Coastal Agricultural Landscapes:: Mapping and understanding grazing intensity on Welsh Saltmarshes

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--Manuscript Draft--

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Abstract:	Coastal wetlands such as saltmarshes, support local communities and industries through ecosystem services, and benefit the well-being of local communities in many regions of the world. Along sheltered temperate and sub-tropical coastlines, saltmarshes provide coastal protection, provision of recreational space and wildlife habitat. Those in northwest Europe provide a valuable resource for local agricultural communities through livestock grazing. Following the UK's EU Exit potential changes to agricultural policies and markets, it is timely to evaluate the status of saltmarsh livestock grazing. In particular, knowledge of grazing patterns, policy futures and stakeholder perceptions are required to support traditional cultural practice and the ecological status of saltmarshes. This study focuses on the devolved UK nation of Wales, as it has a strong traditional agricultural and pastoral economy, and a landscape of significant conservation value. Yet there are substantial evidence and knowledge gaps regarding livestock grazing and its saltmarsh impact. We present the first map showing the spatial distribution of saltmarsh grazing practice in the UK. Drawing on insights gathered through an expert workshop and interviews with saltmarsh landowners and managers across Wales (n=35), the paper discusses the challenges and benefits of coastal grazing on saltmarshes, highlighting the diverse values, personal connection and sense of identity associated with marshes. Interviews reveal deep rooted social and cultural values attributed to saltmarshes from the rural coastal community. The study illustrates the need for an integrated approach to management of saltmarshes, accounting for the social, cultural, economic, and environmental values within decision-making.
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December 22nd 2021

Reference: Revisions to manuscript entitled 'Coastal Agricultural Landscapes: Mapping and understanding grazing intensity on Welsh Saltmarshes

Dear Editors,

I hope this finds you well. Please find enclosed the revised manuscript: **"Coastal Agricultural Landscapes: Mapping and understanding grazing intensity on Welsh Saltmarshes"** written by Drs Emma McKinley, Rachel Harvey, Rhoda Ballinger, Kate Davidson, John Griffin, and Martin Skov, to be submitted as an article to *Ocean and Coastal Management* for consideration for publication. This revised version of the manuscript has been seen and agreed upon by all co-authors and, as before, there are no financial interests or other conflicts of interest to report. We can confirm that the submission is original work and is not under review at any other publication.

Thank you to the reviewers for their further feedback and comments on this manuscript. We hope we have addressed your comments appropriately. Your input has been extremely valuable and led to a much-improved paper. Thank you.

We look forward to hearing from you in due course. Please do not hesitate to contact us should you have any queries.

With best regards,

Yours sincerely,

Dr Emma McKinley (Corresponding Author)
Mckinleye1@cardiff.ac.uk

	Response to Reviewers
Reviewer #1: OCMA-D-21-00402R1: Review of Revised Submittal	Thank you for these detailed comments on the revised version of the manuscript.
Title: Why is 'saltmarshes' initial-capitalised?	This has been edited – thank you.
Abstract: 1) Delete comma after 'saltmarshes'. 2) Line 7 The phrase 'UK's EU Exit' is still awkward in general (see comment to Line 45 below), and here especially so, because the sense of 'Exit potential' could be misconstrued as 'the potential for exit' which would be nonsense historically. Also, why initial capital 'Exit'? It doesn't avoid the possibility that some readers might think that it's the EU that is leaving. To improve this first occurrence, please consider 'Following the departure of the UK from the EU, potential changes to local…' noting the comma needed after 'EU'. 3) Replace 'from' with 'by' in line 18.	Thank you for these suggested edits to the abstract – these have been addressed as suggested.
Highlights: 1st and 2nd highlights have active present tense verbs, whereas 3rd and 4th highlights have only past participles, and used in an adjectival form. The grammar and form of highlights should be consistent, so please amend by adding 'is' twice, so 3rd highlight becomes 'Emphasis is on…' and 4th highlight becomes '…management is discussed'.	Edited as suggested.
Graphical Abstract: In 'Challenges' box, insert hyphen between 'Decision' and 'making' to improve readability.	Edited as suggested.
Line 28 Instead of 'Yet,' which is a jerky start to a sentence with 6 commas, please try 'However, coastal landscapes such as saltmarshes are facing unprecedented change…' emphatically noting no comma after 'saltmarshes' and which leads to only 4 commas in total.	Edited as suggested.
Lines 31 and 34 replace the second occurrence of 'has/have long been' with 'are recurrent concerns' (or 'are persistent concerns').	Edited as suggested
Line 42 another sentence starting with one word followed by a comma. Just say 'Wales is a devolved country within the UK which has a long-standing and highly significant pastoral economy as well as extensive landscapes of conservation value'.	Edited in response to this comment
Line 45 Why is there an initial capital for 'Exit'? I get that the article should have a shorthand for the 'UK's departure from the EU'. In looking for some solution to this, 'Exit EU' just isn't as catchy as 'Brexit'. And so, perhaps the	We have chosen to use EU Exit as this was the term being used at a government level. We are happy to be advised by the OCMA editors on the best approach to this.

OCMA Editor can decide on 'Brexit' after all, because it is recognised internationally (unfortunately).	
Line 46 Suggest starting this sentence with 'Wales is an especially interesting case study, with its strong agricultural community, relatively recently devolved powers for agricultural and conservation policy, and a suite of innovative natural resource and sustainable development legislation.' That way round the sentence has much more impact and follows directly the idea 'it is particularly timely…following its exit from the EU'.	Thank you for this suggestion – we have edited this as indicated.
Line 51 Classic split-infinitive should be changed to '…to manage coastal fringe environments effectively and sustainably (Environment Agency, 2011)'.	Edited as suggested
Line 55 'Natural Resource Wales': there should be 's' on 'Resources'. See also Line 793, the reference to 'Natural Resource Wales' should also have 's' on 'Resources'. The authors said they could not locate these errors, so here is the comment again.	Thank you for this – apologies for not spotting this in the initial review. Thank you for highlighting it for us.
Line 57 again broken up by too many commas.	We have edited this to reduce the commas in this sentence
Lines 59-60 Move 'Ladd et al, 2019' to the end of the sentence and consider dropping the phrase 'as demonstrated by').	This sentence has been edited in response to this comment.
Line 72 Add 'd' to 'improve' to make 'improved'.	Edited as suggested.
Lines 73-76 There are too many clumps of references and the remainder is not a real sentence. At a minimum, I think the vital word 'to' is missing from between 'attributed' and 'agricultural'. Even then, the sentence is extremely long and difficult to follow. So, delete 'While' at the very start and then finish the first sentence immediately after 'Potts et al, 2016)'. Rather than being indigestible as was, this may also go some way to providing a summary of more existing literature.	We have edited this sentence
Lines 76-77 In the new second sentence, does 'separately through a range of different lenses' add anything really new to the 'various values attributed to agricultural, rural and coastal areas? If not, then delete the 'lens' phrase or at least replace it with 'inter-disciplinary' or similar before 'values' back on Line 73. The next sentence should then start with	Thank you for this comment. We have edited this section so that it now reads as: "Numerous scholars have mapped and explored various values attributed to agricultural (e.g. Assandri et al., 2018; van Berkel and Verburg, 2014; Geneletti, 2007), rural (e.g. Howley, 2011; Scott, 2010; Suckall et al., 2009; Nijnik and Mather, 2008), and coastal areas (e.g. Himes-Cornell et al., 2018;

'Saltmarshes occupy an unusual space…'. If all these edits are done, then it works just fine.	Kelly, 2018; Brown and Hausner, 2017; Potts et al., 2016). Saltmarshes occupy an unusual space in that they are both coastal and rural, supporting diverse uses, including agricultural activity."
Line 80 Please insert 'with' between 'interact' and 'the' (line 80).	Edited as suggested
Line 90 Delete 'Furthermore' because this is a new paragraph (and you had an acceptable 'Further' on Line 81. Also no comma is needed after 'saltmarshes'.	Edited as suggested
Lines 91-109 This great paragraph is extremely topical, and ideally should end by saying something like: 'There are still only scant details of what will gradually replace the EU farming subsidy (Basic Payment Scheme) starting in December 2021 with planned completion in 2024. At a time of rising prices of oil (for diesel) and gas (for ammonium nitrate fertiliser), this is increasing the anxiety among farmers. There is a case for the argument that marginal small farms should continue to receive their current BPS income until finalisation of the replacement arrangements (Environmental Land Management Scheme)'.	Thank you for this suggestion – the text has been edited based on this comment and now reads as: "These expressions of commitment to the agriculture sector notwithstanding, there remains only scant details of what will replace EU farming subsidies (such as the Basic Payment Scheme). At a time of rising prices of oil (for diesel) and gas (for ammonium nitrate fertiliser), this is causing increasing anxiety among farmers with some arguing that small farms should continue to receive their existing subsidies until replacement schemes are finalised (Institute for Government, 2021)."
Lines 114-116 Avoid repetition of 'up-to-date' (twice in one sentence).	Edited as suggested
Line 120 Insert 'out' after 'Carried'.	Edited as suggested
Line 144-45 Suggest adding 'Wildfowl & Wetlands Trust' to this list, as was mentioned in the authors' response to the first review.	Added in as suggested
Lines 180-184 Very long and jerky sentence, not helped by three commas in the first 8 words, and tailing off with 'to name but a few…'. Split this sentence up, and shorten ponderous phrases like 'as well as knowledge of their views'.	Edited as suggested
Lines 202-3 Repetition of the phrase 'wild geese were included' or very similar in neighbouring sentences.	Edited as suggested
Line 209 write out 'isn't' in full.	Edited as suggested
Line 214 Table 1 caption has a floating vertical bar before 'Weighting'.	This was a formatting choice – however, we have removed this to ensure it is standardised across the paper.
Line 254-5 Delete 'in addition to', 'with' and 'most common', leaving it as 'Analysis found that agricultural use, dog walking, wildfowling and scientific use were the main activities (Table 2)'.	Edited as suggested

Line 265 Add 's' to interview.	Edited as suggested
Line 279 Why 'only'?	We have deleted this.
Line 274 Figure 3 caption has a rogue word 'dark' before 'Marshes'.	Thank you for spotting this – this was missed in the previous review process.
Line 285 Add 'ha' after each of '137.3' and '206.2' to be consistent with line 284 '22.19 ha'. Also delete the two trailing zero's as shown in this comment.	This has been edited – thank you for this suggestion.
Line 293 Figure 4 caption has a floating vertical bar before 'The'.	Removed as with the previous table

