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What Wetland are We Protecting and Restoring? Quantifying the Human Creation of Protected Areas in Scotland

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ABSTRACT

This paper presents an archaeological perspective of modified lacustrine environments in Scotland currently designated as protected areas for biodiversity. After introducing how 'natural' is embedded in biodiversity protection and restoration, an approach to archaeologically assess the anthropogenic creation of protected biodiversity is laid out using an existing dataset on historic drainage of Scottish lochs. This approach is one way to quantify the degree to which valued and protected wetland habitats are products of human activity, specifically drainage. Where this is the case, wetland archaeology of historic drainage can improve management and habitat restoration through articulating processes of shifting ecological baselines and defining natural states in environments. This is explored with a case study and argued to support novel ecosystems frameworks for protected areas and restoration. With this view, a model is proposed for how wetland archaeology can improve wetland restoration while reducing possible conflicts with the preservation of wetland archaeology.

KEYWORDS

Protected areas; natural; novel ecosystems; historic land-use change; drainage; wetland restoration; habitat management; Scotland

Introduction

Wetland environments around the world are facing enormous pressure from the dual challenges of the Anthropocene – climate change and biodiversity loss. In most cases, this follows the degradation of these environments in past decades and centuries frequently through dewatering via reclamation and drainage schemes, but also including eutrophication, warming temperatures, the introduction of invasive species and combinations thereof. Led by the UN 'Decade of Habitat Restoration', these environments now face ever greater calls for their restoration to achieve a wide variety of ecosystem services (see Verhoeven 2014; Finlayson, Horwitz, and Weinstein 2015; Smolders et al. 2015). With a current estimate putting the value of the world's wetland ecosystem services at $47.4 trillion annually (Canning et al. 2021) and harbouring as much as one-third of the world's vertebrate species (Strayer and Dudgeon 2010), restoration of reclaimed and otherwise altered

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wetland environments is frequently seen as a cornerstone in efforts addressing those main threats of the Anthropocene. The importance of wetland environments has been understood in biological conservation around the world for at least the last 50 years. A key strategy in conservation of wetland and other environments has been to designate them as protected areas with limits on what kinds of human activities can take place in them (from virtually none to only minimal restrictions). These designations have positioned themselves conceptually and legally along an axis of 'naturalness' – with designated, and thus highly valued, wetland environments possessing lower degrees of anthropogenic influence. While there is greater recognition than ever that human-modified environments can still have ecological value, management and restoration still generally aims to remove anthropogenic influence, and in wetland this usually relates to drainage. However, defining 'natural' and the extent of human influence can be very difficult. Archaeological and palaeoecological evidence has been sometimes used in defining these natural reference states, but the unique insight wetland archaeology has for understanding drainage histories itself has not. Developing ways this insight can be leveraged is important for wetland protected areas' management and for the expansion of restoration programmes as they gather pace to meet the challenges of the Anthropocene.

This paper sets out one way to do this, quantifying the human creation of areas protected for valued biodiversity, specifically in lacustrine and related wetland environments in Scotland which collectively are simultaneously well understood to have long histories of modification but also are prized for being 'wild', 'untouched' and 'natural' (Carver et al. 2012). Using wetland archaeology's understanding of drainage histories at different scales, it is revealed that while historic drainage has greatly reduced the quantity of valued biodiversity in some areas, historically modified lacustrine systems have also harboured and increased valued biodiversity in certain ways. It is argued that this approach can improve wetland protected areas' management and restoration programmes in novel ecosystems frameworks through the greater articulation of the human co-creation of valued biodiversity and will also help avoid conflict with the preservation (*in situ* or by record) of rich wetland archaeological deposits.

Historic Drainage, Wetland Protected Areas and the Axis of 'Naturalness'

Wetland environments of all kinds play an outsized role in a wide variety of ecosystem services, covering around 2% of the Earth's surface, but accounting for as much as 40% of total global ecosystem services by some calculations (Costanza et al. 2014; Xu et al. 2020). The ubiquity of historic drainage for agriculture and other purposes has been a key aspect of freshwater biological conservation and restoration (Davidson 2014). Degradation through drainage is recognised as a primary factor in the distribution, quantity and quality of wetland environments around the world with global estimates of wetland environment loss due to drainage over the past few hundred years ranging from around 33% up to 87% (Davidson 2014). The consequent impact to wetland biodiversity is usually taken as a universal negative (Cantonati et al. 2020), and the broader trend of global biodiversity decline is largely attributed to land-use changes (IPBES 2019). In the United Kingdom, estimates for historic wetland loss range up to 80% (Everard 1997), and for certain regions and types of wetland that figure can rise to greater than 90%, for example lakes in parts of lowland eastern Scotland (Stratigos 2016a). Remaining wetlands in most regions around the world are therefore often surviving small fragments of formerly more extensive, functional and connected environments (e.g. Uden et al. 2014). Those wetlands that have not seen significant historic drainage are prized for their lack of human impacts, usually via monitoring assessment metrics which give preference for unmodified systems (e.g. Clarkson et al. 2003; Pearman et al. 2006; Bainbridge et al. 2013), even to the point of downplaying otherwise positive aspects of modified or artificial wetland environments (e.g. increased diversity of species in artificial wetlands compared to natural ones, Spadafora et al. 2016, 469).

