 Examples of HLF initiatives are HLF initiatives on dry stone walling (see https://www.hlf.org.uk/our-projects/get-dry-stone-walling) include the North Pennines AONB http://www.northpennines.org.uk/our-work/heritage-skills/ and Nidderdale Landscape Partnership's Building Blocks Scheme with young offenders http://uppernidderdale.org.uk/training-skills/heritage-skills/building-blocks/

31 Dry Stone Walling Association: http://www.dswa.org.uk/about-the-dswa.asp

Romano-British and medieval walls at Roystone Grange; and – although without any additional statutory protection - walls within Registered Parks and Gardens and the National Park's 109 Conservation Areas. The latter are concentrated in villages and hamlets rather than in areas of historic dispersed settlement where the walls can be very ancient. Recent revisions such as Monyash include dry stone field walls as part of the historic setting to the heritage assets within the settlements.

10 APPENDIX D: ROYSTONE GRANGE

10.1 Introduction

Roystone Grange lies on the southern edge of the White Peak limestone plateau, just to the north of the shrunken medieval village of Ballidon, located on the claylands to the south, tucked up against the limestone escarpment (Figure 16). At the core of the mapped area is Ballidon limestone quarry, greatly extended northwards in the 20th century, and Roystone Grange to its east. The north-south routeway which passes through Roystone Grange is at least Romano-British in origin and has almost certainly been used since prehistory to link the limestone plateau to the lower claylands to the south. It is paralleled to both east and west by other routeways that utilise gorges in the edge of the limestone plateau that provide access to and from the now more-extensively farmed clayland landscapes to the south.

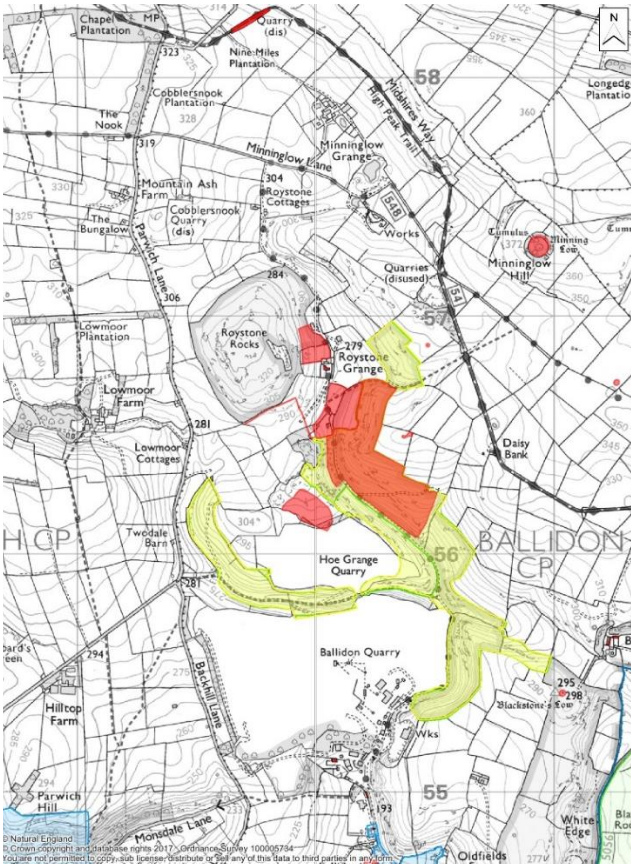


Figure 16: Designations map of Roystone Grange

Figure 16 shows, in light blue, where medieval strip fields have been incorporated within the Ballidon village to the south. Special Areas of Conservation (in yellow) mostly relate to species-rich Daleside Enclosures (see Figure 17). Designated heritage assets are shown in orange: at the centre of the map is the late-18th century farmhouse and attached farm buildings at Roystone Grange, listed at grade II, and Scheduled Ancient Monuments comprise the prehistoric sites at Roystone Rocks and Minninglow Hill, and Bronze Age burial mounds. They also include dry stone walls and associated heritage assets resulting from decades of detailed investigation through the Roystone Grange Project, a landscape archaeology project initiated by Richard Hodges in 1978 when lecturer in the Department of Archaeology at the University of Sheffield.

10.2 Project results

The project concluded in the late 1980s. When David Twigge, the farmer at Roystone Grange Farm, retired subsequently, the National Park Authority purchased the farm, using a National Heritage Memorial Fund grant, retaining the archaeologically and ecologically important areas and selling off the remainder, effectively breaking up the farm. Further archaeological works were undertaken by the Authority in subsequent years, in the course of refurbishing the field walls, testing and, in the main, supporting the models of field boundary development put forward by the project and by Martin Wildgoose in particular.[32] In summary, the project identified virtually continuous human occupation of this remote Peakland valley from the immediately post-glacial Mesolithic to the modern day. Roystone Rocks and Minninglow Hill both retain evidence for Mesolithic and Neolithic activity, Bronze Age burial mounds dot the landscape and an Iron Age presence is suggested only by a pottery sherd. The Romano-British period saw significant activity, with farmsteads, field systems and lead mining leaving their impressions on the landscape. A charter indicates activity in the Late Saxon period. Roystone Grange served from the later 12th century into the 14th century as a grange farm for the Cistercian Garendon Abbey in Leicestershire, founded in 1133. Documentary and field evidence also attests to the development of the grange, of yeoman farmers, developments in field systems and shifting settlement foci. Earthworks and dry stone walls, including the remains of an aisled building, survive from the farmstead which specialised in the production of wool. To the north-east of the grange lies 12th-13th century ridge-and-furrow (which may originate in the Romano-British period), testifying to the production of some cereal crops in an area now bounded by dry stone walls with medieval bases. Earthworks to the west of the field indicate the location of the later-medieval/early post-medieval farmstead, occupied since at least the 16th century and which was subsequently shifted to its current location on higher, drier land slightly to the north in the late 18th century. The Pump House, south of Roystone Grange Farm, originally contained a liquid-fuelled, water-cooled engine supplying compressed air to rock drills in the limestone quarries adjacent to the ex-Cromford and High Peak Railway line to the north-east.

[32] Wildgoose (1991), and Chadwick and Evans (2000) for some reconsideration of this work which emphasise the importance of the wider landscape context, suggesting that the early walls extended beyond the distribution of orthostatic walling.

10.3 Walls in the landscape

These investigations have demonstrated that the Daleside Enclosures and Enclosures of Uncertain Date (Figure 17 in light green) - the latter being far less common in the White Peak than in other parts of the National Park - have origins in the Romano-British and earlier periods. The field system (Pre-1650 enclosures of strip fields, coloured red) on the limestone to the south of Ballidon Quarry (in purple) relates to the village of Parwich, thus reflecting a key characteristic of the White Peak. Another key characteristic is the Post-1650 enclosure of former wastes and commons, and the retention of prehistoric monuments within these areas which remained in use from at least the Romano-British period until ruler-straight walls and associated plantations, farmsteads and cottages were imposed upon it.33 The farmsteads in these areas of Post-1650 Enclosure (in light and dark grey) are large in scale and date from the late 18th and 19th centuries. They form, together with field lime kilns and dew ponds, an integral part of the planned enclosure of this period which sought to ensure higher productivity from cattle wintered in farmsteads and land improved and subdivided for hay, corn and pasture for sheep as well as cattle. There is a relative lack of field barns at a distance from the farmsteads, which may reflect the relative accessibility of this landscape and/or the reliance on sheep rather than cattle to manure the further fields. The overall impression of a landscape of the 'Age of Improvement' is particularly strong in the north of the area, where the early 19th century farmhouse at Minninglow Grange has been orientated to face southwards towards a new routeway and is set against the dramatic backdrop of the stone-faced embankment of the 1832 Cromford and High Peak Railway. This, and the associated industrial development that occurred along and adjacent to its route – silica sand brickworks, lineside quarries and lime kilns – must have shattered the quiet solitude of the remote Roystone Grange landscape.

[33] Prehistoric ritual focal points in the landscape include the large Neolithic Minninglow chambered round cairn (3400-2400 BC) and the Bronze Age bowl barrows which pre-date 1500 BC. The bowl barrow at SK 20469 56874 is one of a number that now lie within the post-1650 enclosures, another, at SK 20384 56495 is now accompanied by an animal pen with foundation levels built of large dolomitised limestone boulders indicating a medieval origin.