Line 308 Figure 6 and accompanying text - The new figure has a clearer legend than the first draft of the map, from which the Taf saltmarsh wintering and grazing geese have apparently disappeared; please check this (and see below under the nearby Tywi valley). From either map alone (i.e. without expansion of the text) I don't think you can say in the caption 'it was clear geese were found across Wales…', although the statement may be both true and reflected in the interview data. However, if the map is almost bare why bother with it in its present form? If WWT and RSPB were unable to attend the study workshops (or were not asked the question: "how many geese are there on Welsh saltmarshes?"), I would understand why goose data are so sparse. To fix this criticism does not entail any major re-working of the study. I therefore repeat the parts of my original comment that I believe were not fully addressed in the authors' response: "Fig. 6 caption is not full of confidence in the goose data, and indeed the text does not seem to have consulted wildfowling groups such as the British Association of Shooting and Conservation on the numbers and diversity of quarry species that are taken on the study marshes. The monthly non-breeding Wetland Bird Survey (WeBS; https://eur03.safelinks.protection.outlook.com/?url=http%3A%2F%2Fwww.bto.org%2Fwebs&data=04%7C01%7Cmckinleye1%40cardiff.ac.uk%7Ccc1759577a204da8c00b08d9ae49dc29%7Cbdb74b3095684856bdbf06759778fcbc%7C1%7C0%7C637732454564090773%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000&sdata=P2fNg%2FBzWKNKLzFNH6WCCiNz9AntPFpoAs%2BM0vsvbVw%3D&reserved=0) was started in 1947 and is led by the British Trust for Ornithology (BTO) with RSPB, Joint Nature Conservation Committee (JNCC) in association with WWT using a team of over 3,000 volunteer surveyors. The vagueness of the Fig. 6 caption and of the wildfowling component of this study could be tightened by brief use of the above comments".	Thank you for providing additional details about this particular point. The aim of this study to explore stakeholder reported data, and comparing this to other sources was not within the remit of the study. Therefore, while we acknowledge the additional sources suggested by the reviewer, we do not think it possible to account for them in the study. With this in mind, and given the reviewer's concerns and comments, we have made the decision to remove the Figure and just comment on the wild geese grazing in the text, and as suggested, included additional text in Section 4 – "*This should encompass an assessment of varying uses and potential trade-offs, including, for example, the potential conflicts between grazing wild geese and agricultural use of saltmarsh and adjoining farmland"* as well as adding text in Section 5, through the inclusion of examples in the following sentence: "*This paper presents an integrated approach to mapping and understanding coastal grazing on saltmarshes and the potential trade-offs between uses (e.g. wild geese grazing and agricultural use, or impact of recreational uses) that may need to be taken account of for future management."*

If the authors look at the WeBS survey website (https://eur03.safelinks.protection.outlook.com/?url=http%3A%2F%2Fwww.bto.org%2Fwebs-reporting&data=04%7C01%7Cmckinleye1%40cardiff.ac.uk%7Ccc1759577a204da8c00b08d9ae49dc29%7Cbdb74b3095684856bdbf06759778fcbc%7C1%7C0%7C637732454564090773%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000&sdata=M9o64JoMM4wrY15fe1SCcLojlhkDHVuZuUAo60iD7hU%3D&reserved=0) they can easily abstract peak winter counts of the dominant goose species for some of their study estuaries over many decades, using the 5-year moving averages between 2015 and 2020, as follows: The lower Tywi valley used to be critical in winter for the European race of White-fronted Goose (Anser albifrons albifrons). The Greenland race A. a. flavirostris numbers halved during the last decade to 2020 with Anglesey and the Dyfi estuary as the main sites in Wales. The Pink-footed Goose Anser brachyrhynchus had a 5-year moving average of 12,681 on the Dee estuary, but numbers are not always given separately for the Welsh side given the frequent moves between sub-sites. Anglesey and the Cardigan Bay estuaries also support small numbers of A. brachyrhynchus. The Greylag Goose Anser anser is widespread in Wales, but never reaches the numbers counted elsewhere, mainly in northern UK. The introduced Canada Goose Branta canadiensis is widespread and common across Wales (Dee 1,889; Dyfi 1,435; Nevern 1,014, Traeth Bach 767; Teifi 719) and, being non-migratory, is a resident grazer throughout the year. The naturalised Barnacle Goose Branta leucopsis has a local population on the Teifi (83), and the Light-bellied Brent Goose Branta bernicla hrota occurs on the Cleddau (78) and Anglesey, while the Dark-bellied Brent Goose B. bernicla is more common on the Severn. If these criticisms and suggested additions are fair, then something should also be added to Section 4 and the recommendations Section 5 for future work. This is not a trivial issue, because there are often severe conflicts	

between farmers and the grazing geese that move between saltmarsh and nearby agricultural land. This is happening in many of the key wintering wildfowl sites in the UK, even if not emerging from this Welsh study's interviews and expert workshops. This conflict is also potentially exacerbated by the non-migratory or naturalised geese species growing in numbers relative to the less common species, and by the differing attitude of wildfowlers to hunting native species compared to e.g. Canada Goose.	

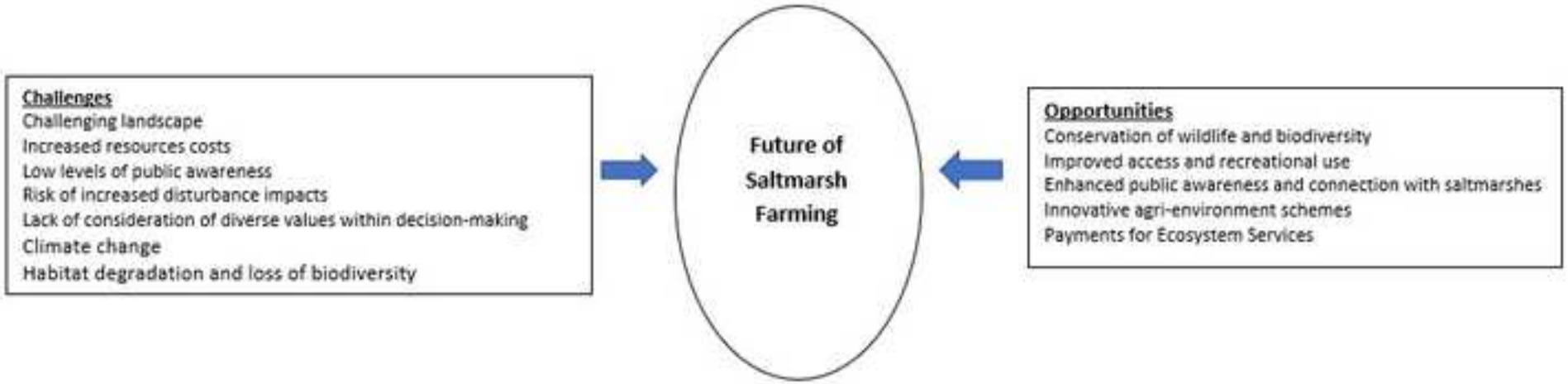
Line 343 This is another example of a sentence with a jerky and confusing start: in succession we read 'Perhaps not unsurprisingly,' a double negative that just means 'perhaps surprisingly' (and why is it surprising?), then 'overall,' followed quickly by 'diverse' (rather contradictory). All this leaves the reader no wiser…please just start with 'Respondents has diverse views…' and yes, do put this sentence in bold (if approved by the Editor).	Edited as suggested
Lines 343-498 Key text in bold (if approved) should be very brief and, wherever possible, should be placed at the start of each subsection, or at the end (perhaps prefaced by the phrase 'In summary'). Most importantly, an unused tier of the sub-sub-heading hierarchy that would make the text clearer in Section 3.3 is already available to the authors, and should be used as follows:	Thank you for this comment. Rather than attempt to rewrite all of the relevant sentences to change the position of the bolded text, we have taken the decision to remove the bold formatting throughout this section. These key themes are now reflected in Figure 8 and so we feel that, on reflection, highlighting them through bold text was no longer necessary.
Line 333 should become a proper sub-sub-heading 3.3.1 'Introduction'.	Edited as suggested
Line 342 should become a proper sub-sub-heading 3.3.2 'Benefits'.	Edited as suggested
Line 390 should become a proper sub-sub-heading 3.3.3 'Challenges'.	Edited as suggested
Line 511-614 The same as above should happen in Section 4 Discussion to make everything clearer.	Edited as suggested
Line 512 should become a proper sub-heading 4.1 'Introduction'.	Edited as suggested
Line 515 should become a proper sub-heading 4.1 'Selling saltmarshes… etc'.	Edited as suggested
Line 578 should become a proper sub-heading 4.2 'Improved monitoring of coastal grazing'.	Edited as suggested
Line 614 should become a proper sub-heading 4.1 'Adopting an integrated…etc'.	Edited as suggested
Line 625 Start a new paragraph with 'Developing'… Line 635 Start a new paragraph with 'Finally'… Line 648 Section 5 why not just use 'Conclusions and Recommendations'? Obviously they are 'thoughts' and all recommendations are 'for the future'.	Edited as suggested
Lines 648-683 See recommendations from the end of my review, starting at Line 308 Figure 6. In my opinion need to be included (I suggest ~ Line 653) 'to ground-truth and to add to our dataset'. Or it could be inserted in respect of text in lines 662-665. WeBS data are gathered in a classic citizen science project already in use for >7 decades and crucial in many planning	A reference to the WeBS data has been added into this section. Thank you for this suggestion.

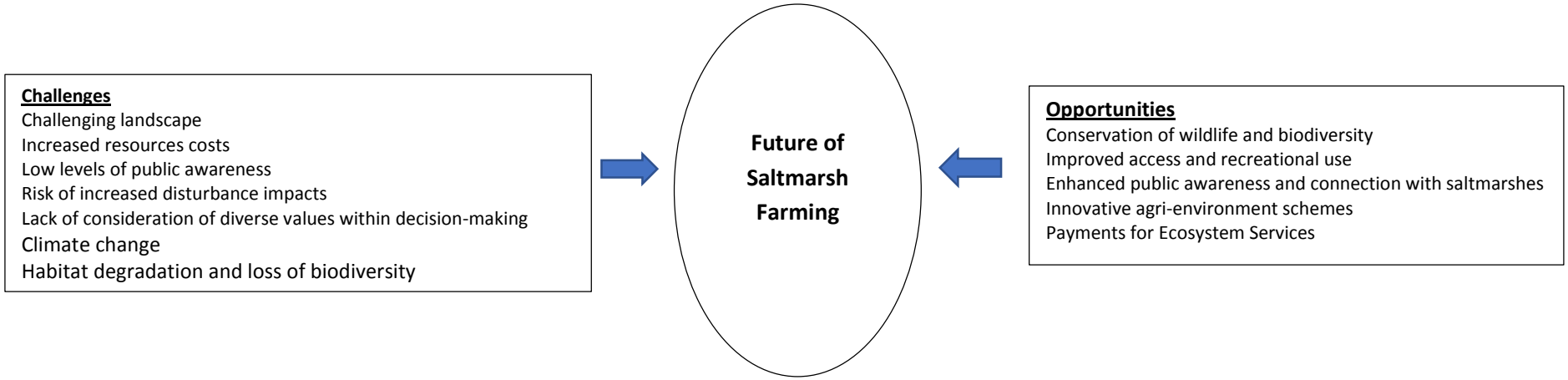
applications and decisions (e.g. Public Inquiry into ABP proposal at Dibden Bay, 2001-2) and annual monitoring of existing ports (e.g. Harwich and Felixstowe Harbours) in the Stour and Orwell SPA).	
Line 670 Start a new paragraph with 'Furthermore'… Line 676 Start a new paragraph with 'Finally'…	Edited as suggested
Reviewer #3: Thank you for the opportunity to review these revisions. The manuscript is much improved, so I have just noted a few minor points below:	Thank you for providing further comments to improve the manuscript – we welcome these additional minor points and hope that we have addressed them sufficiently.
Note, in some places you use n=35 and in others, N=35.	Thank you – this has been edited.
Fig 1: typo (Majpr rivers). Note that the saltmarshes are not distinguishable when the map is viewed in black and white.	This has been amended.
72: improveD understanding	Edited as suggested in response to Reviewer 1's comments
80: interact WITH	Edited as suggested in response to Reviewer 1's comments
120: Carried OUT as part…	Edited as suggested in response to Reviewer 1's comments
129: perhaps 'alongside semi-structured interviews and a workshop' would better describe your methods here?	Edited as suggested – thank you for this suggestion as it provides additional clarity to the approach we adopted.
131: suggest cutting 'Both' because it may be confused for two interviews having been carried out (rather than 35)!	This has been edited to read as follows: "The research was carried out in accordance with Cardiff University's Ethical Approval Process with participants in each research phase provided with a project overview, and opportunity to provide confirmation of informed consent to participate in the process."
174: not a criticism, but interesting all the same - I wonder if you could say anything about why none of the interviewees attended the workshop (time commitments, distance etc.?)	Thank you for this comment. This is an important point, and although all interviewees were invited to participate in the workshop, they didn't attend as indicated in the paper. We didn't ask for any reason as to why this was not possible for them and, as a result, we don't feel we have the information available to be able to make any comment on this. It is perhaps something to consider for future work, however.
Table 1: because you mainly refer to LSU abbreviation in the text, it would be useful to state the abbreviation (as well as the full term) in the table if you have room.	We have added this into the table as suggested.