The significant impacts of historic drainage along with other hydrological modifications has led to widespread conservation efforts that designated wetland environments. Globally, this has been led by the Ramsar Convention (1971), and most nations have specific wetland habitat protection legislation or directives which augment or work parallel to the Ramsar Convention and other international agreements or legislation. The United Kingdom ratified the Ramsar Convention in 1976 and now has 149 different designated wetlands under the convention (JNCC 2019) in addition to its other types of protected areas. The UK's network of protected areas range in their biodiversity protection from minimal (for example within National Parks, Areas of Outstanding Beauty, and National Scenic Areas) to those that make it a criminal offence to knowingly damage the designated protected feature (Sites of Special Scientific Interest) (Lawton et al. 2010, 25–26). Protected areas usually target either rare or threatened species (regardless of the anthropogenic qualities of the habitat), or environments and habitats without significant human modification (Stolton and Dudley 2015). This is specifically the case for Sites of Special Scientific Interest, where 'naturalness' has been and remains an explicit criterion (Ratcliff 1977; Bainbridge et al. 2013). While there is scope to designate artificial wetland environments as SSSIs, it is meant as a last resort where rare or threatened species are taking refuge as opposed to designating the wetland habitat or environment which should be natural (Mainstone et al. 2018, 10–11).

'Naturalness' is recognised in ecological literature as an important semantic debate, but one which is ultimately difficult to resolve (see Angermeier 2000; Ridder 2007; Schnitzler et al. 2008; cf. McNellie et al. 2020). 'Novel ecosystems' have been proposed as a conceptual framework to account for and accept anthropogenic influence on otherwise functional and valued ecosystems (Hobbs, Higgs, and Hall 2013), yet there remains in protected areas and restoration efforts a preference towards the unmodified end of a 'naturalness axis' (Keenleyside et al. 2012; McNellie et al. 2020, 6072; Figure 1). The recent historic and contemporary preference is seen clearly in a wide range of legislative frameworks, specific guidance and scientific literature that has influenced designation of protected areas of wetland biodiversity (Table 1). These legislative and policy frameworks continue to underpin most ecological conservation and restoration. Restoration of wetland in protected areas can be seen as key centres for wider conservation efforts and restoration programmes, 'naturalness' continues to be a chief goal for restoration (Acreman et al. 2020). In practice for protected wetlands, this can take many forms including managing species populations or chemical characteristics of the water (Geist & Hawkins 2016), but especially in temperate regions of the world, it focuses often on removing historic drainage to rewet areas (Biebighauser 2007; Verhoeven 2014, 7). The difficulties of removing most or all anthropogenic influence is recognised (Bowman et al. 2017) and arguments have been proposed that this can be acceptable for

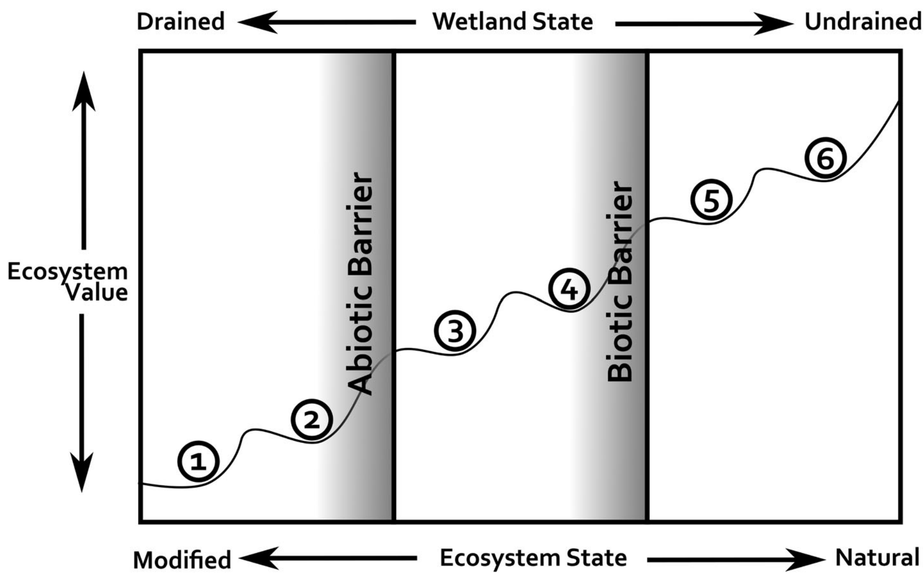

Figure 1. The naturalness axis in biodiversity conservation favours wetlands which are apparently unmodified by drainage. States 1 and 2 represent the range of wetlands impacted by drainage and other physical changes (e.g. eutrophication) which restoration would aim to remove. States 3 and 4 represent wetlands which have been impacted by perceived negative changes in biodiversity (e.g. invasive species). States 5 and 6 represent functional and 'natural' wetlands – the most highly valued positions. Wetland restoration aims to move any particular wetland towards higher states. Generalised scheme developed by Hobbs & Harris (2001) (but see also, Machado 2004), image adapted from Keenleyside et al. (2012, 6).

conservation (Morse et al. 2014). However, the pervasiveness of the 'natural imperative' as Angermeier (2000) coined it, seems to have galvanised in broad ecological restoration approaches like 'rewilding' (e.g. Tree 2018; Perino et al. 2019), 'stage-zero' river restoration (e.g. Cluer and Thorne 2014) or nature-based solutions (Maes and Jacobs 2017) – all of which find strong proponents in Scotland and the rest of the UK.

