Recognising geodiversity and encouraging geoconservation—some lessons from Callander, Loch Lomond and The Trossachs National Park, Scotland.

Eileen Tisdall[1] and Angus D Miller[2]

[1] *Biological and Environmental Sciences, Faculty of Natural Sciences, University of Stirling, Stirling FK9 4LA.*

[2] *Scottish Geology Trust, 23 Summerfield Place, Edinburgh EH6 8AZ*.

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ABSTRACT

In the past decade progress has been made recognising the contribution that geodiversity makes to biodiversity and society. Scotland's Geodiversity Charter, launched in 2012 and revised in 2017, has attracted the support of almost 100 organisations and encourages signatories to work together to recognise the value of geodiversity and ensure it is managed appropriately and safeguarded. The case study presented here highlights that while there is a real desire to protect sites that are scientifically valuable, significant challenges exist to balance this with societal demand for resources and development. There are also challenges for geoscientists and geoconservation groups to communicate effectively with planning authorities and local communities. The case study also sheds light on the problems associated with the systems of designating geosites of national and regional importance, the maintenance of these systems, and how the value of these sites is conveyed beyond the scientific community. Scotland's Geodiversity Charter offers a framework that stakeholders can use to work in partnership to increase awareness of the issues and help achieve the sustainable management of geosites. Case studies such as Callander provide lessons and solutions to overcome the challenges that arise and highlight the need for the participation of both national and local stakeholders.

1. Introduction

Scotland, for its size, has an internationally recognised geodiverse landscape (Gordon and Barron, 2011; Gordon et al., 2019). With a geological history of over 3 billion years, geological resources have contributed to the wealth of the nation and historically this geoheritage has stimulated scientific thinking across natural history, with several eminent scientists from the 18th and 19th centuries, including James Hutton, Charles Lyell, Charles Darwin, Archibald Geikie and James Croll, all inspired by Scottish landscapes (Ballantyne, 2021; Rose, 2021). The importance of such geodiverse landscapes in Scotland has been recognised in the formation of UNESCO Global Geoparks (North West Highlands and Shetland), National Geoparks (Lochaber and Arran) as well as the National Parks (Loch Lomond and The Trossachs National Park and Cairngorms National Park).

The Geological Conservation Review (GCR) was carried out from 1977 to the early 1990s by the Nature Conservancy Council and the Joint Nature Conservation Committee to identify the sites of national and international importance representing the geological history of Great Britain (Wimbledon et al., 1995; Ellis et al., 1996; Ellis, 2011). The GCR provides the geoscience basis for the establishment of a national network of Sites of Special Scientific Interest (SSSIs) designated for geoheritage reasons. Although an important process for conservation, there was perhaps a disconnect between work at a national scale carried out by academics and national bodies, and local awareness of the importance of these sites (Fig. 1).

Browne (2012) reviewed the role of the planning process in conserving geodiversity in Scotland. Local geoconservation groups have been closely involved in the process of designating Local Geodiversity Sites (LGS) (formerly known as Regionally Important Geological or Geomorphological Sites (RIGS)), under the Local Nature Conservation Site (LNCS) framework (Scottish Natural Heritage, 2006). However, this process is patchy across Scotland, with nearly all progress driven by largely voluntary Local Geoconservation Groups (formerly RIGS Groups) (Whiteley and Browne, 2013). Local site designation requires support and action by local authorities to survey, designate and monitor networks of local geosites and there are large parts of Scotland where no such action has been taken.

More generally, there have been calls to consider geodiversity in the same light as biodiversity, both in terms of active policy and in terms of enhancing public understanding (Brazier et al., 2012; Gordon et al., 2012; Gordon and Barron, 2013; Gray, 2012, 2013; Crofts, 2014). NatureScot (formerly Scottish Natural Heritage) and the British Geological Survey (BGS) published a commissioned report 'Scotland's Geodiversity: Development of the basis for a National Framework' (Gordon and Barron, 2011). It set out objectives to use the ecosystem approach as a framework to deliver better recognition of geodiversity and geoconservation across a range of policy areas. The report also established a vision for a 'Scottish Geodiversity Framework', which would allow for the recognition of geodiversity as integral to the environment, economy and heritage of Scotland. This vision manifested itself as Scotland's Geodiversity Charter first published in 2012 by the Scottish Geodiversity Forum and revised in 2017 (Scottish Geodiversity Forum, 2013). It is supported by statutory bodies (NatureScot and BGS). The Charter provides a framework for stakeholders and agencies to engage with geoconservation. It has 96 signatories including many significant national organisations, local authorities, community groups and businesses. The Charter is a voluntary sector-led initiative to encourage the promotion and management of Scotland's geodiversity, and better integration of geodiversity into policy and guidance. Three different Scottish Government ministers have contributed forewords to different editions of the Charter, showing some awareness of the importance of geodiversity. However, direct Government involvement and support for the Charter has been limited.

The Charter is viewed as a significant first step towards ensuring that the economic, social, cultural and environmental values and benefits of geodiversity are both recognised and sustained (Browne, 2012; Gordon et al., 2012; Crofts, 2014; Gordon et al., 2018). The innovative approach contained within the Charter provides an overarching framework for

groups and stakeholders interested in conserving and managing geological landscapes as well as important sites through the development planning process (Fig. 1). Despite this progress there remain significant gaps at a local level in terms of both acknowledging the value of geodiversity and then ensuring that valued sites are recognised in the planning process (Fig. 1). The Charter has been widely praised and successful in highlighting the importance of geology to Scotland (Crofts, 2014, 2017), and it has attracted the support of a wide range of national and local organisations. These organisations have signed up to a shared vision, but there are no targets or reporting back on actions. The Charter has been poorly resourced, relying almost entirely on volunteer effort. It is a positive first step but needs to be succeeded by more robust initiatives, through recognition across a range of Scottish Government policies, that do more to drive action in local authorities.