248: although you use the term questionnaire in your supplementary material, I would stick with 'interview' here to avoid confusion, because throughout the rest of the main manuscript you refer to these as interviews.	Thank you for spotting this – this was an error on our part. We have edited as suggested.
254: cut 'with'	Edited as suggested
Table 2: I suggest 'Participant/marsh characteristics…'	Edited as suggested
Figure 3 caption: I think you have a rogue 'dark' in here	Edited as suggested
286: clarify if you mean the majority of saltmarshes BY AREA (as opposed to by number)	Thank you for this comment. This relates to the information presented in Figure 4, which includes both number and area of marshes – the 16% etc stated in line 286 refers to 16% of Area as indicated by the grey bars in Figure 4. We have included an additional cross reference to the Figure which we hope clarifies this.
Figure 8: this is a very useful diagram and a welcome addition to the manuscript. You could make it clearer by having each point on its own line or using bullet points.	This has been edited as suggested.
436: the mention of 20 topics leaves me wondering what these were - might you be able to include these in a table?	We decided to keep the focus on the key themes discussed in the paper, and have removed the reference to '20' in the paper.
595: can you say something briefly about how the findings are inconsistent?	Additional details have been included to provide clarification on this point.

Highlights

- Stakeholder interviews explore complexity of saltmarsh agriculture in Wales.
- Current grazing intensity and patterns are mapped and discussed.
- Emphasis is on the personal connection and sense of identity associated with saltmarshes
- Need for integration of diverse values within saltmarsh management is discussed.




Challenges
Challenging landscape
Increased resources costs
Low levels of public awareness
Risk of increased disturbance impacts
Lack of consideration of diverse values within decision-making
Climate change
Habitat degradation and loss of biodiversity
Future of Saltmarsh Farming
Opportunities
Conservation of wildlife and biodiversity
Improved access and recreational use
Enhanced public awareness and connection with saltmarshes
Innovative agri-environment schemes
Payments for Ecosystem Services

Coastal Agricultural Landscapes: Mapping and understanding grazing intensity on Welsh Saltmarshes

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Coastal Agricultural Landscapes: Mapping and understanding grazing intensity on Welsh saltmarshes

Abstract

Coastal wetlands such as saltmarshes support local communities and industries through ecosystem services and benefit the well-being of local communities in many regions of the world. Along sheltered temperate and sub-tropical coastlines, saltmarshes provide coastal protection, provision of recreational space and wildlife habitat. Those in northwest Europe provide a valuable resource for local agricultural communities through livestock grazing. Following the departure of the UK from the EU and the related potential changes to agricultural policies and markets, it is timely to evaluate the status of saltmarsh livestock grazing. In particular, knowledge of grazing patterns, policy futures and stakeholder perceptions are required to support traditional cultural practice and the ecological status of saltmarshes. This study focuses on the devolved UK nation of Wales, as it has a strong traditional agricultural and pastoral economy, and a landscape of significant conservation value. Yet there are substantial evidence and knowledge gaps regarding livestock grazing and its saltmarsh impact. We present the first map showing the spatial distribution of saltmarsh grazing practice in the UK. Drawing on insights gathered through an expert workshop and interviews with saltmarsh landowners and managers across Wales (N=35), the paper discusses the challenges and benefits of coastal grazing on saltmarshes, highlighting the diverse values, personal connection and sense of identity associated with marshes. Interviews reveal deep rooted social and cultural values attributed to saltmarshes by the rural coastal community. The study illustrates the need for an integrated approach to management of saltmarshes, accounting for the social, cultural, economic, and environmental values within decision-making.

Keywords: Saltmarshes; Rural landscapes; Wales; Farming; Coastal management.

1. Introduction

Globally, shoreline environments provide coastal communities with a diverse range of societal benefits, (MEA, 2005; UK NEA, 2014). Saltmarshes are a dynamic and transitional coastal fringe environments (Jones et al., 2013; Boorman, 2003) and deliver substantial value through a range of ecosystem services. These range from coastal protection and carbon storage (regulating services) to the cultural and provisioning services associated with agricultural use (Costanza et al., 2008; MEA, 2005; Davidson et al., 2017; McKinley et al., 2018). However, coastal landscapes, such as saltmarshes, are facing unprecedented change with increasing pressures from anthropogenic activity, including land-use change, urbanisation, and growing impacts from climate change (Mcowen et al., 2017; MEA, 2005). Livestock grazing has long been one of the most common uses of coastal saltmarshes globally (Gedan et al., 2009; Barr and Bell, 2016; Davidson et al., 2017; Muenzel and Martino, 2019), with saltmarsh meat regularly achieving higher than average market price (Jones et al., 2011; Gedan et al., 2009). Despite the role of saltmarshes in coastal agricultural practices, there are recurrent concerns about the impact of livestock grazing on saltmarsh biodiversity, stability, functionality, and structural integrity with numerous studies examining these interactions (See Ford et al., 2012; Harvey et al., 2019; Mueller et al., 2017; Mandema et al., 2014; Pages et al., 2018, Harvey et al. 2019, and Davidson et al., 2017 for a review of grazing relevant studies). Causes for concern associated with agricultural use of saltmarshes include loss of habitat through trampling and/or over-grazing, compaction of sediment, and reduction in water quality as a result of animal defecation (Gedan et al., 2009; Davidson et al., 2017).

Wales is a devolved country within the United Kingdom with a long-standing and highly significant pastoral economy as well as extensive landscapes of conservation value. Livestock grazing here is known to be widespread across coastal marshes, similar to that found in other parts of north-western Europe (Adams, 2002). It is particularly timely to evaluate saltmarsh grazing in the UK following its Exit from the European Union (EU), associated common markets and agricultural policies. Wales is an especially interesting case study, with its strong agricultural community, relatively recently devolved powers for agricultural and conservation policy, and a suite of innovative natural resource and sustainable development legislation. With over 60% of the Welsh population living, working and undertaking recreational activities along the coast, increasing attention is being paid to the need to manage coastal fringe environments effectively and sustainably (Environment Agency, 2011). Welsh saltmarshes make up an estimated 6950 hectares of this coastline, often located within low energy enclosed bays and estuaries (See Figure 1). In such settings, these marshes are a key connector between land and sea, and indeed freshwater and marine systems (JNCC, 2008). As such, a significant number of Welsh saltmarshes are designated for their nature conservation value (Natural Resources Wales, 2020). Moreover, since Roman Times, coastal marshes in Wales have been viewed as highly prized grazing areas for both domestic livestock as well as wild species (e.g. geese) with extensive reclamation of saltmarshes taking place in the Romano-British and later periods (Rippon, 2000; Kneafsey et al., 2001; Chatters, 2017; Allen and Fulford, 1986). However, as dynamic ecosystems, Welsh saltmarshes have undergone periods of significant change, experiencing both accretion and erosion processes that influence their delivery of ecosystem services and benefits (Ladd et al., 2019).

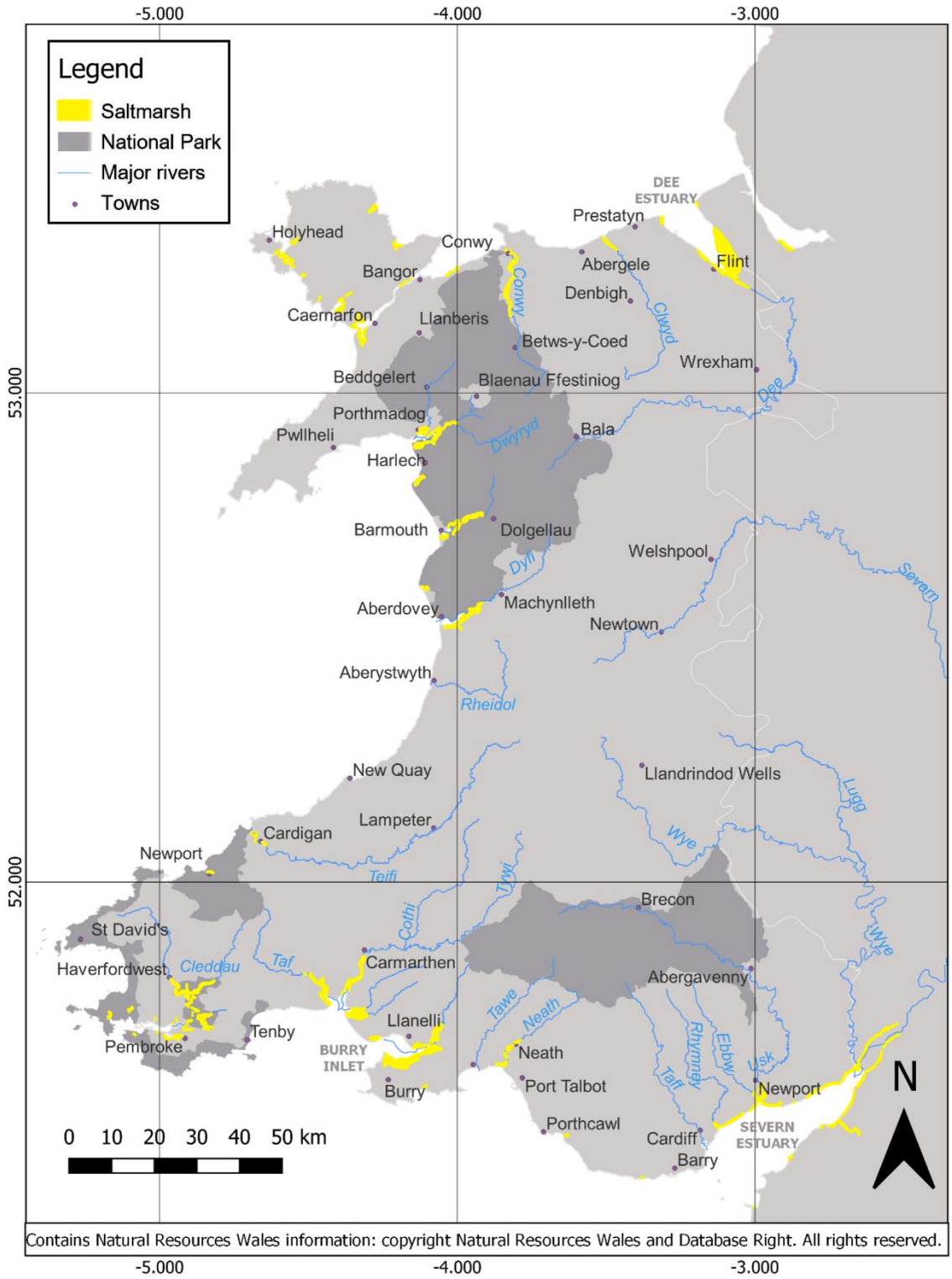

Figure 1: Distribution of saltmarshes across Wales. Saltmarsh extent, rivers and place names data is from Lle, a Natural Resources Wales open-source geo-portal. Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.