Wetland Archaeology Insights on Wetland Biodiversity and 'Naturalness'

Archaeology and heritage, like biodiversity conservation, deal with issues of loss and conservation often with similar conceptual approaches to the designation of exceptional and/or representative types. An additional parallel also comes from the challenges accelerated change due to climate change and other Anthropocene pressures forcing rethinking on the traditional twentieth century approaches to archaeological and heritage conservation (DeSilvey et al. 2021; Jones et al. 2022a). These parallels underline the importance of interdisciplinary approaches to the conservation of natural and cultural heritage together which can for institutional and historical reasons be more or less common in different parts of the world (e.g. Moore, Guichard, and Sanchis 2020; see McManamon and Hatton 2000 for further examples). One area in which wetland archaeology can be used for biodiversity conservation is as an 'archive' of past ecological states (Buckland 1993; Gearey and Fyfe 2016). Here, archaeological and palaeoenvironmental records

Table 1. Various forms of 'natural' appear in legislative and policy frameworks that guide the designation, management and restoration of wetland Protected Areas. This has been a defining force of ecological conservation for more than 50 years.

Legislation/Framework/ Agreement	Jurisdiction	Excerpts from Legislation/Framework/ Agreement	Reference
Ramsar Convention (1971)	International	Criterion 1 to meet Ramsar's threshold for a wetland of 'international importance' is that it should 'contain a representative, rare, or unique example of a *natural* or *near-natural* wetland type found within the appropriate biogeographic region'(emphasis added).	Ramsar Convention (1971)
Water Framework Directive (2000)	European Union	In guidance defining reference states for lakes and rivers 'natural' is not used specifically, but is implied with the replaced terminology of 'pressure' meaning human influence, 'High status or reference conditions is a state in the present or in the past corresponding to very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physicochemistry, hydromorphology and biology'	WFD 2000/60/EC Guidance Document No. 10
Criteria for selecting lakes and rivers as Sites of Special Scientific Interest	United Kingdom	Sites should be selected primarily on the basis of: '1) their contribution to representing the full range of natural variation in freshwater habitat conditions in the wider habitat resource (based on consideration of typicalness and rarity); and 2) their naturalness, to ensure that the most natural remaining examples are selected'	Mainstone et al. 2018, 8.

are brought together to demonstrate, the presence/absence of species through time (e.g. Newton 2011) or more specific processes like changing pastoral regimes impact on floristic diversity (e.g. Hjelle et al. 2012). While wetland archaeology can be an immensely useful tool in this way (although there is some debate here, see Whitehouse 2009), the role archaeology can play in understanding drainage histories may be more valuable in protected areas' management and restoration. Given the importance of historic drainage to the survival and value of wetland biodiversity (see above), it follows that greater understanding of this history would provide important insight on what is responsible for the valued biodiversity (nature, drainage or another anthropogenic influence?) and how to address issues posed by drainage for the management and restoration of valued biodiversity.

Wetland archaeology's insight on historic drainage is borne out of understanding the survival and study of wetland archaeological deposits where drainage has been a defining feature (Chapman and Cheetham 2002; Lillie et al. 2008; Brunning 2012; Malim, Morgan, and Panter 2015; inter alia). Like biodiversity, the discovery and survival of wetland archaeological sites and material culture is directly related in a majority of cases to historic drainage (e.g. Chapman and Van de Noort 2001; Stratigos 2016b). While comprehensive programmes are rare, wetland archaeology in the UK has still developed substantial assessments of historic drainage impacts to wetland archaeology deposits at site-specific (e.g. Stratigos and Noble 2018), regional (Van de Noort 2004) and national scales (Crone and Clarke 2006). Information on where, when and how programmes of wetland drainage took place are standard, often desk-based, research topics carried out in wetland archaeology. But this information can and should be leveraged to provide significant new lines of evidence for questions of wetland biodiversity conservation and restoration.