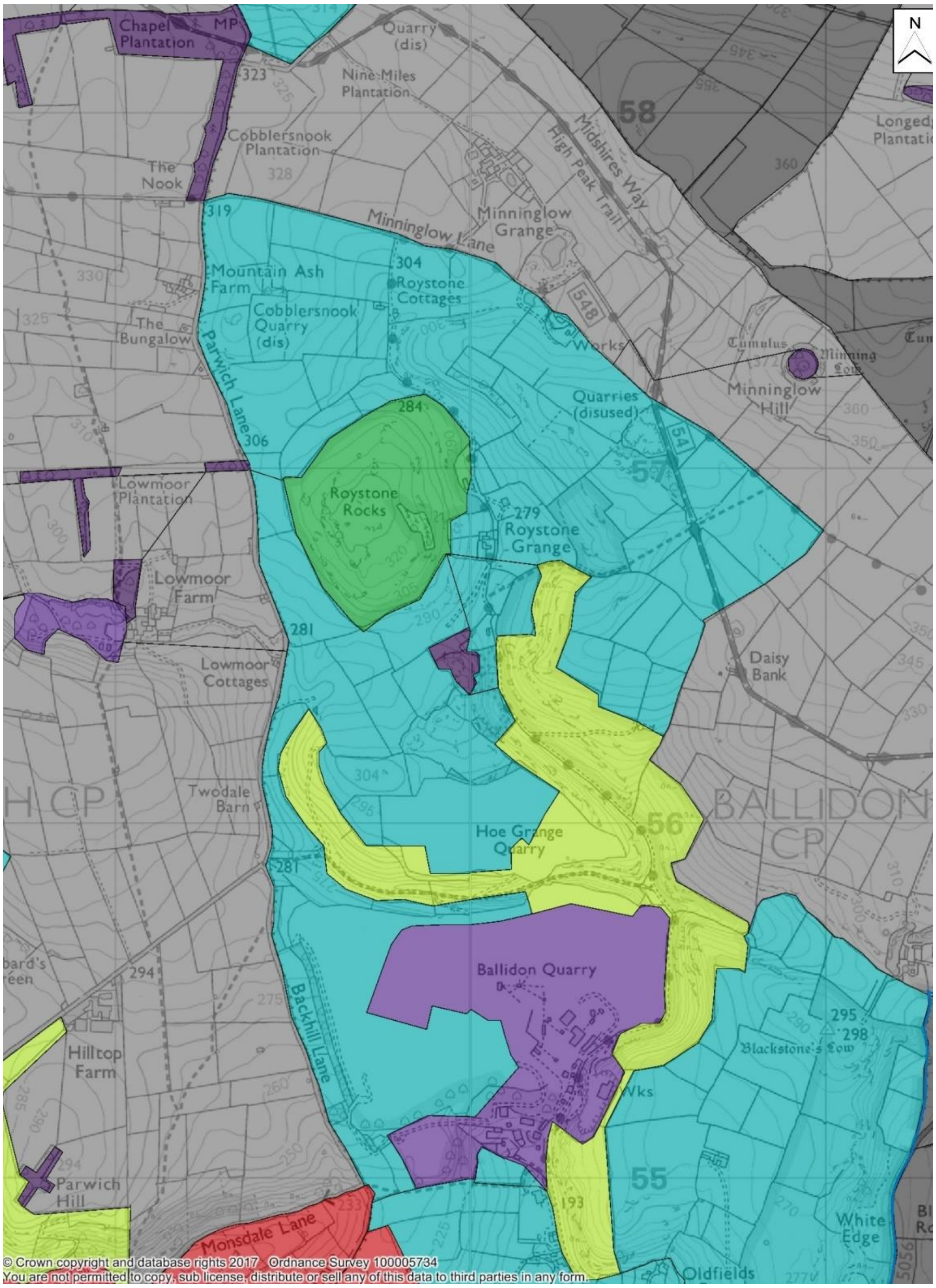


Figure 17: Historic Landscape Character of Royston Grange

Late 18th century enclosure wall, looking east towards the 18th-19th century farmstead at Roystone Grange, and the Romano-British enclosures on the rising land behind it.

Improved farming landscape to the north of Roystone Grange with walls mostly stock-proof and well maintained, all dating from the early 19th century. Minninglow chambered Neolithic round cairn lies within the tree-covered knoll top right while the embankments of the Cromford and High Peak Railway cross the upper half of the image. To the right is Minninglow Grange.

Figure 18: Roystone Grange: Dry stone walls in the landscape © John Powell

11 APPENDIX E: TIME DEPTH OF DRY STONE WALLS AND ASSOCIATED HERITAGE VALUE, DRIVERS FOR CHANGE AND ECOSYSTEM SERVICE ISSUES

HLC type	Historic character	Historic function	Heritage value	Drivers for change	ES Issues
Pre-1650 enclosure Irregular (fossilised strip fields and on strip fields)	Enclosures (mostly 14th-18th century) with reversed-S boundaries that retain the pattern of medieval strip fields.	Intensively manured and used for grazing and cropping, the extent of cropping declining since the 14th century with the exception of peaks in arable use – c.790-1815, 1840-70. 18th century and earlier field names may indicate use.	Close relationship to medieval villages, hamlets and estate farms. High densities of field barns also indicate intensity of use and dispersal of holdings into 19th century. Field lime kilns also indicate desire to boost fertility. Can be rich in archaeological potential, their boundaries responding to the alignment of ridge and furrow cultivation.	These patterns are a highly distinctive of the Peak District in a national context, and are particularly sensitive to enlargement of fields and holdings. Some close to settlements are included in conservation areas.	Fossilise patterns of communal farming Highly distinctive patterns close to settlements, mostly in White Peak

HLC type	Historic character	Historic function	Heritage value	Drivers for change	ES Issues
Irregular and/or rectangular (NOT strip fields)	Mixed patterns of sub-rectangular and irregular fields, comprising early (including prehistoric) enclosures to isolated farmsteads and medieval grange farms. Strip fields are not legible, but may have been reordered.	As above, the fields close to farmsteads and with field barns being typically manured the heaviest, remoter and large-scale fields being most likely to be used for permanent pasture.	Close association in areas of nucleated and dispersed settlement with surviving traditional farmsteads including 17th century and earlier buildings, field barns and historic houses (including former farmhouses). Field barns and field lime kilns also indicate the desire to boost fertility. Can be rich in archaeological potential, relating to medieval and earlier boundaries and land use. Boundaries may cut across as well as follow the alignment of ridge and furrow cultivation.	Sensitivity to enlargement of holdings varies depending on their scale and form which (as with Enclosures of Unknown Date) varies more than other HLC types.	Embody efforts of individual farmers and reordering of communal fields. Often high biodiversity value in areas of permanent pasture

HLC type	Historic character	Historic function	Heritage value	Drivers for change	ES Issues
Post-1650 enclosure Parliamentary enclosure award Private enclosure	Fields set out as blocks with straight boundaries, known from map evidence to post-date 1650. Range from small-scale in areas of industrial by-employment to large-scale pastures on poorer soils.	Enclosure undertaken for conversion to arable and hay production, and mostly the management of pasture for sheep and cattle. Enclosure and grazing has seen replacement of heathland and moorland cover by mat grass and wavy hair grass. The fields close to farmsteads and with field barns have been typically manured the heaviest, remoter and large-scale fields being most likely to be used for permanent pasture.	Close association with isolated and newly-established farmsteads, and in some cases with earlier farmsteads in nucleated or dispersed settlement. Field barns indicate a desire to manure farmland, field lime kilns also indicating the desire to boost fertility. Boundaries often cut across earlier patterns of land use (e.g. lynchets and ridge and furrow) and earthworks of settlements. Enclosure often retained prehistoric sites within or on the borders of former unenclosed land which had remained as legible features in these liminal landscapes.	Sensitivity to enlargement of holdings varies depending on their scale. Walls located at furthest distance from farmsteads and on edge of Unenclosed Land are most likely to experience collapse and removal.	Embody efforts of individual farmers and estates.

HLC type	Historic character	Historic function	Heritage value	Drivers for change	ES Issues
Enclosure of unknown date	Fields that are often a combination of sub-rectangular and irregular shapes, including post-1650 enclosure and reordering of earlier farmland and unenclosed land; can include irregular and oval enclosures to medieval and earlier ring-fenced farms, but within an overall mixed and piecemeal pattern.	Fields shown for the first time in mid-19th century maps, comprising 25% of the National Park and concentrated in South West Peak and parts of Dark Peak. which relate to 17th century and earlier farmsteads and farming hamlets. Mixed land use. The fields close to farmsteads and with field barns have been typically manured the heaviest, remoter and large-scale fields being most likely to be used for permanent pasture. 18th century and earlier field names may indicate use.	Close relationship with pre-1650 and post-1650 farmstead sites in nucleated and especially dispersed settlement. Investigation has revealed evidence for medieval and prehistoric fields. Field barns indicate a desire to manure farmland, field lime kilns also indicating the desire to boost fertility. Can be rich in archaeological potential, relating to medieval and earlier boundaries and land use.	Sensitivity to enlargement of holdings varies depending on their scale and form which (as with Pre-1650 Irregular and/or rectangular enclosure) varies more than other HLC types. Fields located at furthest distance from farmsteads and on edge of Unenclosed Land are most likely to experience collapse and removal.	Embody efforts of individual farmers and farmers working co-operatively.