The Scottish Geology Trust was established in 2020, partly from a desire for the wider geological community in Scotland to work together on issues of national importance, to promote Scotland's geodiversity and support initiatives such as the Geoparks. The Scottish Geology Trust will actively support groups and institutions working towards the vision of Scotland's Geodiversity Charter (Fig. 1). The Trust is in its early stages and aims to address some of the gaps and shortcomings identified above.

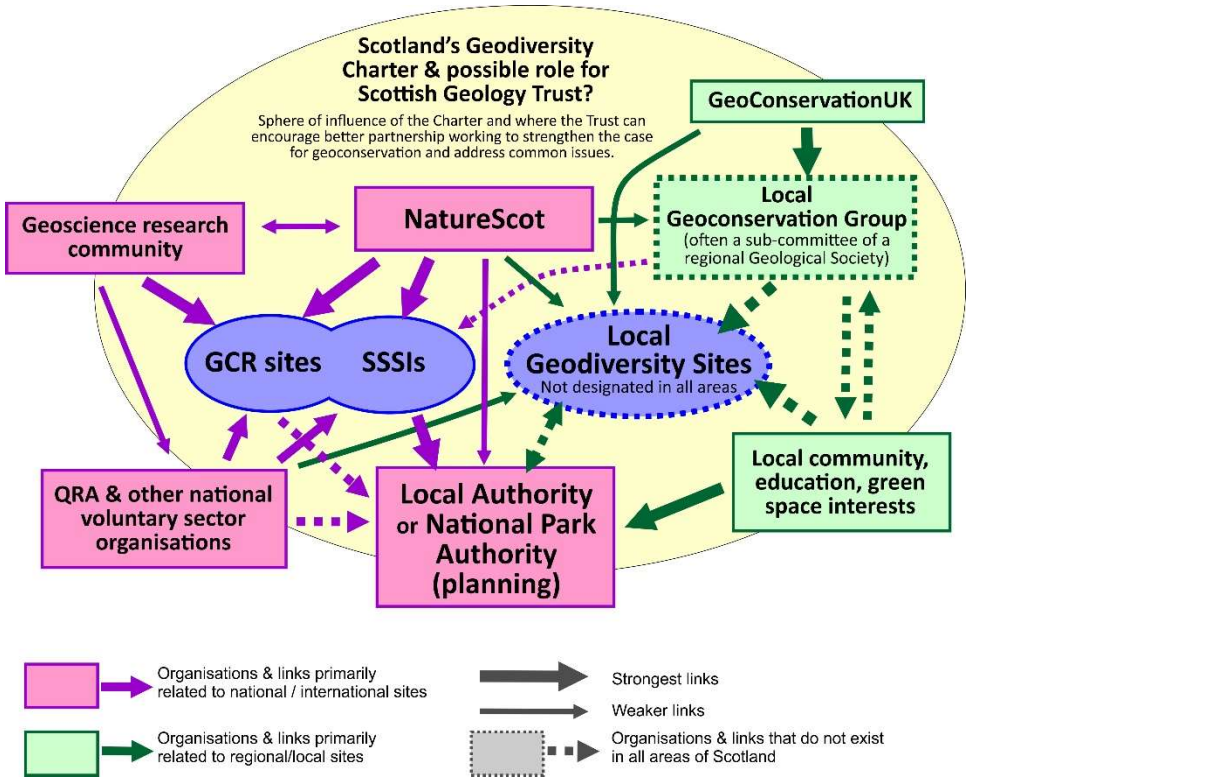

Fig. 1. Relationships between the different national and local organisations involved in geoconservation and planning in Scotland. This diagram is simplified, as there are some connections between all elements. There is a divide between sites of national/international importance (usually involving the geoscience research community, government and local authorities (pink boxes)) and sites of regional/local importance, with strong reliance on local and community voluntary effort (green boxes). Dashed lines indicate links and components

that do not exist in all regions of Scotland – where these are missing, there is often a significant gap in the conservation of important geodiversity.

This paper highlights some of the barriers and challenges around how national importance and awareness of geodiversity translates into local geoconservation. This case study has been developed from the experiences of the authors (and others from the geoconservation community) of working to gain recognition for, and better management of, glacial geomorphological sites at Callander, Stirlingshire, in the Loch Lomond and The Trossachs National Park. The observations and perspectives presented here contribute to the theme of this special edition 'Valuing the Quaternary: Nature Conservation and Geoheritage'. The lessons learnt and recommendations presented here in terms of development planning processes, the role of the academic community, and what official designation of sites means for geoconservation of Quaternary landforms will be of relevance to those working to resolve similar geoconservation issues.

2. Glacial geomorphological sites at Callander, Stirlingshire

Callander acts as a gateway to the Loch Lomond and The Trossachs National Park (LLTNP) (Fig. 2). LLTNP was established in 2002 through the National Parks (Scotland) Act 2000. Callander has been a tourist destination since Victorian times, but within the geoscience community it is also known for its exceptional set of glacial geomorphological features. These include eskers, kame terraces, kettle holes and push moraines, which together with the important biostratigraphical evidence contained within them, form a landscape that has been used to determine the limit and timing of the final ice advance during the Loch Lomond Readvance (Younger Dryas) in Scotland between around 12.9 to 11.7 ka (Merritt et al., 2003; Walker and Lowe, 2019; Lowe and Brazier, 2021) (Figs. 3, 4 and 5).