Scotland's Lochs and related SSSIs

To demonstrate one way in which this can be achieved, data developed by the author to address questions of the survival of wetland archaeology in Scotland using documentary evidence for drainage was applied to lacustrine and related freshwater habitats designated as Sites of Special Scientific Interest in Scotland (Table 2). SSSIs were first designated by the National Parks and Access to the Countryside Acts (1949), and they are the most stringent among the UK's and Scotland's protected areas. Biological features are designated under a set of criteria that, since the 1970s, have included specific guidance on establishing the 'naturalness' of the designated feature (Ratcliff 1977). The SSSI designation is not unique to wetland habitats, they can be of any habitat or species (as well as geological/geomorphological features). They were selected here as SSSIs are a key way in which wetlands are protected in Scotland. Additionally, SSSIs have detailed management plans and have been centres for wetland restoration efforts by government and NGO environmental bodies, so give an idea of what and how wetland might be restored and managed in the future. Designated freshwater habitats included in the study are listed in Table 2.

Accounting for Loch Drainage

The Roy Military Survey of Scotland (1747–1755) is the basis of the dataset used, a unique mid-eighteenth century map which shows Scotland before the majority of loch drainage

Table 2. Habitat definitions for SSSI features identified and used in this analysis. Compiled from Ratcliff 1977; Palmer, Bell, and Butterfield 1992; Mainstone et al. 2018.

SSSI habitat features	Definition
Flood-plain/meadow fens	Develops on a waterlogged, often periodically inundated flood-plain adjacent to a river or stream
Basin Fen	Develops in a waterlogged basin with limited through-flow of water. The proportion of open water, if present, is small.
Basin Fen – Shwingmoor type	A repeated process of rafting vegetation colonising an open water surface eventually sinks to form a layer of peat.
Open water transition fen	Develops around a body of open water, the proportion of open water is large.
Valley Fen	Develops along the lower slopes and floor of a small valley.
Spring Fen	Arises on a slope beneath a spring or line of water seepage. It is discrete and not part of an elongated mire.
Wet Woodland	Woodland found in poorly drained soils of different kinds. Usually dominated by Alder glutinosa, Betula (sp.) and Salix (sp.).
Loch trophic range	A loch (or series of lochs) which could be categorised within multiple trophic types.
Base-rich loch	Standing open water with pH greater than 7.4 with moderate to rich nutrient levels.
Oligotrophic Loch	Standing open water with pH between 6–7 and characteristically nutrient poor.
Mesotrophic Loch	Standing open water with pH around 7 with moderate nutrient levels.
Eutrophic Loch	Standing open water with pH greater than 7 and typically nutrient rich.
Dystrophic Loch	Standing open water with pH below 6 and characteristically nutrient poor.
Hydromorphological mire range	A series or mosaic of mire types occurring together as part of a coherent group.
Raised Bog	Can be located in lowland or upland zones, where peat has accumulated over 50 cm and forms (or formed) a dome.
Transition grassland	Community of grass species that form a transition from mire to dry species communities

was carried out associated with the Improvement Period (c. 1750–1850) (see Stratigos 2018 for discussion for further information on the historical context of loch drainage). The drainage dataset was compiled by tracking individual depictions of lochs on the Roy Military Survey of Scotland which covers all of mainland Scotland at a scale of one inch to the mile, through editions of more recent mapping identifying areas depicted as open freshwater. Evidence for the reduction in area extent or altered drainage was recorded (see Stratigos 2016a, 36–37 for full methodology). For this study, the dataset in Stratigos (2016a) was first buffered by 200 m, and then intersected with the current gazetteer of SSSIs in Scotland in QGIS (ver. 3.20.1). The intersected dataset was then filtered to remove all non-freshwater designations (see Table 2 for habitat types included), all designations to a specific water body that was not the body of water depicted on the Roy Military Survey of Scotland and all species-only designations. Removing species-only designations controlled for SSSI designation criteria which specifically allows for artificial environments to be designated for species protection where there are no or few 'natural' alternatives (Mainstone et al. 2018, 10–11). The remaining subset of freshwater SSSIs should therefore meet the 'naturalness' and other criteria. The resulting dataset provides all lochs depicted on the Roy Military Survey of Scotland which are designated as SSSIs in mainland Scotland, with information on if or when they were drained (partially or completely) between c. 1750 and the present.

What Wetland is Protected and Restored?

Two-hundred and twenty-four lochs were identified in the Roy Military Survey of Scotland dataset as designated SSSIs for their lacustrine or related wetland habitat (Figure 2; Supplementary 1). Nearly two thirds ($n = 144$) of the lochs in the dataset showed no signs of drainage. The lack of drainage here is to be expected given the criterion for 'naturalness' desired in designation. There are however clear trends and biases in the identified lacustrine SSSIs. Nearly half of all the lochs in the dataset are designated as nutrient poor oligotrophic or oligo-mesotrophic lochs ($n = 104$). There are geographic trends that mirror population density, with the north and west seeing less loch modification, while central regions of the country have greater shares of heavily modified designated wetland habitats. This trend continues with a heavy bias here towards designation of lochs at higher elevations (above 200 m OD, $n = 98$) and also to lochs which are designated in groups as part of very large SSSIs (more than 1000 ha, $n = 104$) – in other words these are expansive, relatively undrained upland wetland landscapes of poorer agricultural potential, for example Abernethy Forest SSSI, located in the central Highlands and a part of Cairngorms National Park. These tend to be located in landscapes that are less populated (although historically this may or may not have been the case) and thus have relatively less intense anthropogenic pressures. These are also areas of relatively less recorded archaeology and uncertain archaeological potential (Crone and Clarke 2006, 8).