HLC type	Historic character	Historic function	Heritage value	Drivers for change	ES Issues
Unenclosed land Wastes and commons/moorland	Open land, including land with medieval and prehistoric evidence for land use and settlement. Walls in these areas mostly remain from post-1650 enclosure to bound extensive sheep pastures and mark divisions in ownership and tenancy.	Retains the main concentrations of surviving blanket bog and upland heathland, together with some upland flushes, fens and swamps. These habitat types result from prehistoric clearance and subsequent grazing, and the use - usually in common and closely integrated with surrounding communities - of resources for fuel and construction. Some agricultural use with amenity and biodiversity needs being dominant.	Particularly rich in paleo-environmental evidence for prehistoric and historic land use and vegetation change. Prehistoric and medieval field boundaries, boundary markers and settlement remains. Cairnfields. Medieval ridge and furrow. Some field barns for feeding and sheltering livestock, stock pounds and sheep stells. Routeways. Peat cutting and its trackways leave their own patterns	Walls in these areas are the most prone to neglect and replacement with post-and-wire fences.	Walls commonly embody marking out of estates and allocation of extensive summer pasture and other rights.

HLC type	Historic character	Historic function	Heritage value	Drivers for change	ES Issues
Unenclosed land Open pasture including Daleside enclosures	Extensive area of valley-side pasture, often bounded but not enclosed by dry stone walls.	Most of these have functioned, at least since the 16th century, as sheep walks and cow pastures - either in common or privately managed large enclosures - within areas dominated by enclosed land. Supports high proportion of species-rich grassland.	Paleo-environmental evidence for prehistoric and historic land use and vegetation change. Prehistoric and medieval field boundaries, medieval ridge and furrow and settlement remains. Field barns indicate a desire to boost fertility of pastures. any field lime kilns ?? also indicating the desire to boost fertility.	Boundary walls prone to neglect.	Embody efforts of communities working on co-operative basis to manage pastures.

12 APPENDIX F: LEGIBILITY, TIME-DEPTH AND INTER-RELATIONSHIPS

12.1 Introduction

This pilot project considered the most effective method for determining the historic value of dry stone walls as an integral part of the capital stock. This is summarised for the purposes of this report as ‘heritage value’, which is intended to be distinct from the more narrowly-defined ‘heritage interest’ set out in the NPPF and ‘heritage significance’ in Historic England’s Conservation Principles. Concepts of ‘natural capital’ and ‘ecosystem services’ in fact offer the potential for the integration of the ‘historic environment’, as defined in the NPPF, and ‘landscape’, as defined in the European Landscape Convention, into a much broader and inter-disciplinary framework for informing change and valuing the environment as a whole.

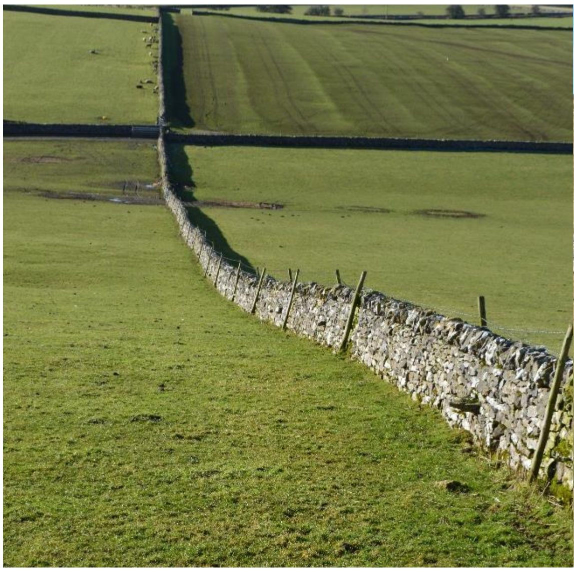
12.2 Legibility

A report on landscape change in the National Parks of England and Wales, published in 1991 by the Countryside Commission, estimated that in the PDNP there were 8,756 km of dry stone walls, 1,710 km of hedges and 472 km of fences. Although the PDNP has experienced greater loss of field boundaries than any other National Park, it still has the third highest density of dry stone walls in any of the National Parks - at an average of 7.6 km^2 (Countryside Commission 1991). The collation of agri-environment scheme data suggests that this rate of loss has slowed down since the 1990s.[34]

The *Landscape Change in National Parks* project, which compiled data on wall lengths in 1970 and 1980, suggests that the rate of total loss was highest in areas of dairy farming with an inherited high density of dry stone walls, where the move to larger farm units was accompanied by conversion to silage production.[35] Walls tend to be highest in their density and best-maintained on the fringes of settlements and least legible - due to a combination of large field sizes and often long stretches of lost or collapsed walls - in moorland fringe areas. There are also some areas, particularly those with deeper soils where trees and shrubs have been a far more dominant part of the landscape, where walls are intermixed with hedges or are even absent altogether. The map produced by the HLC for the PDNP (Figure 2) shows the dominance of dry stone walls across the Peak District with the exception of the open moorlands and areas mixed with or dominated by hedges in some of the broad valleys and riverside meadows.

[34] Haines-Young (2007). Tracking change in the character of the English landscape, 1999-2003. Natural England, Catalogue Number NE42.
[35] Countryside Commission (1991) http://publications.naturalengland.org.uk/publication/5216333889273856

Derelict wall replaced by post-and-wire-fence



Well-maintained stock-proof wall (left). Bellying walls close to Roystone Grange (right).

Figure 19: Dry stone wall condition

12.3 Time-depth

Local variation in the density of dry stone walls in the landscape results from historic patterns of enclosure. The HLC of the PDNP, published in 2003,[36] has mapped these historic patterns of enclosure, in addition to surviving areas of unenclosed wastes and commons and daleside enclosures, using early 17th century surveys to distinguish between known and unknown areas of pre- and post-1650 enclosure.

- Pre-1650 enclosure (also termed Ancient Enclosure) comprises:
  - Medieval Strip-Fields where enclosures on a piecemeal basis have retained the pattern of medieval strip fields, mostly around nucleated settlements in the White Peak and dales elsewhere.
  - Rectangular and/or Irregular Fields, the former mostly associated with early estate farms and the latter with medieval and earlier enclosures from woodland and wastes.
- *Post-1650 enclosure* comprises survey-planned and regular fields with ruler-straight boundaries which result from enclosure by private agreement or parliamentary act. Most of these date from the late 18th or 19th centuries and, unlike earlier boundaries, may overwrite the earthworks and other remains of medieval and earlier settlements and field systems.
- *Enclosures of Uncertain Date*, whilst not being clearly shown on pre-1650 maps, are often a combination of sub-rectangular and irregular shapes, including oval enclosures, which may date from the medieval period or earlier and include later rationalisation and planning in the form of straight-sided boundaries and fields.

Although there has been no systematic survey of dry stone walls across the Peak District, the over-riding impression is that they represent a massive investment of capital and labour that is largely concentrated in the century after 1750, coinciding with the rebuilding of much of the Peak's stock of houses and agricultural buildings (leaving earlier cores within structures and typically more intact higher-status houses). Walls do occur in Unenclosed Land, and mostly comprise post-1650 walls in the HLC-type Enclosed Moorland (typically large sheep pastures that have not been maintained for over 100 years) and Daleside Enclosures which may have early outer walls.