As urbanisation and industrialisation of rural and coastal spaces continues, there has been a growing call for an improved understanding of these cultural landscapes and the socio-ecological linkages

therein (Tieskens et al., 2017). Numerous scholars have mapped and explored various values attributed to agricultural (e.g. Assandri et al., 2018; van Berkel and Verburg, 2014; Geneletti, 2007), rural (e.g. Howley, 2011; Scott, 2010; Suckall et al., 2009; Nijnik and Mather, 2008), and coastal areas (e.g. Himes-Cornell et al., 2018; Kelly, 2018; Brown and Hausner, 2017; Potts et al., 2016). Saltmarshes occupy an unusual space in that they are both coastal and rural, supporting diverse uses, including agricultural activity. While there has been substantial research effort assigned to understanding saltmarsh ecological and biogeophysical attributes, there has been limited focus on the human dimensions, and even less emphasis on how these interact with the agricultural use of these coastal landscapes. Further, it is increasingly recognised that the values of cultural ecosystem services, those services considered to be intangible or non-marketable, have been relatively neglected or considered too challenging to measure (Hirons et al., 2016). There is, therefore, a clear need for an improved understanding of the complex interactions and relationships between these aspects (McKinley et al., 2020a). This is essential so that management of coastal areas and associated decision-making can take account of potential trade-offs between agricultural use and other uses and benefits derived from saltmarsh. A detailed understanding of contemporary grazing practices, activity and intensity is lacking, despite Welsh saltmarsh lamb being highly prized commodity in Wales with Protected Geographical Indication (PGI) status (Welsh Government, 2021).

In the context of agriculture and Welsh saltmarshes various issues need to be considered. Firstly, the impacts of EU Exit remain of concern to the Welsh agricultural sector, with particular insecurities around the loss of EU subsidies and any changes in market demand for Welsh agricultural products (Welsh Government, 2017; Dwyer, 2018). In response to these, and indeed UK wide, concerns, the UK Government proposed a new Agricultural Bill (Defra, 2020), which includes temporary powers for Welsh ministers until specific Welsh legislation is introduced. Furthermore, Welsh Government has explored the implications for Welsh agriculture through a public consultation, published through the 'Brexit Our Land' Report (Welsh Government, 2019), and a recently published Agriculture (Wales) White Paper outlining proposals to provide more support to Welsh farmers. The proposed *Sustainable Farming Scheme*, for example, is designed to reward farmers for producing non-market goods at levels over and above those already stipulated by regulation (Welsh Government, 2020). In recent years, Welsh Government has issued bold statements clearly outlining their aspirations and commitment to the future of farming in Wales - "We need to keep farmers on the land. Welsh land must be managed by those who know it. We need to ensure our agriculture sector can be prosperous and resilient, whatever that may be" (Welsh Government, 2018). These aspirations are further supported by the 'Securing Wales' Future' report (Welsh Government, 2017), which commits to supporting sustainable green growth across Wales, with emphasis on natural resource-based sectors, including farming. The report also calls for funding support for Welsh farming to fill the gap left by the removal of the Common Agricultural Policy (CAP) subsidies, as well as better alignment between agricultural and environmental management.

Despite being recognised as a key ecosystem service (i.e. habitat provision to support agriculture) and benefit (e.g. supporting agriculture based livelihoods) derived from saltmarshes (McKinley et al., 2018, Mcowen et al., 2018), substantial evidence and knowledge gaps remain regarding agricultural use of saltmarshes, and more specifically grazing regimes currently implemented across Wales. Through a series of interviews with Welsh landowners and managers, this paper provides an up-to-date view of grazing activity on Welsh saltmarshes, based on self-reported data from landowners, mapping

saltmarsh grazing across Wales. Furthermore, the paper provides an insight into farming activity more generally in rural coastal Wales, highlighting both potential forthcoming challenges and opportunities.

2. Methodology

Carried out as part of the research being undertaken by the RESILCOAST and CoastWEB projects, this study sought to develop a comprehensive understanding of the relationship between agricultural grazing and management of saltmarshes in Wales. Funded through the NRN-LCEE from 2013-2018, RESILCOAST aimed to examine the resilience of Welsh saltmarshes and the implications of this for future coastal management (for more information, see www.lceernw.ac.uk/resources). CoastWEB, which ran from 2016-2020, explored the contribution of coastal habitats to human health and wellbeing in the context of hazards, such as coastal flooding (for project details, see https://pml.ac.uk/Research/Projects/CoastWEB). To gain insight into how Welsh saltmarshes are being used and managed, a mixed methods approach was employed – using desk-based research alongside a semi-structured interview schedule and a workshop. This allowed the research team to collect data used to map grazing intensity (including variation in grazing species), challenges of saltmarsh farming and opportunities for the future. The research was carried out in accordance with Cardiff University's Ethical Approval Process with participants in each research phase provided with a project overview, and opportunity to provide confirmation of informed consent to participate in the process.

2.1. Data gathering: Mapping of saltmarshes, grazing activity and farmer interviews

A publicly available GIS polygon of Welsh saltmarshes (Natural Resources Wales, 2009) was used as a base for the saltmarsh mapping. Individual saltmarshes were then identified by cross referencing with satellite imagery, through existing saltmarsh knowledge and through clarification with landowners. Saltmarsh names were confirmed using Ordnance Survey mapping standards and by names included in previous data sets or through conversations with landowners.

Saltmarsh landowners and tenant farmers were initially identified using a purposive sampling approach, using the researchers' existing networks. A snowball sampling approach allowed additional participants to be identified through contact with local landowners and collaboration with other organisations including Natural Resources Wales and environmental NGOs (for example Royal Society for Protection of Birds, National Trust, Wildfowl and Wetlands Trust). Data was collected through direct interviews with landowners and tenant farmers, or via informal personal communication with neighbouring landowners (where contact with landowners was not possible). A short interview schedule was designed encompassing three key sections (see SM1 for the final version of the interview schedule):

1) General questions about the farmer and farm (e.g. length of time farming, tenancy or land ownership arrangements, location of the farm, location of the saltmarsh being farmed, stocking density, species farmed, seasonal variation of saltmarsh grazing),
2) Information about farming activity on saltmarshes, the benefits of saltmarsh farming, and the factors influencing use of the saltmarsh,
3) Access and future of the saltmarsh, including information about the potential challenges and opportunities associated with agricultural use of saltmarshes.

Interviews were carried out in accordance with Cardiff University's Ethical Approval Process. The interview schedule was piloted in December 2017 with 11 farmers working in the Burry Inlet and Three Rivers area of south Wales (near Llanelli and Carmarthen, see Figure 1) participating. These participated in either face-to-face or telephone interviews. As no changes were made to the interview questions based on the pilot, this data was included in the final sample. Interviews were conducted between June and October 2018 and were predominantly carried out as telephone interviews. The final sample included 35 interviews, which represented 20.6% of Welsh saltmarshes (55% by area). However, grazing data was collected for a further 80 marshes (a further 48% of the saltmarshes, or 32% by area) through more indirect means. This involved as discussion with neighbouring landowners, talking with landowners who did not want to take part in an interview, and information gathered from third parties, covering a total of 67.6% of marshes, or 87% by area (see Figure 2). The interview schedule was edited and adapted to produce a bilingual (Welsh and English) online questionnaire version, which was made available to potential respondents through an online link. However, despite early requests for the questions to be available in this format from farmers, no data was collected through this means.

2.2. Expert workshop

In October 2018, a stakeholder workshop was held to further examine some of the themes identified through the interview schedule. In the first instance, all interviewees were invited to participate in the workshop; however, none attended. All other participants were invited using a purposive sampling process, based on participants' experience and knowledge of Welsh saltmarshes from a range of perspectives and the organisation they were based at to ensure representation across sectors. The workshop had 26 attendees representing different aspects of farming and saltmarsh management in Wales, including local authority (1), government agency (6), national infrastructure (e.g. water company) (1), non-governmental organisations (4), national government (1), consultants (3) and researchers (9). Attendees brought a diverse range of experience, including knowledge of flood and coastal erosion risk management, saltmarsh ecology and conservation management approaches, agricultural use of saltmarshes, as well as their views on the challenges and opportunities which may be experienced by those in the Welsh agriculture sector. This breadth of experience and expertise included representation from a range of sectors, ensuring that the workshop discussions could explore potential conflicts in use and trade-offs.

Through the workshop, three key topics were examined (see SM2 for the Workshop Agenda):

- Uses and trade-offs in Welsh saltmarshes,
- Opportunities and challenges for coastal grazing on saltmarshes,
- The future for Welsh saltmarshes and agricultural coastal grazing.

For each discussion, attendees were split into four groups; each with a facilitator to support the discussion and capture data and observations. Discussions were recorded using a range of recognised stakeholder engagement techniques (e.g. notes captured on flipchart paper by the facilitator), as well as recording on a Dictaphone. Where possible, transcripts from these discussions were captured verbatim. As no data were collected in Welsh, there was no need for bilingual translation of transcripts.

2.3. **Data analysis**

Using the data collected through the interviews regarding stocking density and grazing species, grazing intensity was quantified in terms of livestock units (LSU) per hectare per year. LSU standardises grazing pressure across different livestock species and ages. Due to their role in protected site designations, wild geese were also included in this analysis; geese occur on saltmarsh in significant numbers, particularly over the winter months. Weighting of different species and ages were obtained from Defra reports (Welsh Government 2017; Woodend 2010) (summarised in Table 1); a cow has a greater grazing impact than a sheep, which has a greater grazing impact than a goose, and these weightings help us take that into account. Livestock units per year were calculated as the number of livestock multiplied by livestock weighting and grazing duration on the marsh. Many livestock are taken off over the winter months, while many marshes are grazed by geese only during the winter months, so grazing pressure is not consistent throughout the year. However, by dividing the grazing pressure by the number of months the livestock / geese are on the marsh, we could calculate an overall grazing pressure for the marsh per year. This figure was then divided by the marsh area to determine livestock units per hectare per year so this could be compared directly between marshes regardless of size.

Livestock Type	Livestock Units (LSU)
Cattle – 24+ months	1.00
Cattle – 6-24 months	0.60
Sheep	0.11
Horses	1.00
Ponies	0.50
Goats	0.15
Geese (wild)	0.003

Table 1: Weightings of different types of livestock in terms of Livestock Unit calculations.

Grazing was expressed on a continuous scale (LSU ha^{-1} yr^{-1}) and a categorical scale, where un-grazed was 0.0 LSU ha^{-1} yr^{-1}, lightly grazed was ≤ 0.32 LSU ha^{-1} yr^{-1}, moderately grazed was 0.32 – 0.70 LSU ha^{-1} yr^{-1}, and intensively grazed was > 0.70 LSU ha^{-1} yr^{-1}. The grazing intensity categories were based on Adnitt et al. (2007) and Harvey et al. (2019). They were also comparable to grazing intensity categories in both saltmarsh and grassland literature (Rauzi and Henson 1966; Berg et al. 1997; Neuhause et al. 1999; Hickman and Hartnett 2000; Kiehl et al. 2001; Cao et al. 2004).