More surprisingly, there are also many SSSIs which designate heavily modified loch basins. Thirty-nine of 224 lochs designated as SSSIs are partially drained. These sites represent a wide range of modified lacustrine environments, and of these it is probable that some designated SSSI habitats have increased in their prevalence or quality as a result of drainage. This is even more stark in cases where lochs have been completely or near-

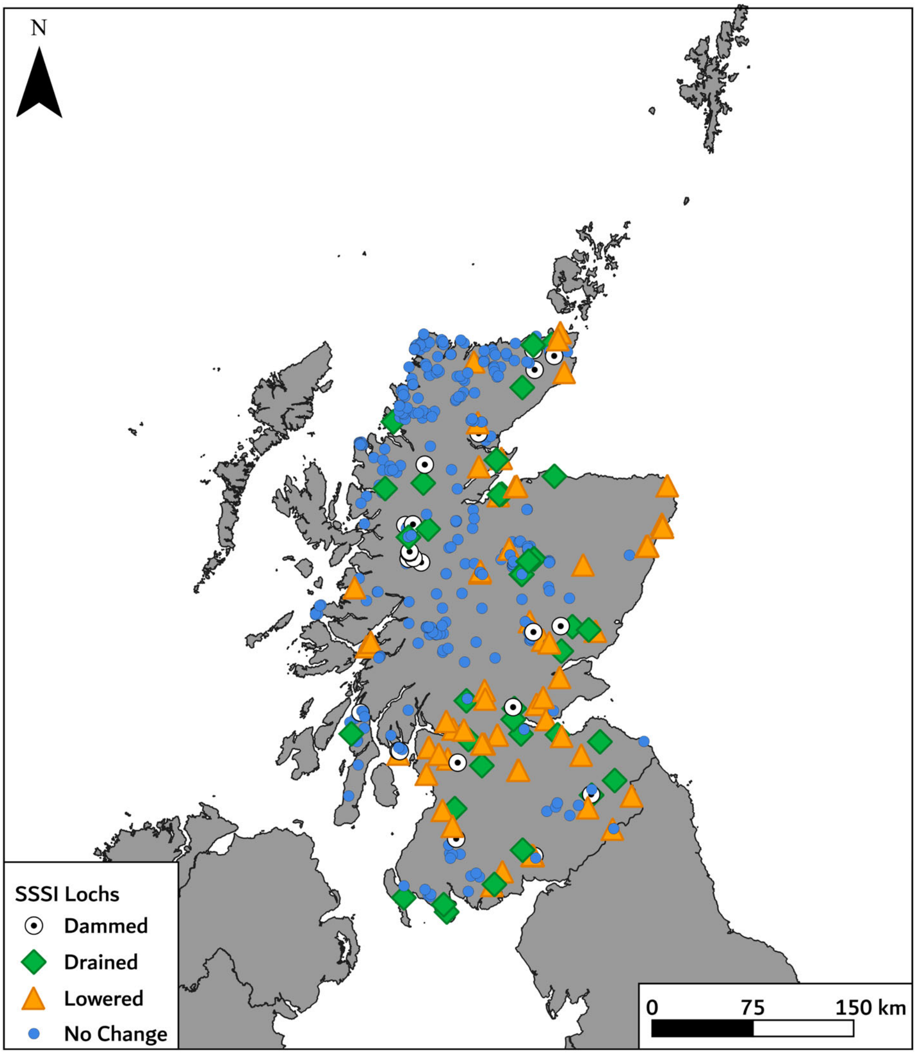

Figure 2. Lochs depicted on the Roy Military Survey of Scotland (1747–1755) now designated as wetland SSSIs.

completely drained yet are still designated as SSSIs. There are 32 of 224 SSSIs identified as completely or near completely drained since being surveyed by the RMS in the middle of the eighteenth century. In these cases, the resulting habitat now designated is completely transformed from what was prior to c. 1750, changing from a loch to some other type of wetland. Most commonly, the transition is from a loch to a basin fen or raised bog (e.g. Restenneth Moss, Angus, which was a loch, but now a basin fen). In other words, these sites' valued biodiversity owe their existence to the drainage itself, the kind of environment present has been transformed through drainage. Fuller archaeological, palaeoenvironmental, documentary and palaeogeographic analysis would be required to articulate specific site histories on a case-by-case basis. These are also the lochs which tend to have substantially greater archaeological records from which crucial information on their anthropogenic histories can be gleaned. This is in great part specifically due to drainage and other reclamation activity which has revealed and made accessible the archaeology. Short of direct intervention fieldwork, collation of available archaeological, documentary and geotechnical data can provide estimates and testable models for how and to what degree drainage is responsible for valued biodiversity in these protected areas. An example, Dowalton Loch SSSI, is explored below.