Historic maps, if available, cannot be used unquestioningly without fieldwork: this is because walls could be built on the same alignments as their predecessors, leaving earlier bases but sometimes requiring building up from the foundations. Nevertheless, HLC offers the most cost-effective framework for identifying the archaeological potential or time-depth of dry stone walls in the landscape (see Figure 7), prior to the much more intensive process of investigation in the field. Detailed field survey and even excavation can then, as at Roystone Grange (Appendix D), assist in dating stone walls with any precision. HLC also offers a framework for initial consideration of the potential benefits that flow from the

[36] Barnatt (2003) http://archaeologydataservice.ac.uk/archives/view/peaks_hlc_2016/

different types of wall-pattern across the National Park. One significant impediment to the study of dry stone walls is the paucity of documentation for them, one key source of evidence obtainable from tithe and other maps being field names.[37] Any accounts of the cost of construction, including piecework rates for specified lengths of wall, are very rare and not recorded for the Peak District. There is plentiful evidence - both nationally and in the Peak District - for the successive rebuilding of stone walls on the same alignments, and for significant early boundaries to display a mix of constructional types such as live and dry hedges, ditches and earth banks.[38] Detailed archaeological investigation within an area of *Enclosures of Uncertain Date* at Roystone Grange (Appendix D) to the south of the White Peak[39] has associated walls with orthostat bases with 12th-13th century and Romano-British field boundaries. Walls with orthostat bases and walls built from stone cleared off the ground can, however, also represent a practical solution to making use of available stone in survey-planned enclosure of the 18th and 19th centuries. Walls built from stones of different sizes are commonly associated with 16th to 18th century walls, although they could be earlier or later. Walls built to a standardised form, using quarried stone and increasingly professional skills, are the most likely to be late 18th or 19th century in date.[40]

37 Richardson (2002)
38 Winchester (2016), 11 and 17-20; Smith and Barnatt (2004), 77-78
39 Wildgoose (1991)
40 Winchester (2017), 44-5

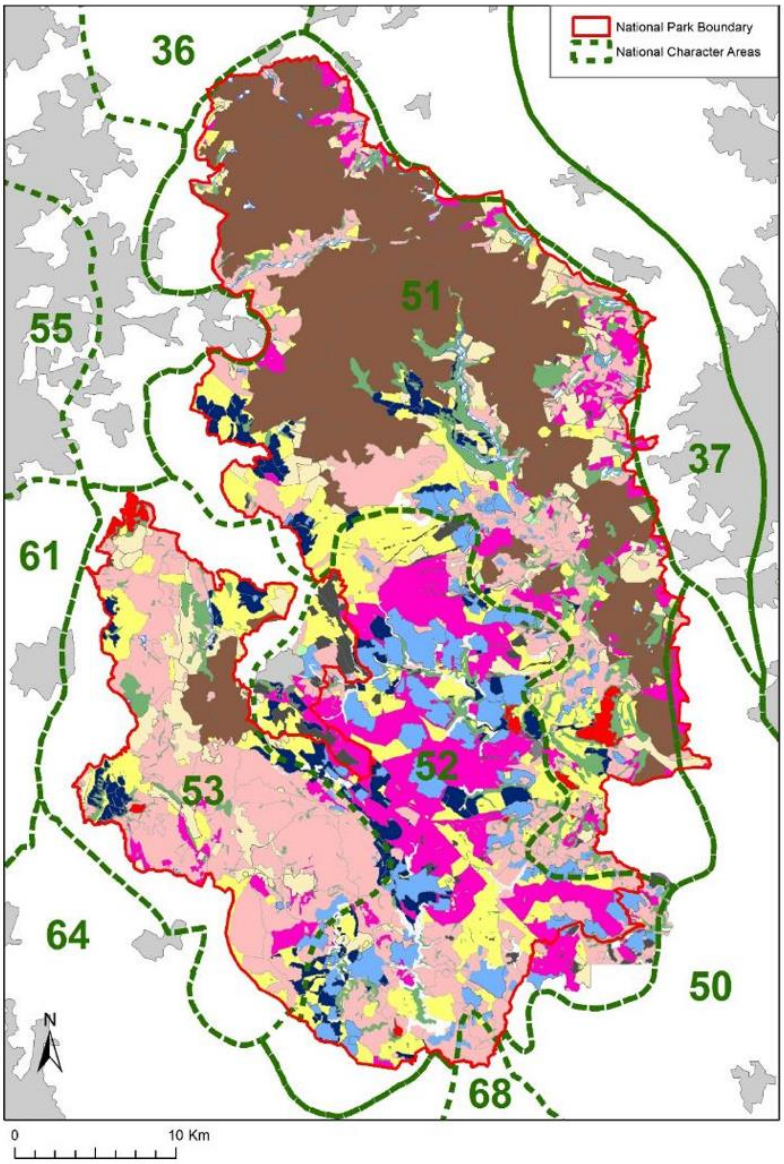


Figure 20: Simplified map of the Historic Landscape Character within the Peak District National Park. Showing the numbers and boundaries of the NCAs within and around the main phases of enclosure:

- Pre-1650 enclosure (also termed Ancient Enclosure) comprises:
  - Medieval Strip-Fields - light blue
  - Rectangular and/or Irregular Fields - dark blue
- Post-1650 enclosure - yellow
- Enclosures of Uncertain Date - pink
- Unenclosed land - brown
- Parkland – red
- Woodland and scrub - green

12.4 Inter-relationships with other heritage assets

Understanding the range of benefits offered by dry stone walls must also be informed by identification of the types of site and asset with which they are associated in enclosed and unenclosed land. The HER offers the principal source of evidence for identification of these and their subsequent mapping in relationship to their broader landscape context including HLC.

12.4.1 Integral relationships of dry stone walls to heritage assets in enclosed land

Patterns of settlement, historic buildings, archaeological earthworks, boundary features and historic routeways have an integral association with the development of dry stone walls in areas of enclosed land (see Figure 7), in particular:

- *Farmsteads as a component of settlement pattern*. 19th century rebuilding has been so extensive and intensive that recorded 17th century and earlier farmhouses and working buildings are very rare in the Peak District by national standards; they are concentrated in nucleated settlements and in areas of Pre-1650 enclosure, areas of Post-1650 enclosure being populated by farmsteads that mostly date from after 1750. Distinct arrangement of dry stone walls around different farmstead types relate to yards, stock ponds and also - typically narrow - enclosures for sorting sheep prior to clipping and inspection. These may also retain evidence for 17th century and earlier origins, as well as showing how farmsteads developed from the linear, dispersed and small-scale courtyards typical of upland landscapes into larger-scale layouts which in some cases include walls surrounding private garden areas.[41]
- *Individual field barns and more substantial outfarms*, also mapped across the National Park, which enabled the use and manuring of remotely-located farmland. Over 2,600 were built, mostly in the early-mid 19th century. Individual field barns typically housed cattle and hay over winter. Outfarms are larger complexes usually with walls to yards, and in some rare instances were built to process and store harvested corn. As in other upland landscapes, field barns and outfarms are concentrated in areas of earlier farmland (the HLC types of Pre-1650 and Enclosures of Uncertain Date) where holdings were intermixed. There are also concentrations in areas of Post-1650 enclosure associated with by-employment in mining and weaving.
- *Boundaries and boundary markers* to parishes, estates and individual farms, which in the Peak District are more usually found isolated than built into walls.
- *Archaeological earthworks including ridge and furrow.* Fossilised strip fields, with later walls following the alignment of medieval ridge and furrow, are concentrated in areas of Pre-1650 Enclosure around the villages of the White Peak, in the south of the South West Peak and in the Hope Valley in the Dark

[41] Edwards and Lake (2016); http://www.peakdistrict.gov.uk/looking-after/living-and-working/farmers-land-managers/historic-farmsteads-guidance. For the integration of farmsteads and historic buildings into the assessment of historic landscapes see Lake and Edwards 2006 and (2007).

Peak and within other areas of Ancient Enclosure with medieval grange farms and areas of post-1650 enclosure. Some ridge and furrow survives associated with medieval and later dispersed settlement within Enclosures of Uncertain Date. Post-1650 enclosure walls - although often avoiding prehistoric barrows and other features - often cut across contours and sometimes the earthwork traces of medieval and earlier land use and settlement, unlike the way that earlier (and later) boundaries shaped by negotiation work around these features and are more sinuous in their form. Areas which have been in more continuous agricultural use have retained less evidence for prehistoric land use, burial sites being far more commonly found in areas of late enclosure from wastes and commons - where they remained as features in grazing landscapes - than in areas of pre-1650 enclosure. Favoured locations for early settlement may well lie underneath villages, or have been ploughed out, in the White Peak and elsewhere.