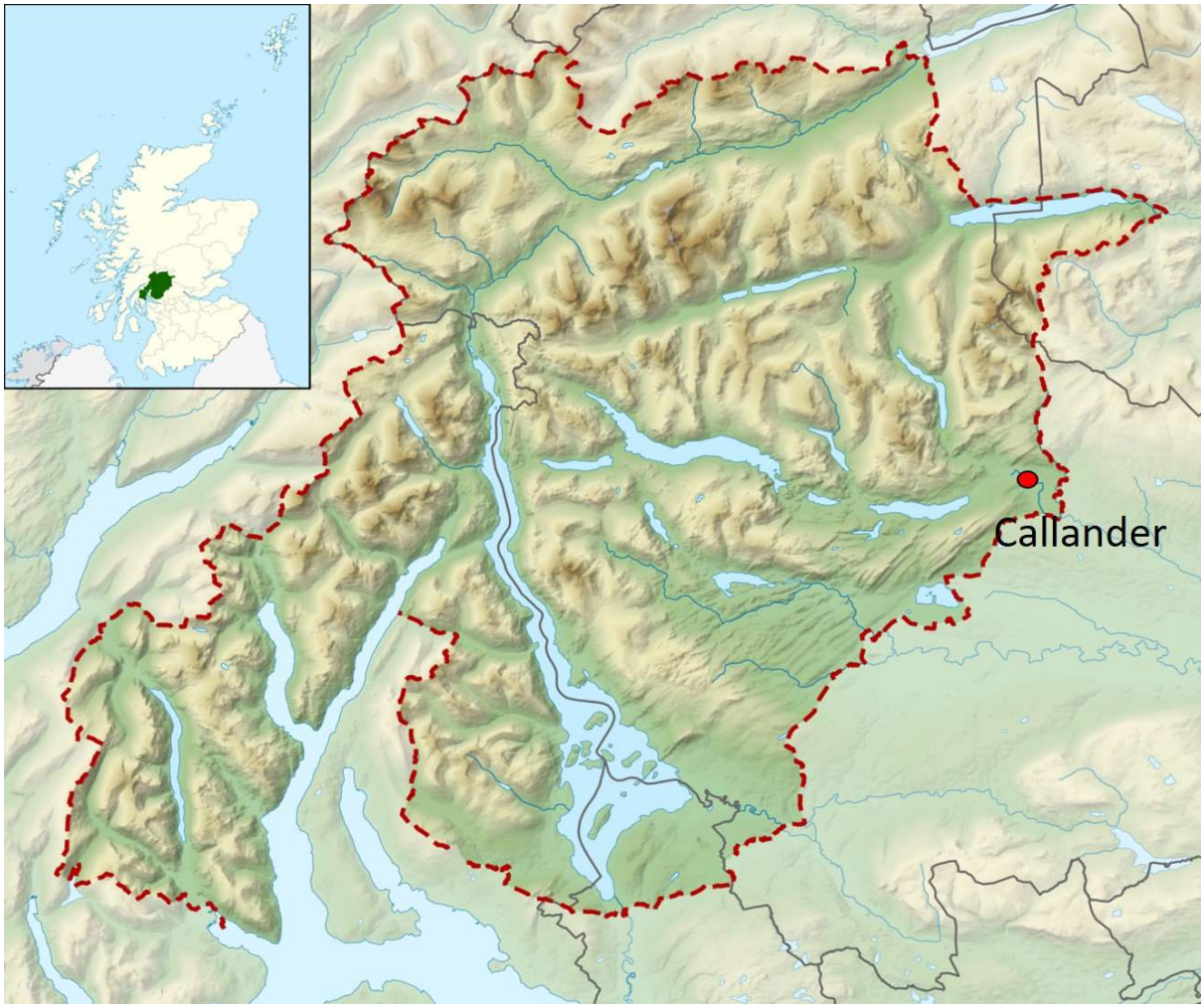

Fig. 2. Loch Lomond and The Trossachs National Park, Scotland. Callander is located at the eastern edge of the park area and is considered a gateway to the National Park. Boundaries of local authority areas are shown in black (Contains Ordnance Survey data © Crown copyright and database rights).

In the Callander area two sites have been designated as SSSIs: Mollands (NatureScot site code 1176) and Tynaspirit (NatureScot site code 1575). In the GCR volume, the Quaternary of Scotland (Gordon and Sutherland, 1993), both localities are described (Lowe, 1993a, b). They occur amongst a set of glacial features within the valley of the River Teith including the moraine at Auchenlaich (also known as the 'Callander Moraine', 'Drumdhu Moraine', and 'Teith Moraine') and the eskers at Claish and the Roman Camp (Figs. 3, 4 and 5). The two SSSI/GCR sites are associated with the adjacent glacial landforms, and the basis for their GCR site selection and therefore SSSI designation is the Lateglacial and Holocene palaeoenvironmental evidence contained in the sedimentary record at the sites and the importance of those records for constraining the timing of the Loch Lomond Readvance in the Teith valley; Mollands occurs within the Readvance ice limits and contains only a Holocene pollen stratigraphic record, whereas Tynaspirit outside the limit contains a full Lateglacial-early Holocene record (see Lowe and Brazier, 2021). The adjacent glacial geomorphological features, although recognised and mapped by Lowe (1993a) were not

given any formal recognition either within the GCR or as sites of regional importance. However, omission from the GCR for remaining intact sections of the Auchenlaich/Callander moraine has now been rectified (Lowe and Brazier, 2021), see Fig. 3b.