Case Study: Dowalton Loch SSSI Fen Woodland, Dumfries and Galloway

As an illustration of how drainage can create valued biodiversity and novel ecosystems, we can look to Dowalton Loch SSSI, Dumfries and Galloway, which, due to its notable wetland archaeology, has a detailed history of its drainage and the kinds of environments which were transformed. Dowalton Loch is situated in the Machars, a region of south-west Scotland characterised by gently rolling hills and known for its good agricultural potential, in particular for grazing. The Dowalton Loch SSSI is protected for its Fen Woodland and Lowland neutral grassland, and its citation document considered the area protected to be among the best examples of both designated features in this region (NatureScot 2010a). Management of the SSSI encourages light livestock grazing (sheep) to maintain the mix of wet woodland and lowland neutral grassland habitats (NatureScot 2010b). But this locality has not always been an extensive area of exceptional fen woodland, as its name suggests.

Dowalton Loch itself was drained via a drainage ditch cut up to 7.5 m deep through solid geology in 1863 by the landowner Sir William Maxwell with the goal of creating pasture and improving surrounding arable land (Stuart 1865, 115). This followed at least some amount of modification before which was understood at the time of draining probably related to feeding mills (Lovaine 1865, 209). The lowered water level allowed two separate investigations of this loch's lake dwellings, known as crannogs, in 1863–1864 and again in 1884 (Lovaine 1865; Stuart 1865; Munro 1885). No less than six separate crannogs were identified in the nineteenth century (Stuart 1865), and an additional three have since been recorded in the loch, including one that saw later medieval occupation as a castle (Figure 3). In addition to the crannogs, a large assemblage of Bronze Age to medieval metalwork artefacts, many reasonably interpreted as votive deposits, were recovered in the months and years immediately following drainage (Hunter 1994). This kind of settlement and material culture assemblage speaks to a deep anthropogenic history of the loch before drainage. Dowalton Loch is far from unique in having such a rich archaeological record, although is notable for the quantity of both settlement and artefacts. This may be due to the somewhat unusual circumstances of having a proprietor who was especially interested in antiquities carrying out the work and thus attuned to discoveries of this kind (e.g. Loch of Leys, Aberdeenshire, Burnett 1851; Stratigos 2016b; Jones et al. 2022b). Using this rich archaeological and documentary record, it is possible to reconstruct how drainage has transformed this particular wetland into the designated and protected area of valued biodiversity in the present.

The former loch prior to drainage in 1863 probably had a shoreline with an altitude between 42–44 m OD. This can be suggested based on documentary evidence (New Statistical Account 1845, Volume 7, pp. 41), cartographic records (Ordnance Survey 1st Edition 1850, Wigtownshire Sheet 29) as well as the archaeological record (Stuart 1865; Munro 1885; Hunter 1994). Specifically, documentary descriptions and historic mapping

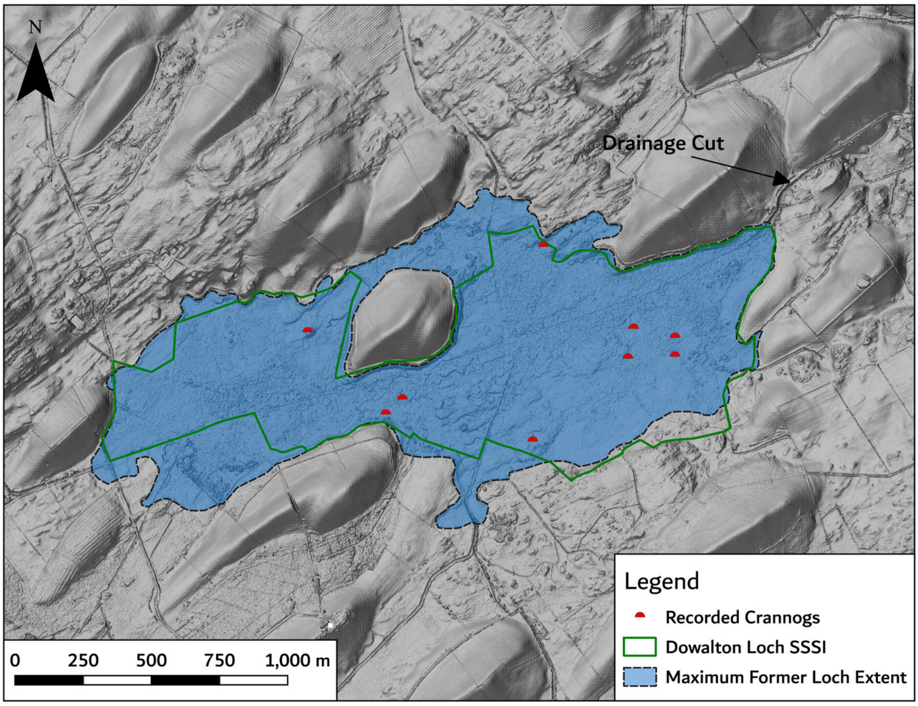

Figure 3. Lidar Composite Digital Terrain Model Scotland (Phase 3) 50 cm resolution hillshaded with modelled former maximum extent of Dowalton Loch at (c. 43 m OD) and current extent of Dowalton Loch SSSI. © Open Government Licence, accessed from EDINA Digimap service.