Historical grazing data collected from the interviews and current day grazing intensity were mapped in QGIS (version 3.10.14) for all marshes by adding attributes to the saltmarshes identified from the Welsh saltmarsh extent polygon. Detailed maps were produced for three main estuaries: the Dwyryd Estuary, near Harlech, the Dyfi Estuary, near Machynlleth, and the Three Rivers and Loughor Estuary, near Carmarthen (Figure 2). Additional attributes were added to the maps for grazing intensity category, LSU ha^{-1} yr^{-1}, livestock type and geese numbers. In addition to calculating and mapping grazing intensity, descriptive statistical analysis was used to examine overall data trends, providing an insight into current and historical use of saltmarshes by farmers across Wales. A one-way Analysis of Variance (ANOVA) was used to determine the relationship between livestock grazing intensity (independent variable: un-grazed, light, moderate or intensively grazed) and marsh size (dependent variable), and Pearson's Correlation was used to describe the relationship between wild goose grazing and marsh size. Both analyses were conducted using the JASP statistical package (Jasp Team 2018).

Qualitative data collected from open questions in the interviews and workshop discussions were analysed using NVivo11. Using standard qualitative analysis processes (Braun and Clarke, 2006), a bottom-up emergent thematic coding approach was adopted. Responses and workshop text were reviewed by the research team to identify emergent common themes. Following a data reduction and thematic coding process, the data were reviewed numerous times to ensure confidence in the final thematic codes.

3. Results

3.1. Mapping Grazing Intensity on Welsh Saltmarshes

Interviews were conducted with the landowners of 35 marshes (21% of the 170 saltmarshes in Wales) and grazing data was gathered for a further 81 (48%) marshes (Figure 2). The interview data represented 55% of the total saltmarsh area in Wales and, in combination with the data collected from other sources, resulted in 87% of the total saltmarsh area in Wales being surveyed.

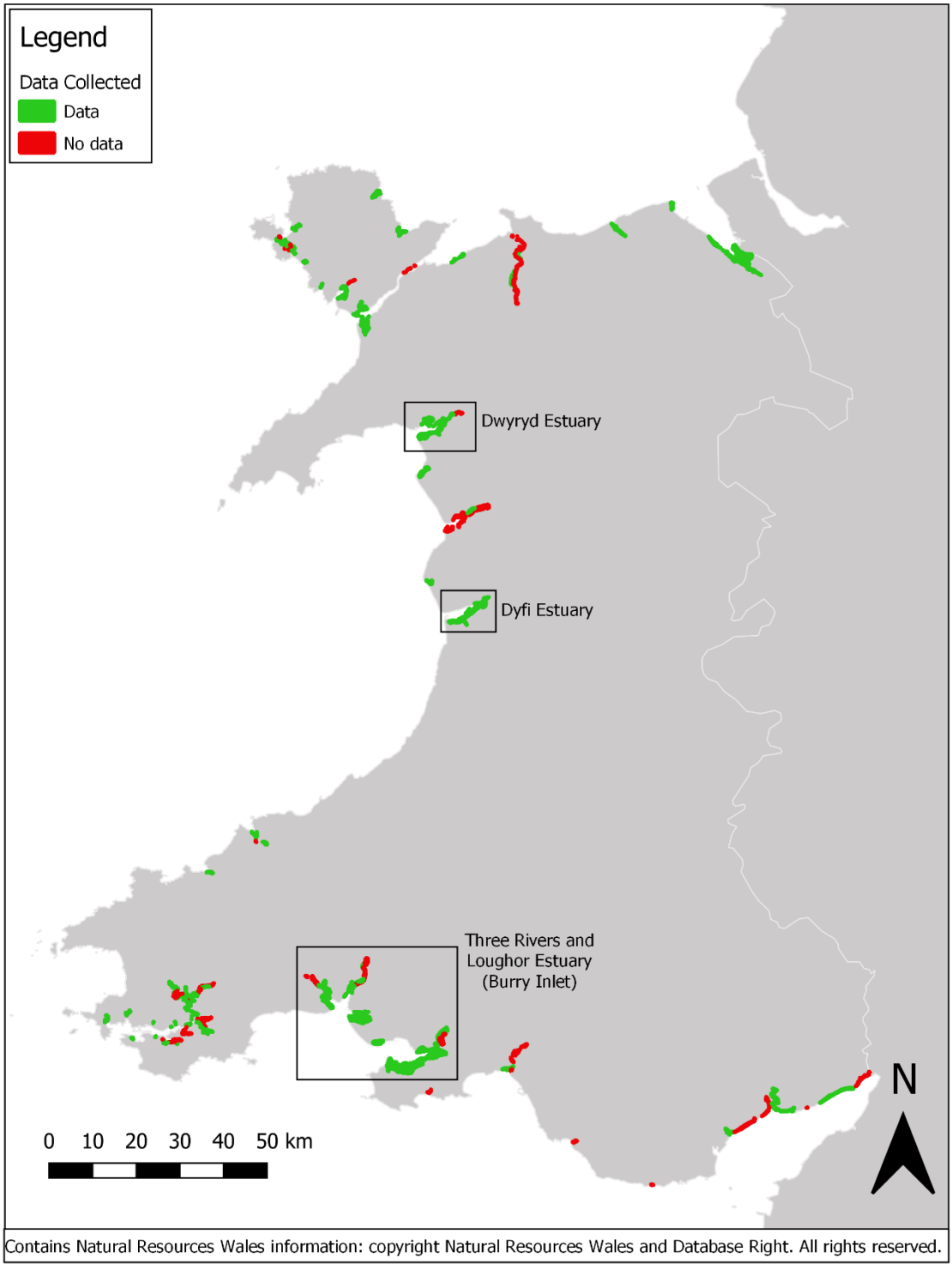

Figure 2: Spatial distribution of data collected (green) and no data collected (red). The three estuaries that were looked at in further detail are outlined and labelled.

The interview provided grazing data and detailed information about the farm, the graziers and the use of the saltmarsh for grazing and other activities. Most of the surveyed saltmarshes (53%) were owned by local farms, with approximately half of saltmarshes grazed by landowner farmers (47%). There was a wide variety of other landowners, many of whom had tenant graziers (36%) (see Table 2). A total of 83.3% of marshes were indicated as being grazed by livestock, mostly sheep and /or cattle. Further

questions were posed to interviewees to gather details about other activities taking place on saltmarshes. Analysis found that agricultural use and dog walking, wildfowling and scientific use were the most common activities (Table 2).

Table 2: Participant and saltmarsh characteristics collected through interview (N =35). N = number of participants, and % = proportion of the total sample group.

Farm and grazier details	**N**	**%**	**Marsh details**	**N**	**%**
Type of land ownership			Size of marsh		
Farm owned	19	52.78	Less than 10 ha	7	19.44
Common land	3	8.33	10-50 ha	13	36.11
Royal Society for Protection of Birds	2	5.56	50-100 ha	6	16.67
Wildlife Centre	2	5.56	100-200 ha	5	13.89
Council	2	5.56	200-700 ha	3	8.33
Joint ownership	1	2.78	Greater than 700 ha	1	2.78
Private company	1	2.78			
Crown Estate	1	2.78	Uses of the saltmarsh		
Wildlife Trust	1	2.78	Cattle and sheep grazing	11	30.56
National Trust	1	2.78	Dog walking	10	27.78
Private (non-farmer)	1	2.78	Sheep only grazing	9	25.00
Minister of Defence	1	2.78	Cattle only grazing	8	22.22
Grazier type			Wildfowling	8	22.22
Landowner Farmer	17	47.22	Scientific	6	16.67
Tennant farmer	13	36.11	Bird watching	4	11.11
Un-grazed	4	11.11	Recreation	3	8.33
Wildfowlers	1	2.78	Hay making	2	5.56
Length of time farming the marsh			Swimming	2	5.56
Less than 10 years	3	8.33	Water sports	2	5.56
10-30 years	5	13.89	Fishing	2	5.56
30-50 years	6	16.67	Cattle, sheep and goat grazing	1	2.78
50-70 years	8	22.22	Sheep and horse grazing	1	2.78
70-100 years	7	19.44	Bog swimming	1	2.78
Over 100 years	2	5.56	Bird ringing	1	2.78
No data / not farmed	4	11.11	Metal detecting	1	2.78
Agri-environment scheme			MOD	1	2.78
No scheme	12	33.33	Not used	1	2.78
Glastir*	10	27.78	Livestock type		
Tir Gofal**	7	19.44	Cattle	20	55.56
Tir Cymen***	1	2.78	Sheep	22	61.11
Organic Farming	1	2.78	Other	2	5.56
No data	3	8.33			

*Glastir is a 5 year whole farm sustainable land management scheme with a range of funding schemes available (https://gov.wales/glastir)

**Tir Gofal: an agri-environmental scheme launched by Welsh Assembly Government in 1999 (https://www.legislation.gov.uk/uksi/1999/1176/made)

***Tir Cymen was an environmental and preservation programme which ran from 1992-1998, aimed at preserving representative examples of the Welsh landscape

The interviews provided insight into the historical agricultural use of Welsh saltmarshes. Most saltmarshes (63.9%) had been under the same grazing or un-grazed regime for more than 30 years, with two marshes having been grazed for over 100 years (Figure 3). Although the Dyfi Estuary showed the most complete and sustained grazing, the Afon Dwyryd Estuary and Three Rivers and Loughor Estuary also included some areas of prolonged grazing (Figure 3). Of the saltmarshes in the survey, 22.2% had historical grazing data for less than 30 years; this did not necessarily mean that the grazing regime had changed in recent years, but that the grazing regime prior to 30 years was unknown.