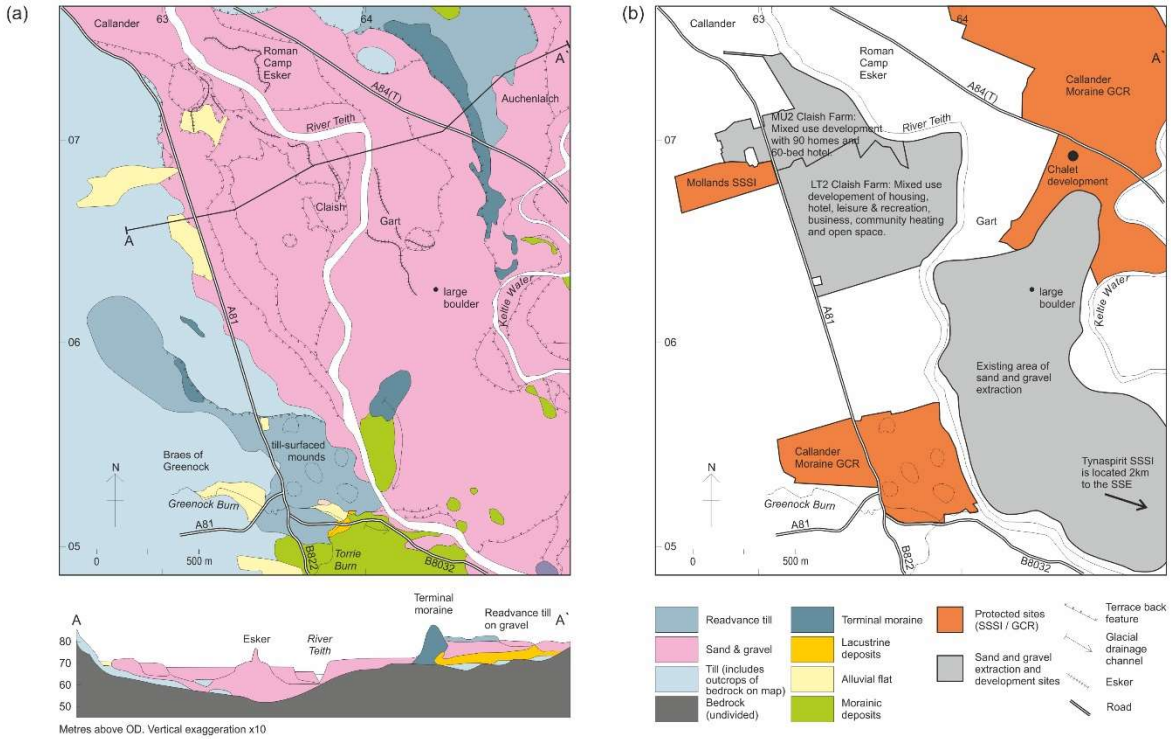

Fig. 3. (a) Glacial landforms (redrawn with permission from Merritt, 2015) and (b) protected sites and areas of sand and gravel extraction and development, Callander, Stirlingshire. The 2019 GCR boundary for the Callander Moraine is from SiteLink (https://sitelink.nature.scot/map) and the MU2 and LT2 Claish Farm development areas are from the Adopted Callander South Masterplan Framework LLTNP, 2018b. The location of Tynaspirit SSSI is indicated.

Within the geoscience community there is clear recognition of the importance of the extensive glacial landforms that are associated with the designated sites (Goodenough et al., 2008; Lowe and Brazier, 2021). These landforms and associated sediments have been the focus of decades of scientific research (Thompson, 1972; Lowe, 1977; Gray and Lowe, 1980; Merritt et al., 1990, 2003; Lowe and Brazier, 2021). More recently, the landforms have been part of the debate about the nature and timing of ice advance during the Loch Lomond Readvance (Bickerdike et al., 2018; Lowe and Brazier, 2021). In their review of the geomorphic evidence for the Loch Lomond Readvance, Bickerdike et al. (2018) point to complex field evidence for the nature and extent of ice in the Teith valley (Merritt et al., 1990). The mismatch between the modelled ice flow limits for the Loch Lomond Readvance in the Teith valley as determined by Golledge et al. (2008) and the empirical field evidence has been explained by the local presence of deformable sediment or water at the bed of the glacier to allow for a surge or locally more extensive glacier advance (Golledge, 2010;

Bickerdike et al., 2018; Benn, 2021). Walker and Lowe (2019) in their review of the evidence for the timing and environment during the Loch Lomond Readvance point to new methodological approaches that will refine our understanding of ice wastage, glacier advance and retreat during this period of rapid climate change. These new research methods lend greater scientific importance to sites such as Callander that contain both the glacial legacy and the potential for the generation of highly resolved palaeoenvironmental data sets (Lowe and Brazier, 2021).