- *Walls on the alignment of earlier boundaries*. Dry stone walls developed from the 16th century as the dominant means of enclosing farmland, but there has been little investigation of their alignment in relationship to earlier live and dry hedges, ditches and earth banks.[42] Simple stratigraphic observation can reveal the extent to which they overlie medieval and earlier field boundaries and terraces and settlements. Later walls tend to butt against earlier walls, representing the enclosure of strip fields around villages, of valley-side cow pastures or the subdivision of fields managed on a co-operative basis by groups of farmsteads.
- *Routeways*, which have developed since prehistory to connect wastes and commons to their surrounding communities, also enabled the export of sheep and cattle for finishing and wintering outside the Peak and cross-Pennines trade including the export of lead and gritstone products.[43] In very wet areas, locally-distinctive causeys paved with slabs of Millstone Grit were created for the pack horses. Routeways which cross moorland, often legible as holloways or as braided patterns where they ascend slopes and open into unenclosed land, were often replaced in the 18th and early 19th centuries by turnpikes which form the basis of the modern road system. As a general rule, winding and sinuous routeways - responding to topography and resulting from a long history of development and negotiation - are concentrated in areas of Pre-1650 and Enclosures of Uncertain Date; straight routeways, Roman roads and turnpikes aside, are typically post-1750 and part of late 18th and 19th century regular enclosure and the reorganisation of earlier farmland.

12.4.2 Relationship of dry stone walls to heritage assets in unenclosed land

The open wastes and commons on the gritstone moors and on the thinner soils of the White Peak had begun their development by around 4000BC, the highest land being largely given over to hunting and grazing and the remainder used - more intensively by at least 2000 BC - as extensive pastures and in some areas for growing crops. A shift from cultivation to extensive grazing followed the combined

[42] Barnatt and Smith (2004), 18-25
[43] see Hey (1980)

effects of climatic deterioration from around 1000BC and the agricultural technology then available, the result being the extensive evidence for prehistoric land use and settlement in areas now covered in blanket peat, blanket bog and dwarf shrub heath.

There is extensive evidence on the gritstone uplands, especially to the east of the Derwent valley, for Bronze Age settlement including hut circles and ring cairns with field systems and associated cairnfields; sufficient barrows survive to indicate that they relate to whole farming communities which cultivated land which has been farmed ever since. There are also earthworks and other remains of farms and their fields in unenclosed land that remain from high points of agricultural expansion in the Romano-British period (AD 43-410, when lead was first mined on an industrial scale) and the 12^{th}-13^{th} centuries. In the medieval period extensive areas of the Peak District were controlled as hunting forest which may have restricted settlement and agricultural development. Whilst some areas of the wastes and commons including sheepwalks were separated from farmland by dry stone walls, earth banks or fences, the boundaries between townships were often only marked by crosses, cairns and natural features. The wastes and commons also retain extensive evidence for industrial activity including quarrying, coal mining and lead production, and played a critical role as open commons which supplied peat for fuel, heather for roofing and bracken for fodder and bedding of cattle. There are some late 18^{th} and 19^{th} century dry stone walls marking ownership divisions and enclosures for sheep and more rarely for growing oats.

12.4.3 Relationship of dry stone walls to other historic features in the landscape

Walls have historically developed around other heritage assets which are not so integral in shaping their development in the landscape:

- *Industrial land*, which in the HLC primarily comprises lead, copper and coal mines, quarries and mineral-processing sites and factories. Lead mining, including as by-employment linked to farming, is associated with areas of relatively small fields and dense concentrations of field barns, for example around Bonsall and Winster. Extensive lead rakes and remains of lead mining are associated with calaminarian grassland - plants which thrive on old mining sites.
- *Parkland*, as defined and mapped in the HLC. Deer parks and ornamental parkland around great houses and manor houses - concentrated in the Derwent Valley (Chatsworth) and northwards towards Hassop in the White Peak. The expansion of the park at Chatsworth conserved significant remains of the medieval ridge and furrow associated with the infield of Edensor, with dry stone walls mostly relating to the improvement of farmland outside the park.
- *Woodland*, as defined and mapped in the HLC:
    - Ancient semi-natural woodlands cling to the valley sides, particularly in the Dark Peak, often with internal banks designed to define and protect former coppice, used for extraction of building materials and in particular fuel for local industries. These woods can retain evidence for medieval

and earlier settlement and land use and 17th century and earlier farmsteads and boundary walls, and evidence for charcoal-burning (platforms) and white-coal (wood-drying kilns) production for the lead smelters. Most of the remaining woodland in the White Peak particularly was cleared by the 17th century to supply the lead mines although areas of intense lead-mining activity such as Lathkill Dale now have a comprehensive woodland cover sufficient for the ash/wych elm woodland to be a principal reason for designation as a SSSI.

  - Plantations, mostly of late 18th and 19th century date, can retain evidence for 17th century and earlier settlement and land use.
  - Some areas of recently-regenerated scrub along the steep sides of the dales (e.g. Monsal Dale) one of results of reduced grazing pressures on the dale sides.

- *The archaeology of pre-medieval land use and settlement*, as identified in HERs and dating from before the establishment of the present settlement pattern in the 8th-11th centuries. It is not unusual for walls to ignore these features in the landscape, particularly where enclosure is the translation of surveyor's plan onto the landscape or where they are earlier land/parish boundaries. For example, the now-derelict wall along the spine of the ridge that is incorporated into Mam Tor hillfort is the parish boundary between Castleton (to the east) and Edale (to the west). It ignores the hillfort, running across the interior and through both entrances, taking cognisance only of the topography. As part of the process of enclosure of the wastes and commons, it is not unusual for heritage assets to be used as focal points for the junctions of dry stone walls. On Burton Moor, above Bakewell, for example, a now-scheduled Bronze Age burial mound was the meeting point of three walls (one now removed as part of field enlargement), part of the enclosure of what was once Bakewell's wastes and commons.

13 APPENDIX G: EXPLORING POTENTIAL HERITAGE VALUE OF DRY STONE WALLS WITHIN NATIONAL CHARACTER AREAS

13.1 Introduction

The text below sets out an assessment of the potential heritage value of dry stone walls based on the information set out in the Peak District Landscape Character Assessment, combining an interpretation of Time-Depth, Inter-Relationships and Legibility. This assessment provided underlying characterisation of the case study areas, which helped inform development of the scoring system for measuring the heritage service flows arising from dry stone walls.

13.2 White Peak

13.2.1 High potential

Limestone Village Farmlands

- Distinctive pattern of Carboniferous limestone walls enclosing narrow strip fields around medieval villages, where soils are relatively deep and fertile soils were used as pastures, for growing hay and crops.
- Walls also line routeways extending from villages.
- Unimproved grassland is very rare.
- Association with medieval villages and the archaeological remains of lead mining.

13.2.2 Medium potential

Limestone Plateau Pastures

- Small to medium-sized rectangular fields mostly derived from post-1650 enclosures of former wastes and commons, associated with farmsteads mostly established on new (post-1750) sites and a low density of 19th century field barns.
- There are some areas of Ancient Enclosure including irregular and sub-rectangular fields associated with pre-18th century farmstead sites including medieval grange farms.
- Unimproved grassland concentrated in small areas of Unenclosed Dalesides, in and around lead rakes and rock outcrops.
- Association with the archaeological remains of lead mining and Romano-British and prehistoric monuments and settlement remains which survived within the enclosures of the wastes and commons.

Limestone Hills and Slopes

- Large to medium-sized rectangular fields mostly derived from post-1650 enclosures of former wastes and commons for sheep pastures, e.g. part of the Castleton Commons around Dirtlow Rake in 1691. There are some areas of Ancient Enclosure including irregular and sub-rectangular fields to medieval grange farms. Areas with deeper soils tend to have remained in use for agriculture
- Rich wildlife habitats including calcareous and acid grassland and heath.
- Association with prehistoric monuments and the archaeological remains of lead mining.

Limestone Dales

- Steeply-sloping valleys, with extensive areas of unimproved grassland and semi-natural woodland, often bounded by dry stone walls dating from the medieval period and sometimes sub-divided by post-1650 walls.

The Derbyshire Peak Fringe

- To the south of this NCA are the Village Farmlands on Shale Ridges LCA, with hedges and dry stone walls which mostly result from the piecemeal enclosure of strip fields around medieval villages - either fossilised or barely legible as a result of enclosure driven by individual farmers; most isolated farmsteads are Post-1650.

13.3 South West Peak

13.3.1 High potential

Upland pastures

- Dry stone walls and thorn hedgerows frame landscapes of mostly Pre-1650 enclosure, including fossilised strip fields close to settlements (e.g. Sheen) and irregular fields in the context of medieval hamlets and farmsteads.

Upper Valley Pastures

- Hedgerows and some dry stone walls frame landscapes of Ancient Enclosure and Enclosures of Uncertain Date which form the setting to medieval to 17th century farmsteads and 19th century field barns.

Densely Enclosed Gritstone Uplands

- These are dominated by Post-1650 enclosure relating to straight walls and late 17th/ 19th century farmsteads, the small-scale patterns also relating to the allotment of plots for small farms and smallholdings engaged in coal mining - all intermixed with some surviving rough ground.