records the position of the loch in the decades leading up to drainage in 1863. Going back in time, the presence of crannogs precludes a former shoreline any lower than 42 m OD, and shorelines higher than 44 m OD become increasingly unlikely due to three sills which would begin to drain the loch above this altitude. Peat formation or damming (humans or beavers) could have potentially increased this altitude, but there is no evidence for this. With a proposed former shoreline at c. 43 m OD (Figure 3), the loch would have encompassed up to 160 ha, with water depth up to 10 m (cf. New Statistical Account of Scotland 1845 vol 4, pg. 24). Although some wet woodland would probably at different times fringed this loch prior to the 1863 drainage, we can suggest that drainage has substantially increased the quantity, and perhaps quality, of wet woodland, undoubtedly altering its composition. Importantly, for this region other open freshwater habitats are relatively common – SSSI designated examples are found at the Mochrum Lochs with three separate lochs covered by one SSSI 12 km to the north-west and at White Loch 32 km to the north-west as well as numerous others undesignated. However, designated wet woodland habitats in this region are exceptionally rare with the only other wet woodland SSSIs in the entire council area of Dumfries and Galloway (6,426 km^2) located at Ardwall Hill (30 km east) which is primarily designated for lowland moorland habitats. Undesignated wet woodland habitats do exist elsewhere in the region, but frequently are found in other drained loch basins, for example at Torrs Loch (another SSSI, although not designated for its wet woodland habitat, NatureScot 2009). While historic drainage in the wider landscape is undoubtedly responsible for a reduction in the quantity and quality of wetland habitats in the region including wet woodland, it does not necessarily follow that all valued wetland habitats were reduced by this activity as well. The historic drainage of Dowalton Loch has increased the quantity of wet woodland in a region not short of lowland meso- and eutrophic lochs.

Discussion – Where does this leave wetland archaeology, biological conservation and restoration?

The analysis of historic drainage in designated wetlands above has shown that wetland environments impacted by historic drainage can be important localities for biodiversity – in the case of designated lacustrine and related environments in Scotland, around one-third of the time. It highlights how patterns in historic drainage programmes are in large part responsible for existing protected areas of wetland biodiversity and one way in which this can be quantified and characterised (cf. de Haas and Schepers 2022 this volume). The results also show how in some circumstances, these types of human-modified and drained wetlands have *increased* valued biodiversity in these places that were not substantially present at that locality. Wetland archaeology (specifically related to drainage, but also of settlement and other activity) has been shown through the Dowalton Loch case study to have a role in articulating this important co-production of valued biodiversity. This adds weight to the idea that biodiversity conservation should consider shifting away from highly valuing environments primarily for perceived 'naturalness' (McNellie et al. 2020; Thomas 2020) and recognise that anthropogenic changes can increase valued biodiversity at some scales (e.g. Danneyrolles et al. 2021) broadly supporting a novel ecosystem framework (Hobbs, Higgs, and Hall 2013; Morse et al. 2014; Macdonald and King 2018). While this is not an endorsement of wetland drainage as an ecological conservation strategy, it does require reconsideration of the naturalness axis and that restoration in wetland environments should seek in all cases to remove anthropogenic influence even if it was possible to do so (Figure 4).

This is also where the wetland archaeological perspective takes on practical importance. As outlined above, the need for wetland restoration in many locations around the world will increasingly become part of typical private and commercial development in addition to central aims of many governments' environmental bodies as well as environmental NGOs. Along with greater integration of understanding how the human co-creation of valued biodiversity has occurred, wetland archaeological data on drainage would be very useful in deciding where and what wetland to restore at broader levels. Figure 4 illustrates where and what wetland archaeology might be useful in any given restoration situation. Where historic drainage is planned to be reversed (State X to B or C in Figure 4), a wetland archaeological approach to the historic drainage itself is likely to be important as a source for useful chronological resolution and historical contextual information for the restoration programme in explaining the process of human/environment interactions driving ecosystem change as well as greater understanding of the specific process of structural changes related to drainage (Macdonald and King 2018, 155). Where biotic barriers are sought to be overcome (in Figure 4 moving from State Y to C), using available wetland archaeology as an 'archive' could be beneficial depending on the circumstances, for example, the rich species information gathered from the Middle Grant Creek Site in the Midwest of the United States (McLeester et al. 2022, this volume).