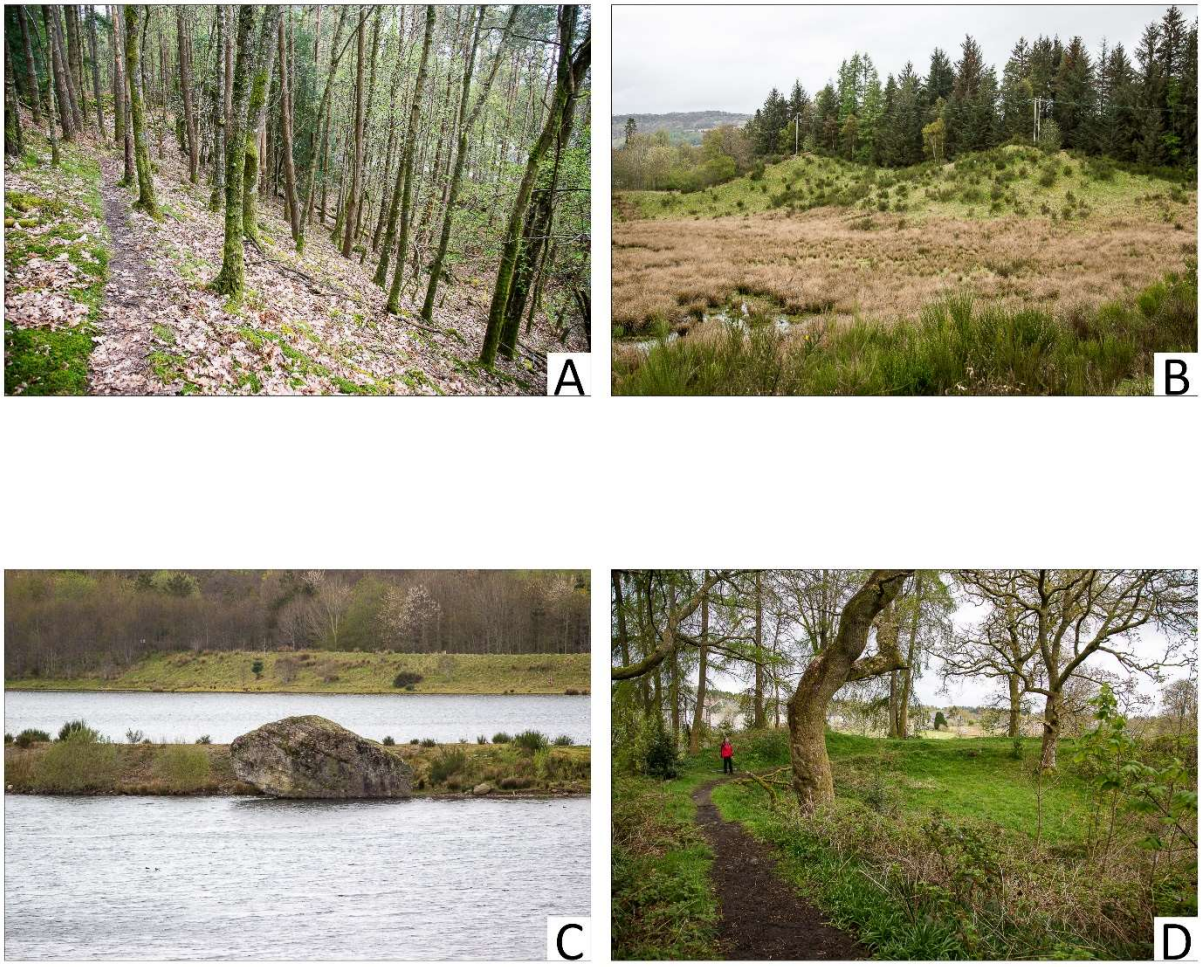

Fig.4. Photographs of glacial landforms and landscapes around Callander; these features are mapped in Fig. 3. (A) Steep ice-contact slope at Auchenlaich Moraine in Drumdhu woods (location 1 in Fig. 5). (B) Cross section of the moraine ridges at the Cambusmore Quarry

(location 3 in Fig. 5)-this section could be reopened to record the sediment stratigraphy (Lowe and Brazier 2021). (C) Large glacial erratic located in the Cambusmore Quarry workings (now a lake). (D) Roman Camp esker as it turns towards the River Teith. (E) View from the road junction, B8032 and B822, north towards Callander, looking down onto new sand and gravel extraction area (location 5 in Fig. 5). Images ©Phil Thompson.

3. Recognition of geodiversity within the Loch Lomond and The Trossachs National Park

The designation of a National Park demonstrates the importance of landscape to local communities and visitors. In 2012 LLTNP signed up to support the vision of Scotland's Geodiversity Charter. LLTNP renewed its support for the Charter in 2017. NatureScot and other agencies promote the contribution of a 'sense of place' and landscapes to communities, but there is recognition that these landscapes also provide important economic resources.

The main mechanism that allows for this oversight of responsibilities in balancing conservation and development planning is through the planning process. The LLTNP Authority acts as the planning authority within the National Park. In 2005, planning permission was sought to extend sand and gravel extraction at Auchenlaich (Figs. 4 and 5), which would have destroyed this section of the moraine. This planning application was challenged by the lead author, as well as many from the scientific community, including formal representations from the Quaternary Research Association, the professional organisation for Quaternary scientists in the UK, and from the UKRIGS Geoconservation Association (now GeoConservationUK). The BGS compiled a short report outlining the importance of the moraine (BGS, 2005) as well as highlighting the other glacial geomorphic sites in the Callander area. However, NatureScot (at the time Scottish Natural Heritage) did not object to the planning application on geodiversity grounds, because this section of the moraine did not have any protected status. As noted above, the Callander moraine was described in the Quaternary of Scotland GCR Volume (Lowe, 1993a, b), but was not recognised as a separate GCR site. The main objection to the permission for sand and gravel extraction raised by NatureScot was that valuable red squirrel habitat would be lost due to the removal of planted Scots Pine woodland on the moraine. In this instance, planning permission was refused. Although the moraine was not included as a site in the GCR, it was hoped that the extensive representations from the geoscience community outlining its importance would have helped raise awareness within the planning authority, the LLTNP.