Enclosed Gritstone Uplands

- Post-1650 and Enclosures of Uncertain Date which form the setting to medieval to 19th century farmsteads and 18th-19th century field barns, intermixed with some surviving rough ground.

13.3.2 Medium potential

Moorland Hills and Ridges

- Large areas of moorland enclosed with large-scale Post-1650 (mostly late 18th and 19th century) enclosures; some smaller-scale Pre-1650 enclosure and Enclosures of Uncertain Date.

Reservoir Vales with Woodland

- Hedgerows and some gritstone dry stone walls frame landscapes of Ancient Enclosure and Enclosures of Uncertain Date which form the setting to medieval to 17th century farmsteads and 19th century field barns. Early 20th century reservoirs, coal mining remains.

13.3.3 Low potential

Open Moors

- Some walls - mostly post-1750 - mark divisions between estates, townships and owners. Some Pre-1650 (including Enclosures of Uncertain Date) and Post-1650 enclosure encroaching onto moorland.

Riverside Meadows

- Post-1650 fields bounded by hedges and some dry stone walls predominate, some Pre-1650 enclosures following the form of strips within meadows.

Slopes and Valleys with Woodland

- Hedgerows frame landscapes of mostly Pre-1650 enclosure, including fossilised strip fields close to settlements and irregular fields in the context of medieval hamlets and farmsteads.

13.4 Dark Peak

13.4.1 High potential

Enclosed Gritstone Uplands

- Dry stone gritstone walls to medium-large scale fields and the setting to farmsteads and field barns, largely the result of late 18th and 19th century enclosure, with Ancient Enclosure on the edges.

Densely Enclosed Gritstone Upland

- Dominated by Post-1650 enclosure relating to straight gritstone walls and late 17^{th}/ 19^{th} century farmsteads, the small-scale patterns also relating to the allotment of plots for small farms and smallholdings engaged in wool production - houses with weavers' windows.

The Dark Peak Western Fringe

- This comprises a lower-lying landscape than the remainder of the Dark Peak, fast-running water being used to power mills in the Goyt, Etherow and Tame valleys. Enclosures of Uncertain Date predominate, much of this relating to 17^{th} century and earlier farmsteads.

Enclosed Gritstone Uplands

- Post-1650 enclosure relating to straight gritstone walls and late 18^{th}/ 19^{th} century farmsteads predominates, some patches of pre-1650 enclosure. Historic quarrying and mining.

The Dark Peak Yorkshire Fringe

- Enclosed Gritstone Upland dominated by Post-1650 enclosure relating to straight gritstone walls and late 18^{th}/ 19^{th} century farmsteads.

Enclosed Gritstone Uplands, Derbyshire Peak Fringe

- Small-medium scale Post-1650 and Enclosures of Uncertain Date which form the setting to medieval to 19^{th} century farmsteads and 18^{th}-19^{th} century field barns, intermixed with some surviving rough ground.

Gritstone Village Farmlands, Derbyshire Peak Fringe

- Dry stone gritstone walls frame landscapes of mostly Pre-1650 enclosure, including fossilised strip fields close to settlements (e.g. Abney) and irregular fields in the context of medieval hamlets and farmsteads.

Enclosed Gritstone Uplands, Eastern Moors

- Large-medium scale Post-1650, Enclosures of Uncertain Date and Pre-1650 irregular enclosure which form the setting to medieval to 19^{th} century farmsteads and 18^{th}-19^{th} century field barns, intermixed with some surviving rough ground.

13.4.2 Medium potential:

Moorland Slopes and Cloughs

- Steep slopes fringing the open moorland plateaux. Some dry stone gritstone walls to medium-large scale fields, largely the result of late 18th and 19th century enclosure, on the edge.

Upland Valley Pastures

- Some gritstone dry stone walls but mostly hedgerows. Dominated by Ancient Enclosure, including fossilised strip fields, and Enclosures of Uncertain Date which form the setting to medieval to 17th century farmsteads and 19th century field barns; historic mills with associated housing.

Riverside Valleys

- Mostly hedgerows and irregular Ancient Enclosure bounded in parts by dry stone walls. Some historic mills with associated housing.
- Slopes and Valleys with Woodlands have small fields enclosed by hedges and gritstone walls; Enclosures of Uncertain Date which form the setting to medieval to 17th century farmsteads, and Post-1650 Enclosure on the higher ground.

Derwent Valley, Derbyshire Peak Fringe

- Although lying within the Dark Peak, this is a valley landscape comprising relatively soft shales with seasonally-waterlogged soils suited to pasture and loamy soils better suited to arable cropping.

Slopes and Valleys with Woodland, Derbyshire Peak Fringe

- Thorn hedges and dry stone walls frame landscapes of mostly Pre-1650 enclosure, including fossilised strip fields close to settlements (e.g. Baslow) and irregular fields in the context of medieval hamlets and farmsteads.

Valley Farmlands with Villages, Derbyshire Peak Fringe

- Hedgerows and some dry stone walls, with multi-species hedgerows and sometimes holloways to winding routeways of medieval or earlier date, frame landscapes of mostly Pre-1650 enclosure, including fossilised strip fields close to settlements (especially in the Hope Valley and around Great and Little Longstone, where the limited survival of ridge and furrow is also notable for the limestone plateau) and irregular fields in the context of medieval hamlets and farmsteads.

Estatelands, Derbyshire Peak Fringe

- Estate improvements focused in these landscapes have created large-medium scale Post-1650 fields and Enclosures of Uncertain Date with much evidence for enlargement and reorganisation, bounded by thorn hedges and dry stone walls, and parkland which has often also conserved medieval ridge and furrow but rarely the fossilised the form of the strips.

Moorland Slopes and Cloughs, Eastern Moors

- Some late 18th and 19th century enclosure associated with plantations and field barns.

13.4.3 Low potential:

Open Moors

- High gritstone plateau with extensive blanket peat covered by cotton grass bog and heather moorland. Some dry stone gritstone walls to medium-large scale fields, largely the result of late 18th and 19th century enclosure, on the edge.

Open Moors, Derbyshire Peak Fringe

- Some gritstone walls - mostly post-1750 - mark divisions between estates, townships and owners.

Open Moors, Eastern Moors

- Some gritstone walls - mostly post-1750 - mark divisions between estates, townships and owners. There are some field barns and isolated enclosures used for sheltering stock or growing oats.

Upper Valley Pastures

- Some dry stone gritstone walls but mostly hedgerows. Dominated by Ancient Enclosure and Enclosures of Uncertain Date which form the setting to medieval to 17th century farmsteads and 19th century field barns.

Reservoir Valleys with Woodland

- Some dry stone gritstone walls but mostly hedgerows. Reservoirs have filled valleys dominated by Ancient Enclosure and Enclosures of Uncertain Date which form the setting to medieval to 17th century farmsteads and 19th century field barns.

14 APPENDIX H: ASSUMPTIONS MADE IN THE MODEL

14.1 Introduction

The model has taken a conservative approach to estimating values of dry stone walls. The focus of the project was methodological development with no capacity for collecting empirical data; therefore, three very different case study areas were selected to test the model, and assumptions have been made regarding aspects such as resident and visitor numbers, wall condition and functions. Assumptions have also been made to ensure the assigned monetary value of service flows was based on identifiable categories of beneficiary. Table 7 below summarises the key assumptions made in model calculations.

14.2 Identification of beneficiaries

Only 'direct' beneficiaries are included in the calculations: essentially local residents and visitors to the PDNP. In some cases, such as improvement in biodiversity arising from habitat provision of dry stone walls, for example, whereby all of society might be considered to have benefitted, the beneficiaries are still limited to local residents and visitors. This reflects the difficulty of assessing social welfare improvements arising from marginal changes from structures such as stone walls in small study areas. If the level of analysis was the whole country (e.g. England) then for certain categories of service flow (e.g. improved biodiversity; aesthetic aspects of landscape) it might be applicable to include all households in England as beneficiaries. As the study is only looking at the PDNP, and the marginal contribution of dry stone walls within the PDNP to improved biodiversity across the country is unknown, it is not appropriate to go beyond what we have termed 'direct' beneficiaries.