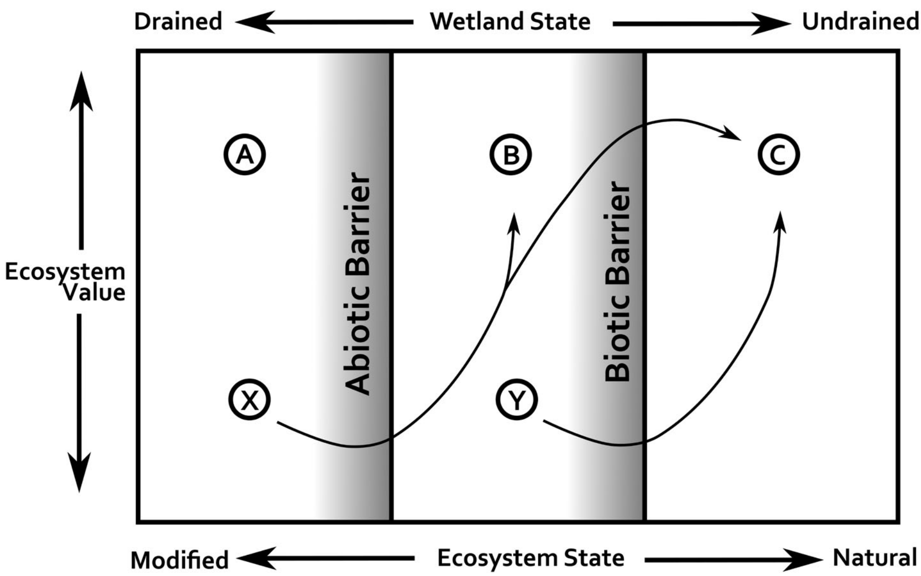

Figure 4. A novel ecosystems perspective on wetland value revising Figure 1. Heavily modified ecosystems can be highly valued (State A). Notably, there is no longer a single axis upon which any particular wetland can slide up or down. Restoration is represented by the sinuous arrows with restoration choosing to move ecosystems to higher valued positions (usually restoration targets ecosystems like X and Y with a goal of achieving states B and C). This framework also provides a blueprint for identifying where and what wetland archaeological perspective is useful as well as helping avoid conflict between wetland restoration and wetland archaeology preservation. Movement across abiotic barriers should include wetland archaeological analysis of drainage to improve the restoration programme while also identifying and avoiding conflicts with preservation of archaeology possibly at risk. Movement across biotic barriers could use wetland archaeology as an archive of past states if necessary to achieve higher value states.

Embedding wetland archaeological perspectives in the expansion of wetland restoration should also help avoid conflict between wetland restoration and the preservation of the wetland archaeological record. Many restoration schemes require significant groundworks (especially the use of heavy machinery) and changes to water levels – both of which can put exceptionally well-preserved wetland archaeological deposits at risk (Gearey and Fyfe 2016, 108–111). More expansive landscape archaeological features are also now recognised as threatened from wetland restoration projects, for example reclaimed estuary in the Basque region of the Iberian peninsula (Narbarte et al. 2022, this volume). In Figure 4, both such examples would be where restoration aims to move environments from State X to B or C. The potential impact wetland restoration may have is further complicated by wetland archaeology, that while frequently exceptionally rich in terms of preservation of material usually lost in other contexts, is often poorly identified and recorded spatially due to difficulties of visibility and access. The challenge therefore is often to simply communicate the importance of an archaeological resource which can be ill defined, difficult to see and appreciate. In this area of incredible, but unspecified, potential, there is substantial value in using wetland archaeological insight on drainage in contextualising and setting wetland restoration goals. It allows archaeology (and archaeologists) to make positive contributions to wetland restoration programmes that can facilitate appropriate measures to benefit both restoration and the preservation (*in situ* or by record) of wetland archaeology. The specifics of any particular restoration programme will be different in a novel ecosystem framework, but the approach, to utilise wetland archaeology's unique perspective in wetland ecology restoration, can be applied widely.

Conclusion

Despite novel ecosystem frameworks and other acceptance of human co-creation of biodiversity and other ecosystem services, 'naturalness' remains an important concept in wetland biodiversity protection and restoration. As wetlands play such an outsized role in a range of ecosystem services, there will be increased pressure to see the expansion of wetland protected areas and the restoration of degraded and reclaimed wetlands. Restoration will be a vital tool in addressing the key challenges of the Anthropocene, and wetland archaeology has a positive contribution to make here. This paper has shown one way this might be achieved. At a broad national level, wetland archaeologies of drainage and reclamation can help to identify the historic modification of wetland habitats and how that has shaped what wetland environments are designated and protected – in Scottish lochs this is historic drainage of the past 250 years in around one-third of the time. The results here suggest that deeply modified wetlands can still be highly valued, such as Dowalton Loch, and this supports a novel ecosystems framework that might reconsider how historic reference state or baselines are utilised in biodiversity protection and restoration. It has been argued this reconsideration puts wetland in a position to positively contribute to wetland archaeology restoration that can also mitigate potential impacts restoration could have to wetland archaeology deposits.

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Data availability statement

The Roy Military Survey of Scotland data used in this paper is available in Stratigos (2016a) <https://doi.org/10.1080/14732971.2016.1248129>. Data on habitat and condition for Scottish Sites of Special Scientific Interest are available from <https://sitelink.nature.scot/home> and boundary data for Scottish Sites of Special Scientific Interest are available from<https://gateway.snh.gov.uk/natural-spaces>.

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