Subsequently, the BGS was commissioned to report on the geodiversity within the whole of the LLTNP (Goodenough et al., 2008). This report noted that about half of the GCR sites within the park were not designated as SSSIs and suggested that these un-notified GCR sites should be given the protection afforded to SSSIs. The report also noted several localities and areas that were of regional importance. It was proposed that these could be recognised as Local Nature Conservation Sites (LNCS) and recommended they should be properly assessed by a full geodiversity audit (Goodenough et al., 2008).

These first engagements between the geoscience community and LLTNP revealed that the newly established National Park had little awareness of the nature of the geosites in and around Callander. With only two sites listed as SSSIs, and information about other valuable geodiversity sites accessible only in academic circles, it is perhaps unsurprising that LLTNP were unclear about the geological significance and scientific importance of these sites (Fig. 1). The local geoconservation group, Stirling and Clackmannan RIGS, struggled to get enough volunteers to effectively engage with all the local planning authorities, and the group is now dormant. The recommendations of Goodenough et al. (2008) for further work to properly assess sites of regional importance were not taken forward. However, for the first time in Scotland, LLTNP adopted the recommendation that un-notified GCR sites should be given the same status as SSSIs (LLTNP, 2011).

Sand and gravel extraction continued to the south and west of the Auchenlaich moraine (Cambusmore Quarry, land area in the LLTNP) under previous older planning permission granted by Stirling Council. Sections of the moraine were extensively quarried between 2011 and 2017 resulting in the gradual removal of the moraine ridge (Figs. 4 and 5, see also Lowe and Brazier (2021) for further images). Much of the demand for sand and gravel came from large infrastructure projects such as the Commonwealth Games in Glasgow in 2014 and the new Queensferry Crossing across the Firth of Forth, completed in 2017. Gravel has been extensively quarried in the Teith valley because of its relatively high quality (Merritt and Laxton, 1982) and proximity to markets in central Scotland. The high cost of haulage and demand for aggregate means that local sources of sand and gravel are valuable, as use of a local supply can significantly reduce the cost of infrastructure projects. However, there were missed opportunities within this period to properly survey the moraine ridge as it was being removed. During the quarrying very limited field observations were made, and no detailed sediment logs were carried out. At the time planning permission for extraction was given, the moraine ridges were not listed as a protected or named site, and there were no conditions in the planning consent to require the quarry company to carry out survey work or sediment logging.

Despite efforts by the authors and others in the geoconservation community, LLTNP did not take the opportunity to facilitate the collection of scientific data at Auchenlaich moraine. Lowe and Brazier (2021) point out that these were lost opportunities to record valuable scientific information on the formation of this feature. It was felt that a lack of designation as a SSSI/GCR or as a local site made arguing the case for any kind of recording of scientific data at the moraine more difficult. There are examples of best practice where conservation agencies and local groups work with planning authorities so that permissions to quarry nationally or locally important geological sites are accompanied by a planning condition for a Scheme for Geological Monitoring and Recording or ‘watching brief’. Such monitoring enables quarry faces to be recorded and sampled periodically whilst extraction is carried out, thereby conserving by recording (Harding et al., 2012; Bridgland et al., 2013). This means that scientific information is not lost through mineral extraction; however, this ‘watching brief’ approach and the collection of data is more common in archaeology than geology.

Fig. 5. Aerial imagery from 2011 and 2017 centred around the quarry at Cambusmore, Callander, Stirlingshire. The Auchenlaich moraine ridge (outlined in red) runs north-south of location 1 (see Figs. 3 and 4) and is covered in woodland; locations 3 and 4 are on remnants of the moraine. (1) Intact section of the Auchenlaich Moraine which was refused planning permission in 2005 to extend quarrying from the east. (2 and 3) Stages of sand and gravel extraction along the moraine from before 2011 (2i and 2ii), to 2017 (3). (4) Proposed chalet development. (5) Current area of quarrying on features mapped as kame terraces (see Fig. 4). (6) Claish Farm eskers. Image sources Digimap and Google Earth.

In 2017/2018 a planning application was made to build chalets on a remaining section of the moraine (Fig. 5) at Gart Lodge. This is a very accessible part of the feature and unusually at this point it consists of two adjacent ridges (Fig. 4). Once again, the authors and the geoscience community (with formal representations from the QRA) responded to this planning application by highlighting the scientific importance of the moraine. LLTNP claimed that the chalets were not to be built on the moraine but on land next to it (LLTNP, 2017). Arguments made by the authors and the geoscience community around the topography of these landforms and the need to protect the landscape context of the moraine did not convince the planning authority and planning permission was given. This application demonstrates the gap in understanding landform and landscape, with the planning authority satisfied that the landform was not being impacted while the geoscience community was unable to convince the LLTNP of the geoheritage value of the wider landscape.