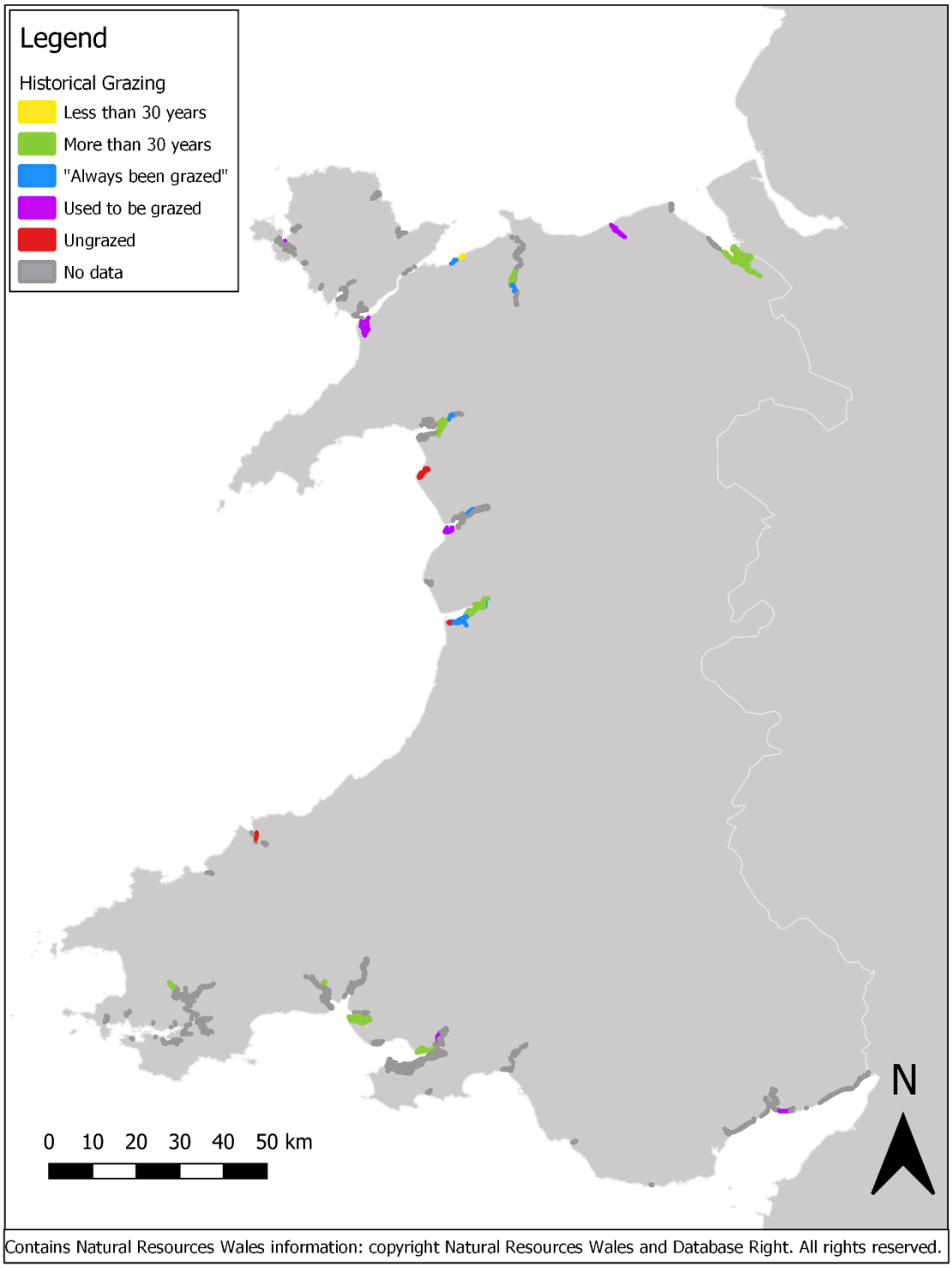

Figure 3: Length of historical grazing on saltmarshes according to verbal history. Marshes with less than 30 years of grazing history are shown in yellow, while marshes with more than 30 years of grazing history are shown in green. Several marshes did not have a historical record in 'number of years', but landowners classed them as "it's always been grazed" – these have been shown in blue. Several sites had been grazed in the past, although they are currently ungrazed (purple). There was no historical data for many sites (dark grey), and while many of these (e.g. small or fringing marshes) are unlikely to have been grazed, we have no data to determine any grazing history for these sites. Some sites were determined to have been ungrazed throughout their history (red).

3.1. Mapping Grazing Intensity across Welsh Saltmarshes

In interviews, landowners identified the majority of saltmarshes in the survey (66%) as un-grazed (Figure 4); however, un-grazed marshes were much smaller ($\bar{x}$ = 22.19 ha, SE = 3.76) than moderately ($\bar{x}$ = 137.3ha, SE = 45.07) and intensively grazed marshes ($\bar{x}$ = 206.2ha, SE = 170.7) (ANOVA: $F_{3,112}$ = 3.413, p = 0.044, η_p^2 = 0.164). Thus, the majority of saltmarsh area was reported by participants as being grazed. Of the very few saltmarshes (5%) which were considered intensively grazed, most were in the Afon Dwyryd Estuary (Figure 4). Overall, participants reported that most grazed saltmarshes were moderately (16%) or lightly (14%) grazed and noted an even spread of each grazing category across Wales (Figure 4).

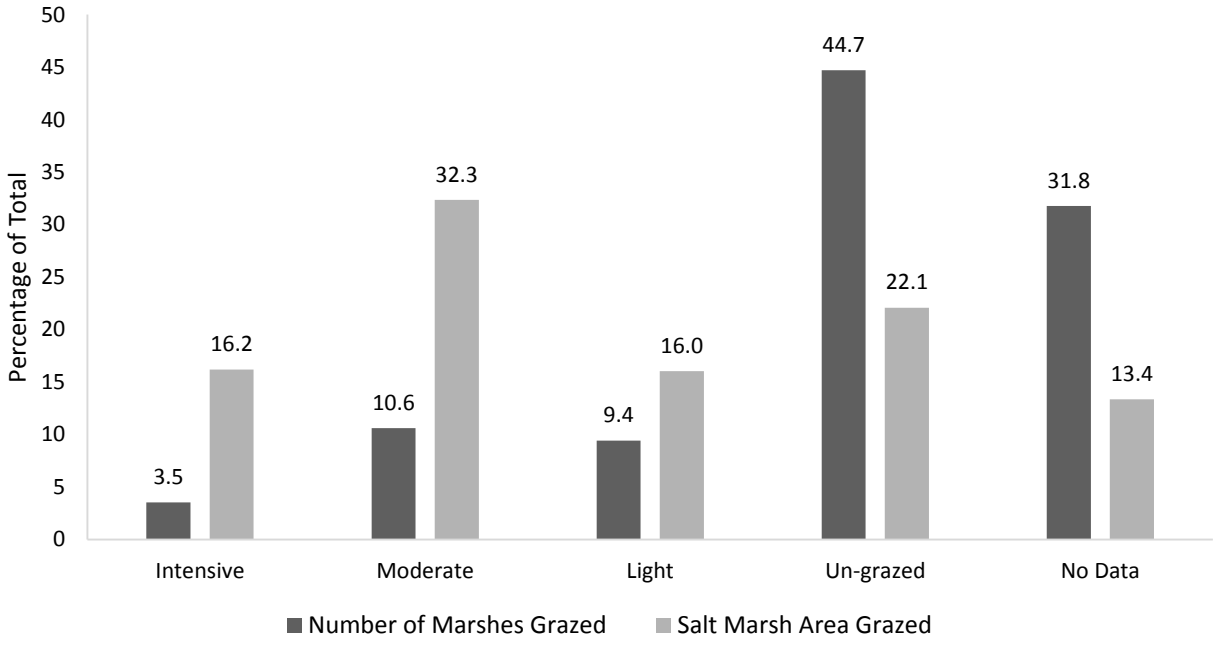

Figure 4: The percentage of marshes in each grazing intensity category by number of marshes and by marsh area, based on land-user interviews.

In terms of variation in livestock grazing, analysis of the data found there to be similar numbers of cattle and sheep-grazed marshes across Wales (21 and 27 respectively). However, some geographical variation was observed with sheep grazing dominating the mid- and north-Welsh saltmarshes, while cattle dominated the southern marshes (Figure 5). Grazing by wild geese was reported by participants as common and widespread across Wales. However, there were only

estimated goose numbers for a few sites (n=17) with goose numbers showing a significant positive relationship with marsh size (Pearson's Correlation: $r_{(169)}$= 0.696, $p < 0.001$).

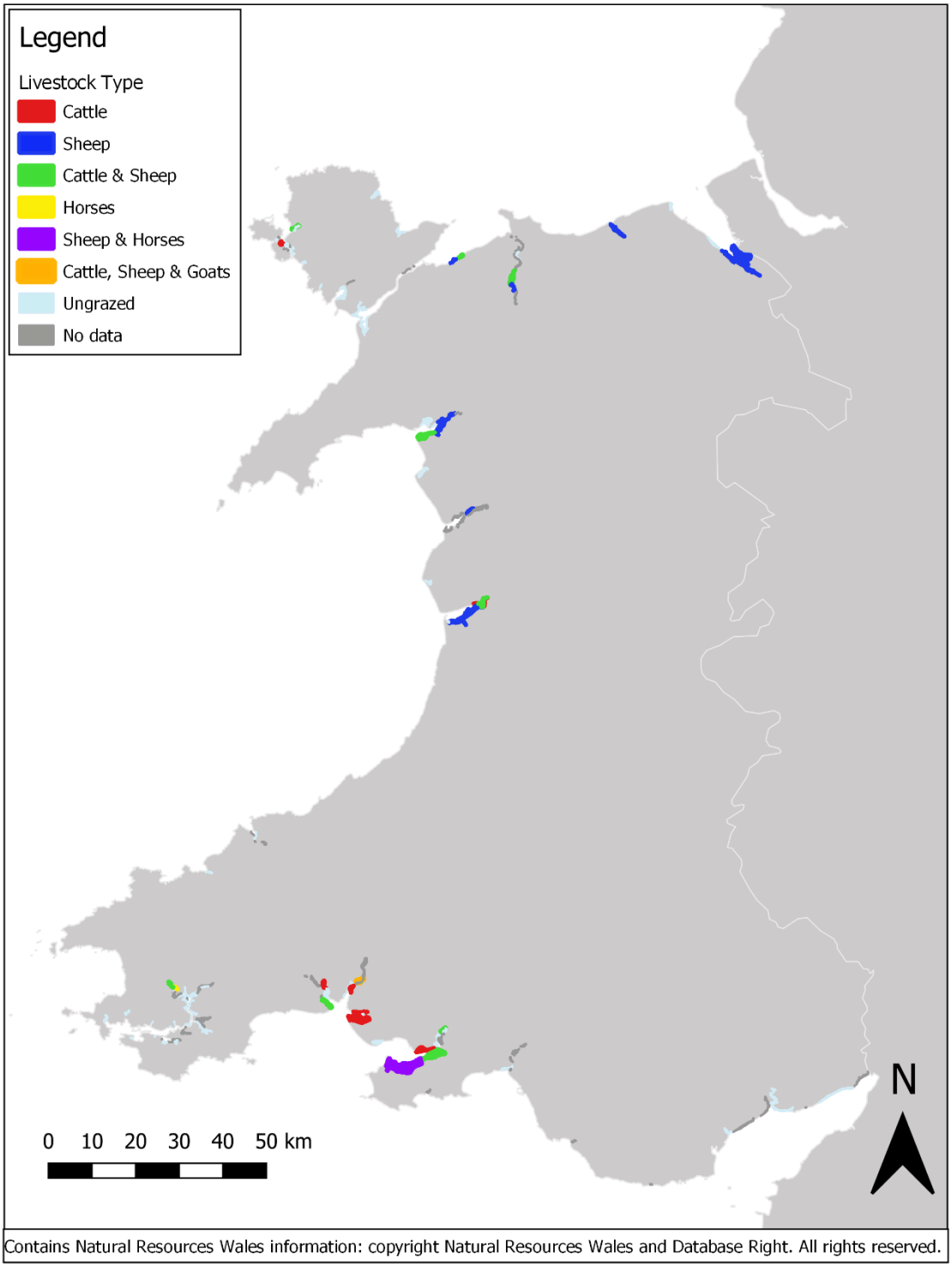

Figure 5: Livestock grazing by type across Welsh saltmarshes, estimated by interviewees. Generally, sheep-only grazing was found in the north, sheep & cattle grazing was found across Wales, and cattle-only grazing was found in the south with some exceptions in the Dyfi estuary and Anglesey. Horse grazing was only found in the south, while goats were only found on one saltmarsh with sheep and cattle.