14.3 Double counting

Double counting is a common error in the operation of valuation models (and in CBA more generally). After identification of all the service flows to be valued, and development of indicators, the model was screened for potential areas double counting issues. As a result, a small number of identified service flows were removed where analysis indicated the same underlying outcome was being valued in different ways. These related to duplication of visitor benefits in relation to aesthetic and cultural service benefits, and local economic benefits generated from tourism. Cultural services in relation to sense of place/historic values and aesthetic values of landscape have been separated as in our view these are different benefit flows. A walled landscape can provide aesthetic value to both residents and visitors. A walled landscape can also provide a sense of place based on intimate knowledge of when the walls were built and by whom, how they are utilised, the permanence symbolised by long enduring features, and familiarity from knowing the pattern of dry stone walls. These benefits are more likely to be experienced by residents to an area, who may know those who built/build the walls, and how they are utilised across the seasons. A sense of place might also be instilled in visitors who get a feel for the permanence of built features in the landscape and its association with the settlement pattern, which is different from the aesthetic landscape values to which walls contribute. Extensive discussion might be required with residents and visitors to explore how these service flows are experienced, and how values are gained in practice; the resources to undertake such activities were not available to this study. The sense of place felt by visitors is also likely to be weaker than that for residents and for these reasons the benefit flows contributing to sense of place and history are only attributed to local residents, and not to visitors, in order to avoid any potential for double counting.

14.4 Construction, maintenance and duration

It is very difficult to determine how long a wall might stand before it needs significant re-construction or repair, especially in more exposed locations close to moorland. Some walls will stand with very little maintenance for 200 years or more, while others might require constant attention. Generally, in the first few years after construction/re-construction a wall requires little in the way of maintenance, but over time it will require more attention, in particular if small gaps and collapses are not repaired.

The model assumes that depreciation in the value of a dry wall does not occur in years 1 – 10 (i.e. there is little degradation of a newly constructed or re-constructed wall) then in each succeeding decade increases exponentially. Discussions with farmers and dry stone wallers indicated wide variation in how long an individual wall might stand without decline in quality. Factors influencing the level of restoration and annual maintenance include:

- Quality of the construction
- Quality of the stone utilised
- Condition of the ground
- Exposure to weather (wind, frost, etc. can influence how long a wall will stand)
- Burrowing animals (e.g. badgers, moles will bury under walls causing collapse)
- Cattle rubbing up against a wall
- Sheep trying to climb over a wall (some breeds more agile than others)

14.5 Case study areas

Number of residents were interpolated from local authority population data, and based on the proportion of a case study area located within relevant administrative units for which census data exists. The average number of persons per household was utilised to determine number of households in each study area.

Agricultural land area, and number of farms within each of the three case study areas have been estimated from OS 1:25,000 maps of each case study area as the data were not available within the case study boundary areas selected.

Visitor numbers within each of the three case study areas were estimated based on PDNP visitor survey data. Information was not available for visitors within the case study boundary areas selected so national park survey data was interpolated based on area size and expert knowledge on area attractions and recreational activities.

14.5.1 Condition and function of dry stone walls in case study areas

Wall length and condition

Wall length and condition within case study areas were determined from expert knowledge, maps and field visits (car-based surveys) to identify type of boundary and current state of dry stone walls in terms of functionality, extent of wall collapse/gaps/removal. Dominant characteristics were utilised to score service flows. Functional values were inferred from field observation of the proportion of dry stone walls in current use and from discussions with livestock farmers. Wall length for each case study area was inferred from measuring the total length of dry stone walls from a sample of grid squares within the case study areas on 1:25,000 OS maps.

Property boundary functions of dry stone walls

The analysis assumed that only 10% walls are utilised for boundary marking, based on the approximate proportion of dry stone walls marking external boundaries compared to the proportion dividing fields within property boundaries.

Flood control function: reduced overland water flow in periods of intense rainfall.

The analysis assumed only 50% walls are situated in a suitable position to regulate water flow; based on field observation and discussions with farmers.

14.6 Recreational value

It is worth noting at this point that dry stone walls form the backdrop to outdoor recreation, in particular walking, cycling and climbing. Recent work undertaken at Exeter University[44] has developed an outdoor recreation valuation model through linking MENE[45] data (providing a raw data set of over 300,000 data points) with greenspace data (128,295 individual sites in England). The model[46] is based on actual visits undertaken by people to specific sites (day visits only) but is essentially a travel cost model. Although purporting to be a measure of individual welfare gained from a recreational visit, site values are based solely on travel cost time (for cars or walking) to access and return form a site.

[44] ORVal - The Outdoor Recreational Valuation Tool. https://www.leep.exeter.ac.uk/orval/
[45] MENE is the acronym for Monitor of Engagement with the Natural Environment, undertaken for Natural England, the Forestry Commission and Defra continually through each year since 2009.
[46] Day, B. and Smith, G. (2017) The ORVal Recreation Demand Model: Extension Project. University of Exeter. Accessed at: https://www.leep.exeter.ac.uk/orval/pdf-reports/ORValII_Modelling_Report.pdf

Assumptions underpinning the model mean that all individuals are treated equally in terms of the value of time, and all are assumed to have perfect knowledge of alternative sites, access to cars, and are indifferent as to which sites are visited. Valuation is based on simple calculations of the number of visits multiplied by time value of travel to access a site. The outcome is a measure of value based purely on estimated travel costs, with lowest values ascribed to those walking to sites closest to their home. The approach provides a very restricted and narrow measure of outdoor recreational value arising from visiting specific sites that does not incorporate value derived from site characteristics.

Table 7: Assumptions made in model calculations

Function(s)	Indicator source	Indicator description	Assumptions in the model
Contribution to sense of place and history	Composite derived from time depth; interrelationships and legibility through expert informed assessment	Mean score from three factors each scored on a 1 - 5 scale (Time depth; inter-relationships; legibility). Scores converted as follows: 1 = 0; 2 = 0.25; 3 = 0.5; 4 = 0.75; 5 = 1.0	Both residents and a proportion of visitors value cultural heritage value of dry stone walls
Contribution of dry stone walls to landscape/aesthetic value for visitors	Composite indicator value derived through secondary data/literature; expert informed Indicator value reported through bespoke character area assessment	1 - 5 scale where 1 = very low contribution of dry stone walls to landscape/aesthetic value; 5 = very high contribution of dry stone walls to landscape/aesthetic value. Scores converted as follows: 1 = 0; 2 = 0.25; 3 = 0.5; 4 = 0.75; 5 = 1.0	Assumes can separate landscape/aesthetic values from cultural heritage and historic values.
Maintenance and reinvigoration of traditional rural skills	Increased skills and confidence among dry stone wall builders	1 - 5 scale where 1 = very low level of change in skills/confidences; 5 = very high level of change in skills/confidence. Scores converted as follows: 1 = 0; 2 = 0.25; 3 = 0.5; 4 = 0.75; 5 = 1.0	Skills and confidence increase with additional investment in wall restoration and maintenance; wallers gain experience from operating in different conditions; learn from different styles of construction
Job creation, contracting and related income and employment multipliers through maintenance and repair	Average days per year per waller (earning an income from dry stone walling) from maintenance/restoration of dry stone walls	Annual number of person-days in wall building generated per km of wall	Assumes investment spent on hiring walling contractors; farmer interviews suggested a large proportion of maintenance and repair work undertaken by on-farm labour and part-time contractors.
Breakdown of stone to release nutrients; nutrient cycling; food for higher source plants; habitat for lichens and mosses.	Expert informed Indicator value reported through bespoke character area assessment; geology, micro-climate, and exposure dependent.	Proportion of dry stone walls in the area with high levels of lichens/mosses (i.e. greater than 50% coverage). 0 = no moss/lichens; 1 = 20% walls have some mosses/lichens present; 5 = 100% walls have some mosses/lichens present.	Variability based on type of stone, location, exposure, quality of stone utilised in construction, etc. is not taken into account due to lack of data. Anecdotal evidence suggests significant local differences in quality of stone utilised. Exposure and shelter have significant effect on proportion of mosses and lichens.
Long term habitat creation for flora and	Expert informed Indicator value reported through	Proportion of dry stone walls in the area with suitable micro-climate and	Anecdotal evidence of extent to which habitat/shelter is created; limited scientific evidence. Assumed relatively