The geoscience community has made repeated objections to planning applications and volunteered expertise to support LLTNP in giving better recognition to geodiversity and to work towards the vision of Scotland's Geodiversity Charter. Progress in the last decade, as

indicated by the case study above, has been limited. Poor communication between LLTNP, academics and local groups has led to short-term, reactionary responses to planning applications. Opportunities have been missed for longer-term co-operation and planning between all groups to progress geoconservation within the national park (Fig. 1). The full Geodiversity Audit recommended by Goodenough et al. (2008) has not been taken forward. Of course, the National Park Authority has many competing priorities, but the lack of any current in-house geological expertise has meant that the development of geo-focussed interpretation and the recognition of important geosites in the planning process has not been taken forward.

4. Ongoing challenges and solutions

The Local Development Plan for Callander (LLTNP, 2016a and b, 2018a) outlines a series of developments that will have significant impacts on sets of glacial features, shown in Fig 3. In what can be viewed as a progressive move by LLTNP, the moraine at Auchenlaich and the Roman Camp esker are marked as geological features in the Local Development Plan Maps (LLTNP, 2016b pp.42-48, 2018a): at the time neither of these sites had any national or local designation. However, not all the known glacial features (BGS, 2005; Goodenough et al., 2008) are indicated on these planning maps. For example, the eskers at Claish Farm (Figs. 3 and 5) are not shown; these features lie in an area zoned for development including housing, visitor experience, economic development and playing fields (LLTNP, 2016b p.45, 2018a; Fig. 3). In further documents submitted as part of the planning application for the above development, the Claish Farm eskers are indicated on development maps as 'natural eskers' and reference is made to 'safeguarding of eskers' (LLTNP, 2019 p.17), however within the document these features are not discussed under the relevant planning consideration sections. The development that directly impacts the eskers at Claish Farm is now under construction and, without the opportunity to visit the site and meet with LLTNP and the developers, it is difficult to ascertain what the developer intends by the term 'safeguarding'. The indication of these glacial features on planning maps may be a positive step, but the piecemeal approach to the recording of features across the different planning maps and documents for Callander means that there is an inconsistency to the management and protection of these sites.

Aggregate extraction continues, mainly to the west of the River Teith. Features that have been mapped as terraces or kame terraces are now being quarried (Figs. 3, 4 and 5). The geoconservation community have called on LLTNP to include a condition in planning consent that the developer should document these features before they are destroyed. Lowe and Brazier (2021) highlight the scientific importance of these landforms and the need to record all scientific data before they are lost. They also suggest that sections in the Auchenlaich moraine could be reopened for sediment logs to be completed and chronological evidence collected (Fig. 4). Here it is suggested that as a minimum, LiDAR 3D laser scanning should also be used to capture topographical data of all the glacial landforms at Callander.

Within Callander there is some interest from local communities to learn more about the geodiversity in and around their town, with invitations from local groups to give talks and guided walks around the geomorphological sites. The Callander Geodiversity Trail (Browne, 2015) includes 5 walks around Callander encouraging local people and visitors alike to visit some of the local sites. The moraine and other geological sites are also featured in an excursion guide published by the Edinburgh Geological Society (Merritt, 2015). However, there are no information boards or signposts on the ground, which restricts accessibility to any information about the sites. As part of the planning permission granted for the chalet development at Gart Lodge (Figs. 3 and 5), information boards are to be installed, but it is not clear if anyone other than those staying in the chalets will be able to access this information as the chalet site is not part of any local path network. The BGS (2005) considered the glacial landscape in Callander to be unique in Scotland and recommended that these geodiverse features were developed sensitively with information and pathways, to realise their full environmental educational potential. To date no such development has been instigated by LLTNP. Jordan (2020) noted the lack of readily accessible geological interpretation of key sites in the LLTNP and suggested that opportunities had been missed to promote the geoheritage of the park. New information resources that perhaps better reflect how people are choosing to access information on local geology are now being used more widely, for example as virtual web-based sources or mobile app trails such as EarthCache (Pica et al., 2018). Such forms of communication have the advantage of being more cost effective and perhaps more accessible but would complement more traditional resources such as guided walks, printed leaflets and information panels.

The National Park Partnership Plan 2018-2023 (LLTNP, 2018b) sets out the long-term vision for conservation and land management, visitor experience and rural development, working to achieve the overall aims of the National Parks in Scotland as specified by the Scottish Government. The longer-term vision is for the National Park to be an 'international renowned landscape where nature, heritage and land are a valuable asset managed and enhanced to provide multiple benefits to all' (LLTNP, 2018b p. 6). The Partnership Plan provides sets of outcomes to achieve the above vision, and it also notes that these outcomes will deliver on sets of national strategies on land and land use management (LLTNP, 2018b p. 20). Despite LLTNP being a signatory, Scotland's Geodiversity Charter is not listed as one such national strategy. Furthermore, the terms 'geodiversity' and 'geoconservation' are not mentioned in the entire document.

Scotland's Geodiversity Charter encourages the promotion and management of Scotland's geodiversity and better integration into policy and guidance, consistent with the economic, social, cultural and environmental needs of Scotland. The Charter encourages all stakeholder groups to work together to designate, monitor and conserve sites that are of local, regional and national importance. In the case study presented here there remains a gap between what LLTNP have committed to by signing the Charter and what they have been able to achieve. The main reasons for this are a lack of in-house expertise and failure to recognise the wider benefits of geoconservation, and to set geodiversity within much broader and outward looking environmental agendas, strategies and polices (Gordon and Barron, 2011; Gordon et al., 2018). However, by actively engaging with Scotland's

Geodiversity Charter and with the Scottish Geology Trust, Scotland's National Parks and other land custodians will be better able to incorporate geoconservation into relevant land management policies and follow the IUCN best practice guidelines set out by Crofts et al. (2020).