3.2. Regional patterns of grazing

To gain a more detailed understanding of the spatial variation of grazing across Welsh saltmarshes, grazing pressure (using livestock units per hectare per year (LSU ha^{-1} yr^{-1})) was determined for three case study areas (the Afon Dwyryd Estuary, the Dyfi Estuary and the Three Rivers and Loughor Estuary). These estuaries were selected due to their inclusion as key case study areas in both the RESILCOAST and CoastWEB projects. In the Afon Dwyryd and Dyfi estuaries, marshes further up the estuaries were reported to be more intensively grazed than those closer to the mouths of the estuaries, while grazing in the Three Rivers and Loughor Estuary was considered to be more varied (Figure 6). For many of these sites, landowners and managers were able provide a good estimate of how long the marsh had been grazed. However, at some sites the marsh "had always been grazed" or had been grazed for generations, but the landowner could not provide details regarding how many years or decades the marsh had been grazed. These sites are noted in Figure 7 alongside the other historical data.

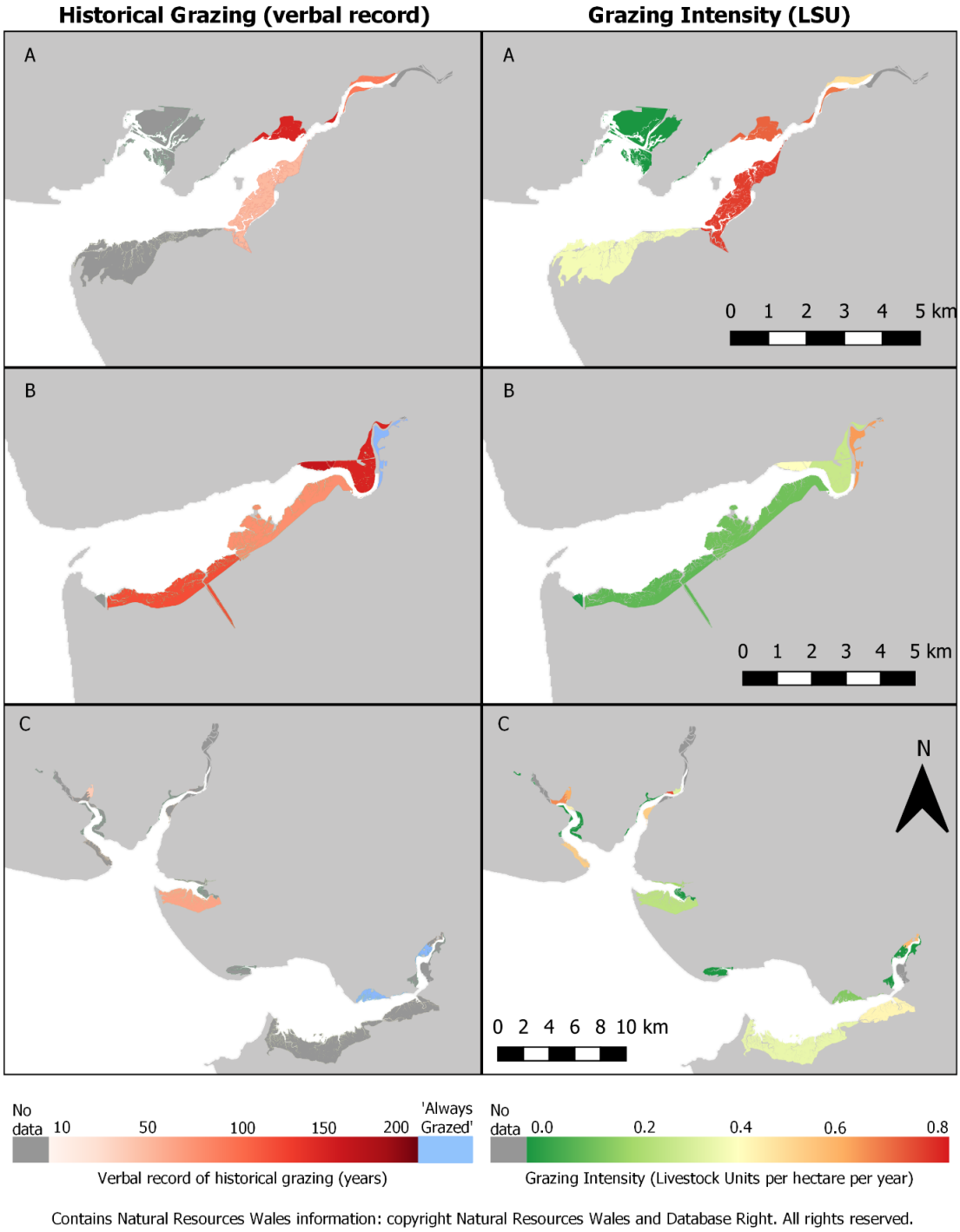

Figure 6: Historical (left) and current (right) reported grazing regimes for three estuaries in Wales as based on interviews: the Afon Dwyryd estuary (A), the Dyfi estuary (B) and the Three Rivers and Loughor Estuary (C). Light blue indicates there is no historical data, while the intensity of the red colour shows the length of time the marsh has been grazed: the deeper the red, the longer it has been grazed. Reported rates of current grazing is shown as a continuous scale of Livestock Units (LSU) per hectare per year, with un-grazed and lighter grazing regimes shown as green, moderately grazed regimes shown as yellows and oranges, and intensively grazed regimes shown as red.

3.3. The future of saltmarsh farming: Stakeholder perspectives

This section draws insight from both the interviews and the expert workshop, with participants examining a further range of topics, including: the benefits and challenges of farming on saltmarshes, the value of saltmarshes and their ecosystem services, and future challenges and opportunities. Thematic analysis of both data sets identified a range of key themes, discussed below, using quotes from both the interviews and workshops (in italics) as supporting statements and summarised in Figure 7.

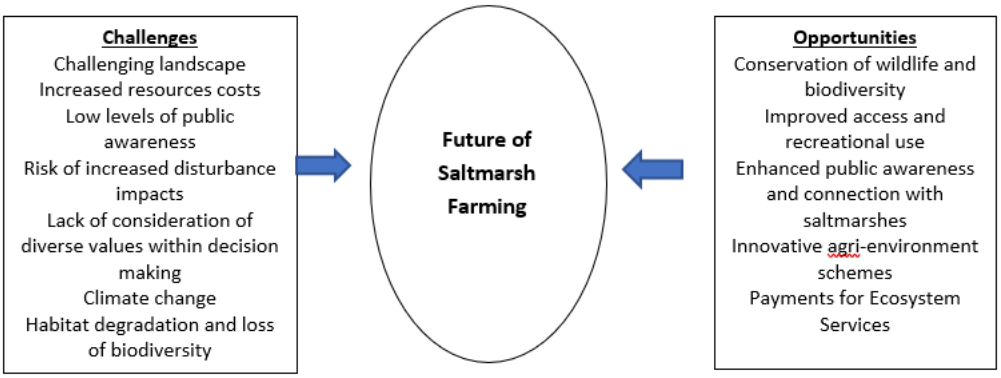

Figure 7: Summary of key challenges and opportunities raised by both interviewees and workshop participants in relation to future farming of saltmarshes.

3.3.1. Benefits of saltmarshes and saltmarsh farming

Overall, respondents had diverse views on saltmarshes as agricultural land, with some recognising them as being spaces that provide "*excellent grazing…far better than inland fields*", and as being beneficial for livestock. Respondents also suggested that grazing supported saltmarsh biodiversity, and contributed to "*nature conservation*", with one respondent (land manager) commenting that nature conservation goals featured within their saltmarsh management plans and therefore heavily influenced any decisions regarding grazing activity on their land.

As part of the interview process, participants were asked to consider any additional benefits that society might derive from saltmarsh ecosystems. Although responses varied between interviewees, there was an overarching awareness of the various services and benefits that saltmarshes provide in addition to agricultural land. One interviewee described them as "*really useful…and they're…fascinating because they're different every day*", indicating an awareness of the dynamic nature of these environments. Further examples of benefits derived from saltmarshes included coastal protection against erosion and flooding, carbon storage, recreational value ("*it's a wonderful place to walk*") and finally the ecological value of saltmarshes ("*wildlife benefit and the diversity of the area*").

In addition to comments on the value of the saltmarshes to the livestock and grazing activities, analysis of the interview data highlighted interviewees personal connections with the saltmarsh. These findings were of particular interest, given the growing recognition of the importance of accounting for diverse and cultural values and sense of place, as explored above. Interestingly, one interviewee

centred the saltmarsh in their response, describing their association with this part of their farmland as "*having nothing to do with the farming, nothing to do with anything else, [it's] that land, that little piece between the water and the land is quite, I'm sure you don't want to hear this but it's a magical bit, it's, sometimes it's sea, sometimes it's land, it's that magical sort of piece that is between and I think we, me and my children, it's quite a unique place to us, yes, I wouldn't like not to have it although it's sometimes a real drag*." This reflection on saltmarshes as a special place to both the farmers and their families, and in some cases, farming the saltmarshes was referred to as '*being in the family*'. While the place attachment and emotional connection expressed by some represents quite a different, yet equally valid aspect of the relationship between farmers and the landscape, it is important to note that these less tangible benefits are often disregarded within decision making processes, with the more commonly recognised (and indeed easier to measure) benefits of carbon storage, coastal protection and agricultural value, acting as the primary drivers of policy and management.

The benefits of coastal grazing on saltmarshes in Wales were also examined through the expert workshop. The data captured various topics of note, with initial analysis identifying nine key themes from a total of 71 suggestions from delegates. The most commonly discussed benefit of coastal grazing was its role in supporting and protecting biodiversity, for example *"maintaining plant diversity leads to positive effect on other faunal diversity (e.g. wildfowl)",* and contributing to the aesthetics of the natural landscape. Further advantages were identified around protecting and maintaining cultural identity and a sense of place through protection of unique farming practices, with one delegate stating that a benefit of grazing activity is *"retaining agricultural culture…– if we lose all the farmers, we lose a lot of cultural identity".* As expected, food production, and saltmarsh lamb particularly, were mentioned regularly, including the potential for locally produced food and effective marketing. Alongside the economic value through food production, the value of the saltmarsh to the farmer was discussed in terms of saltmarshes providing livestock with feed and '*low-cost grazing land*' during hard times. Finally, saltmarshes were recognised as having a role in flood defence, and there was a feeling that the benefits for land and vegetation management would in turn contribute to the coastal protection value of saltmarsh environments.

3.3.2. Current and future challenges of saltmarsh farming

Despite there being appreciation that grazing on saltmarshes can provide a range of benefits, there was a recognition that saltmarsh farming poses numerous challenges to both humans and livestock. The physical nature of the landscape, including its exposure to regular tidal flooding, was considered to limit possible activities on the saltmarsh - one interviewee went so far as to say that "*grazing is the only thing we are able to do on it; there's far too many holes, you could never get machinery onto it*". Further challenges relating to the themes of danger and difficulty were referenced 21 times across the interviews, with one stating that *"[saltmarshes are] quite a dangerous place to go, really"* and that *"it is a place where you do lose livestock [to flooding or injury], even though you've tried to look after them the best you can".* The economic and person hour costs of moving livestock during floods or high tides, or with livestock losses, were also highlighted by different interviewees -"*You've got to take them off, you know you've got to be on the ball, you know the tide doesn't stop for no man sort of thing, does it, when you've got to go you've got to go and get the sheep off".*

Despite interviewees recognising the benefits of saltmarshes for society, there was a limited appetite for increasing levels of public activity or engagement on saltmarshes. While one interviewee outlined a proposal for "*a boardwalk…so [that] the public could walk across it…when the tide is in and see all the different [wild]life coming in*", many expressed concerns about the additional impact of increased visitation. However, as the benefits of saltmarshes are increasingly recognised by both the public and coastal management efforts, analysis indicated that interviewees expect to see increased levels of disturbance and "*conflict between users…conflict between grazers and the public*". Disturbance and threats to livestock resulting from increased footfall and recreational use of saltmarshes for (dog)walking, gyrocopters, drones and wildlife-watching were identified as the second most common theme in the interviews. One interviewee suggested that managing different users presented a "*big conflict…between everybody loving to walk their dogs along the coast and nesting birds and managing livestock*" and detailed livestock losses as a result of dogs being walked off lead ("*we've had four sheep killed on the coast path*"). Conflict between users was further described as being of concern by another interviewee, due to a need "*to manage public access on wildlife sites because we've got to let people get out there, but we really want them to manage their dogs*".