Function(s)	Indicator source	Indicator description	Assumptions in the model
pollinator species leading to enhanced biodiversity	bespoke character area assessment	exposure. 0 = no suitable habitat; 1 = 20% walls have suitable habitat; 5 = 100% walls have suitable level of habitat. Where 1 = 0.2; 5 = 1.0	low proportions of dry stone walls provide suitable habitat (based on field observation and stakeholder discussion).
Separation of arable crops from livestock; separation of livestock for management purposes (e.g. breeding; shearing).	Indicator value / composite indicator value derived through targeted farmer survey	1- 5 scale where farmers indicate functional utility of wall for livestock production. 1 = very low level of functional use of dry stone walls for livestock management; 5 = very high level of functional use of dry stone walls for livestock management.	Large proportion of dry stone walls form boundaries, large proportion encompass single uses. Assume only 50% walls utilised for these purposes
Provision of shelter for livestock in adverse weather conditions; provision of shelter for crops, seeds and fauna from wind	Indicator value / composite indicator value derived through targeted farmer survey	1- 5 scale where farmers indicate functional utility of wall for livestock shelter. 1 = very low level of functional use of dry stone walls for livestock shelter; 5 = very high level of functional use of dry stone walls for livestock shelter.	Assume all walls can be used for this purpose at one time or another.
Identification of land ownership boundaries; provision of certainty over land ownership	Indicator value / composite indicator value derived through targeted landowner/tenant survey	1- 5 scale where landowners/land agents/surveyors indicate functional value of wall in marking property boundaries. 1 = very low level of functional use of dry stone walls in marking property boundaries; 5 = very high level of functional use of dry stone walls in marking property boundaries.	Assume only 16% walls utilised for boundary marking. Based on proportion of dry stone walls forming a boundary for average size farm in the character area.
Reduced overland water flow through periods of intense rainfall.	Expert informed Indicator value reported through character area field-based assessment	1- 5 scale where farmers indicate functional utility of dry stone walls for reducing overland water flow. 1 = very low level of reduction in water flow; 5 = very high level of reduction in water flow.	Assume only 50% walls situated in position to regulate water flow; based on field –based assessment of character areas.

Function(s)	Indicator source	Indicator description	Assumptions in the model
Gap restoration and reconstruction	Metres of wall per km needing reconstruction (i.e. $10m^2$ gap or larger)	Number of days walling required per km	Assume each km of wall needs one $10m^2$ gap re-building every 20 yrs (variability of this kind of work is high, from virtually zero to tens of metres).
Maintenance costs.	Average number of days required for annual maintenance per km of wall.	Number of days walling per km of wall.	Assume 3 days per km per year. Amounts to 30 days every 10 yrs. Based on average farm size and reported number of days walling undertaken by farmer and/or local farm labour. Large variation - depends on wall location and age, quality of construction. Also assumes no additional stone required. Assumptions: a 100 ha farm has fields in range 5 - 10 ha then we can assume approx.5 km of wall per farm as a minimum (depends on size and shape of fields). If average farmer spends 15 days per year mending walls - this then equates to about 3 days per km.

14.7 Financial approximations (proxies)

A range of financial proxies have been utilised based on previous experience with similar models and identification of market values for products that deliver similar functions as walls (e.g. animal shelters). Table 8 below summarises the financial approximations utilised in the current models.

Table 8: Description of financial approximations utilised in the model

Ecosystem service function	Financial Approximation (proxy) description	Proxy Value
Contribution to sense of place and history	Average annual value of wellbeing benefits derived through culture and recreational facilities - based on annual sports club membership.	£3,600 per household
Contribution to sense of place and history	Average cost of individual admission to a heritage site. An estimated 5% of total visitors rate cultural heritage highly. 70% total are day visitors/30% are overnight visitors	£17 per visit
Contribution of dry stone walls to landscape/aesthetic value for visitors	Average cost of individual admission to a heritage site. An estimated 57% of total visitors come to the National Park for the scenery).	£17 per visit
Maintenance and re-invigoration of traditional rural skills	Earnings differential of moving to a level 2 NVQ qualification Based on the estimated number of walling contractors in a defined area.	£1,456 per FTE undertaking walling work
Job creation, income and employment multipliers through maintenance and repair	Average annual maintenance costs per km of dry stone wall (including materials and labour) * local multiplier of 2.5 for wall maintenance and restoration (Courtney et al 2007)	£900.00 per km wall
Breakdown of stone to release nutrients; nutrient cycling; food for higher source plants; habitat for lichens and mosses.	Annual cost of preserving forest and woodland habitats per ha.	£665 per ha
Long term habitat creation for fauna; enhanced biodiversity; pollinator species	Annual Value of biodiversity protection provided by cropland ecosystems per ha (Spain)	£1,444 per ha
Separation of arable crops from livestock; separation of animals by type and gender	Average annual cost of providing alternative boundaries using fencing, (assuming farm has 5 km of boundaries, and a 0.05% replacement rate p.a.)	£1,250.00 per km
Provision of shelter for livestock in adverse weather conditions; provision of shelter for crops, seeds and fauna from wind	Average cost of mobile field shelters assuming 10 shelters per farm holding to provide an equivalent level of shelter and a 20% replacement/maintenance rate p.a.	£3,400.00 per farm holding

Ecosystem service function	Financial Approximation (proxy) description	Proxy Value
Identification of land ownership boundaries; provision of certainty over land ownership.	Average annual cost of providing alternative boundaries using fencing, assuming a 20% replacement rate p.a at a cost of £2,500 per km. Assume only 10% walls utilised for boundary marking.	£500.00 per km wall
Reduced overland water flow through periods of intense rainfall.	Value of erosion prevented by temperate natural grassland environments (Spain). Assume only 50% walls situated in position to regulate water flow	£69.33 per km wall
Cost for gap restoration and more significant reconstruction over the period.	Based on repair of a $10m^2$ gap with costs spread over 20 yrs.	£22.50 per km wall
Historical; landscape and aesthetic; utilisation of existing stone, and maintenance costs.	Average annual maintenance costs per km for dry stone walls (including materials and labour). Based on average farm labour costs in the region. Note: if hiring a skilled waller the costs would be 2 to 2.5 times higher.	£300.00

15 APPENDIX I: VALUING THE STOCK OF THE HISTORICAL ASSET VS VALUING THE FLOW OF SERVICE BENEFITS

The project has not undertaken a valuation of the natural capital itself (the overall stock of dry stone walls in any area), as this is a separate question. Valuing walls within a specific landscape or area as natural capital is not straightforward and raises both methodological and philosophical questions. In one sense the existing natural capital is irreplaceable as the cultural and historic values bound up in the walls, within a defined area, only arises over time, and in that sense therefore 'invaluable'. However, there are several options for valuing the capital stock, which could be explored through a relatively modest study. In terms of methodological approach there are 3 potential options:

- Use the value of the current replacement costs for the same linear extent and pattern of dry stone walls that currently exists. This is a straightforward calculation based on the average cost of construction per m2, modified with estimates of where and how much stone might need to be purchased, and how far it might need to be transported. Such an approach might perhaps form a useful function as a lower bound estimate as it would not account for any embedded heritage value.
- Utilise a construction and maintenance cost approach modified by a positive discount rate to account for increasing historic value over time. Such an approach would need to account for the proportion of dry stone walls in an area of variable ages; each age category would then be assumed to have been built at a specific point in time and a positive discount rate applied from that date to the present. Whether specific service flows (such as livestock management) could be incorporated is doubtful as the function of some walls will have changed over time. This approach does not directly measure embedded heritage value, it uses a positive discount rate as a 'proxy' measure.
- Take a construction and maintenance costs plus the value of service flows over time approach. A minimum time frame might be 200 years (estimated period of time a wall might stand with limited annual maintenance (though this figure can vary considerably depending on quality of stone, quality of construction, environmental factors, livestock activity). The approach would provide PVs for discounted service flows over the specific time period (i.e. the natural capital value is the discounted value of all the service flows over a specific period of time, minus the construction and maintenance costs over the same time period). This approach would incorporate a measure of the 'embedded heritage value' since this has been identified as a cultural service flow, and a financial approximation (Proxy) applied. The approach is complicated by the multiple ages of dry stone walls in an area, the combination of which contributes to the value of the natural capital.

Taking a philosophical perspective there is an issue over whether natural capital in the form of dry stone walls based on historical use and development of the land can be given an appropriate value. In the case of dry stone walls, which have developed over hundreds of years the cultural service values are embedded not just in the age of the walls, but also in the pattern of development, and the combination of dry stone walls of different ages, styles, and functions in a defined area. This cannot be replicated since it is the result of specific set of circumstances occurring over a long time-period. In one sense then, it is invaluable, since it cannot be replicated or replaced. Applying a monetary value to the 'capital' itself does not make sense since it cannot be replaced. The closest we can get to identifying the value of such an asset is to examine the current range of benefits (i.e. the ecosystem service flows) and project those out into the future over a relevant period of time that reflects the age of the walls in the area, then sum the present value of the discounted flow values. Discounting over long time periods comes with a familiar set of problems including the huge reduction in size of benefits occurring far into the future benefits, issues of deciding which discount rate to select, and the need to make assumptions about future costs and continuity of service flows and beneficiary numbers.

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