The geoscience community could be criticised for assuming that because they value the landscapes around places such as Callander, and can readily see the scientific importance, others do so as well. The assumption is perhaps also made that because this information has been published in the scientific literature that it is both accessible and easily understood. In practice, as highlighted by this case study, communication between the geoscience community, local geoconservation groups and LLTNP has been ineffective, with the geoscience community often distanced from the points in the planning process where their input would be productive (Fig. 1). Here it is proposed that a working group formed from academics, the geological community and geoconservation interests, and the Scottish Geology Trust should provide advice and expertise to LLTNP, assisting them in their long-term commitment to Scotland's Geodiversity Charter. The working group could support LLTNP to develop a Local Geodiversity Action Plan and audit sites of geological and geomorphological importance. To develop a more proactive and strategic approach to geoconservation, the working group could also provide the LLTNP with expertise on the scientific importance of geodiversity, facilitate the collection of scientific data and monitor the condition of geosites. The Scottish Geology Trust could support the park in engaging with local communities and visitors to communicate the importance of geoconservation including promotion of sites for geotourism (Gray, 2018; Jordan, 2020), helping the park to deliver longer-term goals for biodiversity, climate change adaptation and mitigation and health and wellbeing.

5. Conclusions and Recommendations

The case study presented here highlights that National Park designation in Scotland does not always provide recognition and protection of important and valuable sites within the planning system. The planning authority may be aware of sites that do not have statutory status, but a lack of expertise, awareness and understanding of their significance means that their scientific value may not be properly recognised. The current planning process within LLTNP and elsewhere relies on individuals raising objections to the overall Local Development Plan or to each proposed development. It takes well-motived, highly organised and knowledgeable volunteers to continue to monitor developments and raise awareness of the value of key sites. This case study highlights that even when these views are heard, they are often still not considered in full. The following recommendations are based on the lessons learnt from this particular case study.

- In recognition of their national/international scientific importance, LLTNP adopted the recommendation that un-notified GCR sites should be given the same status as SSSIs. Here it is recommended that this progressive move by the park should be

followed by other local authorities to provide a level of protection for these geosites within the development planning process.

- A more proactive approach to reviewing the list of Quaternary of Scotland GCR sites is required to avoid problems with unlisted sites. This review would take account of sites that were either overlooked or new sites that have come to light with the significant scientific progress since the original GCR assessment (Gordon et al., 2019).
- Local geodiversity audits and action plans should be developed at an early stage, perhaps with a view to the establishing LCNS. This would lead to a more beneficial and strategic approach to geoconservation and avoid reactive and often confrontational responses to proposed developments.
- Selection of individual features, as GCR sites or LNCS, is important, but it takes effort and time from both conservation agencies and geoscientists. In the case of the Auchenlaich moraine, the listing as a GCR site took from 2005 to 2019, and in that period nearly two thirds of the moraine had been extracted, with opportunities to collect scientific data missed. This case study shows that the proposal and confirmation of a GCR site can work in parallel with the development planning process, but this is not recommended given the pressure of development planning timescales. The focus on individual sites fails to capture the wider landscape setting, the considered management of which is perhaps more valuable in terms of delivering the benefits of geodiversity and ecosystem services (Gordon and Barron, 2013; Gordon et al., 2018). Here it is suggested that local designation or selection of sites (as LNCS) could be widened to a landscape scale and incorporate a range of criteria, including geodiversity, biodiversity and greenspace. A more holistic and integrated approach would avoid considering the landscape as a set of fragmentary and unconnected set of small spaces. This could be a good mechanism to increase the awareness of geosites and landscapes and offer greater recognition within the planning system. However, this type of site designation usually requires practical support and expertise not only from the local geological community but others such as the biodiversity and archaeological communities, often on a voluntary basis.
- Signing up to support the vision of Scotland's Geodiversity Charter is voluntary, but it raises awareness and shows willingness to work with other partners, providing a route to workable and successful solutions. Where an organisation lacks in-house expertise, local volunteers are often very willing to fill the gaps, providing specialist knowledge that will inform planning decisions as well as supporting communities in taking greater custodianship over the conservation of their local sites. Here it is recommended that geoconservation in LLTNP would benefit from a working group to provide geological expertise as well as practical assistance in geoconservation and interpretation, which will help LLTNP in the longer term to achieve their commitments to the Charter. In the short term, this would lessen the need for individuals to react to planning applications and consultations. The Scottish Geology Trust provides a mechanism to bring together a range of stakeholders from the local and academic communities, and relevant Scottish and UK bodies, to provide support for organisations that wish to benefit from positive engagement with geodiversity

and landscapes, to communicate effectively in ways that are meaningful and raise environmental awareness.

- In the longer term there is a need to develop best practice guidelines for geodiversity in planning and development at a national and local level, perhaps along the lines of those in existence for archaeology (The Scottish Government, 2011). There are many relevant Scottish and UK organisations that could contribute to developing better awareness and more robust systems to record, audit and maintain local geosites (e.g., GeoConservationUK as well as local, regional and national geological societies).
- There is a recognition that where national and local conservation demands are over-ruled in the interest of society (e.g., because of the need for aggregates), some measure of conservation could be achieved by monitoring, recording and photographing/surveying of sections exposed during working and by the conservation of sections created during restoration. Such issues should be addressed at an early stage of the planning process. Alongside better recognition and designation of local geosites, geological monitoring and recording would require training (including volunteers from local geoconservation groups) and increased understanding of the use of a 'watching brief' in planning consultations for mineral extraction.

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