Climate change related impacts were highlighted by interviewees as both a contemporary and an ongoing concern for the future. One interviewee stated that "*we seem to get more summer storms so it's becoming more dangerous* [*to graze on the saltmarshes*]". The trends of increased storms, increased sea level rise and more flooding were expected to continue, and there was a view that this would make livestock grazing increasingly challenging for farmers. One interviewee commented that they expected to '*lose the saltmarsh in the future'*, while another mentioned that they had "*seen the maps of predicted coastline change…that's going to be quite challenging…we [will] have to address the challenges on a day-to-day basis with the spring tides and that sort of thing. We have to…really make sure that it's safe for…livestock".*

As expected, the opportunity to brand livestock as 'saltmarsh lamb' was discussed by interviewees, with some highlighting this as a valuable 'niche' market which can obtain "*premium*" prices. However, there were mixed views as to the value of this branding amongst the respondents, with some suggesting that the market opportunities for saltmarsh lamb are not as strong as they have been previously, while others stated that obtaining the saltmarsh branding certification can be "*quite difficult to comply with…it has to be grazing… [for] three or four weeks on saltmarsh before it's salted to comply [with requirements*]".

Further examination of these topics through the expert workshop resulted in workshop delegates suggesting 96 potential negative implications of coastal grazing on saltmarshes. These covered a diverse range of 20 topics, including some more relevant to general saltmarsh use and management rather than specifically linked to coastal grazing of saltmarsh environments. The most commonly mentioned topic related to habitat degradation and negative impacts on biodiversity, with attendees suggesting that there is "*not much benefit for plants and/ or invertebrates [from grazing]*". Linked to this was a concern relating to the risk of overgrazing and subsequent potential damage to biodiversity as well as implications for protected site designations (e.g. Special Areas of Conservation). The potential impact on water quality as a result of agricultural run-off (including faeces) and nutrient enrichment resulting in eutrophication were also mentioned by attendees as being things that must be considered alongside grazing activity on saltmarshes. Perceived risk and a sense of danger related to saltmarshes was mentioned regularly by delegates - there was a feeling that risks could arise from

a lack of public awareness of various aspects of the marshes, including their tidal nature, the unpredictability of their topography which could increase risk of accidents, and from grazing livestock.

Other topics mentioned less frequently by workshop participants included: a reduction in the coastal protection capacity of saltmarshes, caused by instability or compaction of saltmarsh sediment as a result of grazing; the complex management and funding framework for agricultural land use, including saltmarsh grazing; the challenge of balancing conservation with agricultural activity; changing public perceptions and raising public awareness; and the challenge of keeping farmers on Welsh saltmarshes to preserve and protect saltmarsh grazing as a way of life and part of Welsh farming cultural identity. Workshop delegates noted the possibility of further challenges arising from increased footfall on the marshes in the context of tidal and other physical changes as well as future agricultural use. Whilst restating their concerns related to a perceived lack of public awareness and knowledge of saltmarshes, similar themes to those found through the interview analysis were highlighted (e.g. trampling of vegetation and nests, disturbance to nesting birds and other fauna). Finally, there was some concern that increasing livestock grazing could result in deterioration in water quality as a result of higher stocking densities, trampling of bird nests/ wildlife by livestock, as well as an increased level of effort required from farmers to manage and move livestock.

3.3.3. Future Opportunities for saltmarsh grazing

While interviewees indicated that farming saltmarshes poses a range of challenges, they were also positive about the future opportunities for saltmarsh faming. The role of saltmarshes as a natural resource to protect wildlife and biodiversity was the most commonly opportunity mentioned by interviewees – there was a feeling that saltmarshes presented "*opportunities for us…to allow them to grow and give them as much protection as possible so that they can be truly understood as areas that designated wildlife can actually have…away from people, because there are few places…where that can happen*". Further opportunities included the potential for additional recreational use of saltmarshes as well as for increased public access for walking and wildfowling. Although the interviewees recognised these activities as being potential opportunities for diversification, they were also well aware that increasing these activities could bring further challenges, such as destruction of saltmarsh habitat or disturbance of wildlife, as discussed above. Finally, the role saltmarshes play in coastal protection was suggested as an area that could be developed further, indicating an interest in 'working with nature'.

Building on the findings of the interviews, discussions through the expert workshop centred on identifying possible solutions and opportunities to support sustainable management of saltmarsh grazing. Generally, there was consensus that mixed activity on Welsh saltmarshes would be positive for farmers. There was a general feeling that there should be an improvement in public awareness and understanding of saltmarshes, as well as better recognition of the benefits which saltmarshes provide to society. It was advocated that encouraging public appreciation and therefore, hopefully enhancing public awareness, should be done in ways that do not increase footfall on the saltmarshes, with various suggestions presented, such as the use of emerging technology (i.e. webcams, drone footage, virtual reality), or by having visitor centres on the edge of marsh so that visitors/ the wider public can appreciate saltmarsh environments on a landscape scale. This need to raise awareness was not limited to the general public, with proposals for activities to raise awareness within the farming

community of the potential opportunities of saltmarsh grazing and its cultural heritage in Wales also discussed during the workshop.

Delegates recognised that, at the time of the workshop, farming was experiencing 'changing times' (e.g., EU Exit), and that future subsidy schemes may be an opportunity for saltmarsh grazers. Following the UK EU Exit process, some suggested that there could be opportunities to feed into the various financial incentive and agriculture support schemes being discussed (e.g., outcome-based schemes, public money for public goods etc.). Related to this, workshop participants expressed a need for agri-environmental schemes be better promoted, with clear incentives that encourage farmers' committed involvement. The possibility of establishing a range of Payments for Ecosystem Services (PES) schemes as an incentive for implementing specific management measures related to saltmarsh environments was also discussed (Muenzel and Martino, 2019).

Finally, delegates spent some time discussing coastal management tools, with particular attention given to Shoreline Management Plans (SMPs), non-statutory documents which present a broad-scale and long-term assessment of risks relating to a range of coastal processes (Ballinger and Dodds, 2020). The SMPs were produced to support authorities and decision-makers in identifying sustainable policies for coastal areas across England and Wales (UK Government, 2019). There was a feeling that more could be done to raise the profile and understanding of the SMPs for Wales and the role they currently, or, indeed, could play in future coastal management decisions. Workshop participants felt there could be an opportunity to '*restructure SMPs'* as statutory documents to lend more weight and emphasis to their policies –the current refresh programme being undertaken in both England and Wales was identified as a potential opportunity for these discussions. Associated with coastal management more generally, there was also discussion around the need to address the unpredictable ongoing challenges of climate change through forward thinking planning for land-management and implementing the SMP policy options.

4. Discussion and recommendations for the future

This study presents a detailed overview of the role of saltmarshes in coastal agricultural practices across Wales. Drawing on insights gathered from a diverse community of stakeholders, there are several areas which warrant further consideration and discussion.

4.1. 'Selling' saltmarshes: Raising awareness and creating access

While saltmarshes are often considered to be one of the less accessible and historically undervalued coastal ecosystems, this study found that Welsh farmers expressed a strong sense of personal connection and sense of place associated with these environments. Our study findings revealed that the traditional agriculture use of saltmarshes is perceived as an important element of Welsh cultural heritage which should be protected. Evidently there are multiple types of value (McKinley et al., 2020; McKinley et al., 2018), highlighting the importance of taking account of intangible benefits within natural resource management and decision-making (Chan et al., 2014). These findings imply that those working the land have a strong sense of connection, with saltmarshes contributing to their sense of identity. Interviewees went so far as to express strong emotional responses to saltmarshes with some even suggesting that that there would be a sense of bereavement within the Welsh agricultural community should saltmarshes experience further losses. This sense of connection expressed by participants in this study is echoed in a recent study by Roberts et al., (2021) where members of two

coastal communities described saltmarsh systems with multiple positive connotations. In contrast with both this study, and the findings presented by Roberts et al., (2021), a recent national scale study found overall public knowledge and connection of saltmarshes to be considerably lower (McKinley et al., 2020b).

Looking to the future, this research suggests that ongoing management and governance, including any changes in process or objectives related to the UK's EU Exit should actively take into consideration cultural identity and heritage associated with coastal landscapes (Henderson, 2019; Trakadas et al., 2021). Through the devolution process in the UK, Wales' own legislative landscape provides a strong legal mandate for the conservation and protection of cultural heritage and well-being, for example, through the goals set out by the Well-being of Future Generations (Wales) Act (2015). Farmers, and the wider agricultural community, are often framed as the stewards of rural culture and landscapes (Raymond et al., 2016). Drawing insights from this study, it is evident that there is potentially an opportunity for the development of innovative funding programmes which provide active and targeted support to protect this specialised form of agricultural activity in Wales, positioning Welsh farmers as custodians of the unique saltmarsh landscape. In order to promote and continue the ongoing use of saltmarshes in traditional agricultural ways and to protect the cultural heritage, traditional skills and diverse values associated with them, it is recommended that efforts should be made to encourage new entrants into the farming community. This call for support for new entrants to fill the gaps left my retiring farmers echoes those from other studies over the last 10 years or so (Pindado et al., 2018; Ingram and Kirwan, 2011). These should be targeted so that they specifically highlight the value of working with and on these diverse environments and facilitate innovative partnerships which can deliver and facilitate sustainable saltmarsh grazing (Ingram and Kirwan, 2011). While this study is not advocating for the expansion of agricultural use of saltmarsh, diversification of activities to support a more sustainable coastal rural economy should be supported and encouraged, particularly at this uncertain time for Welsh farming following the UK's EU Exit (Welsh Government, 2019). By understanding grazing activity and continuing to work working closely with the wider agricultural community to balance their needs alongside those of natural resource management and conservation, more can be done to support these often-isolated coastal communities through collaborative management approaches and initiatives.

Despite a strong sense of individual connection to saltmarsh ecosystems from those currently working them for agriculture, overall public awareness and connection to saltmarshes is low. A recent survey of over 1000 respondents found the majority of people in Wales have limited known experience of saltmarshes, with over 90% indicating either basic or no knowledge of saltmarshes and high uncertainty about their ecosystem services and benefits (McKinley et al., 2020b). Saltmarshes, like many other coastal fringe systems (e.g. mud flats, seagrass beds) have historically received relatively limited attention (Jefferson et al., in prep) – while this is changing, gaps remain in our understanding of the social dimensions of these ecosystems and their role within wider socio-ecological frameworks. There is, therefore, a clear need to develop awareness raising and education campaigns to highlight the value of Welsh saltmarsh to Welsh farming, and indeed society more broadly (see McKinley et al., 2020b for specific recommendations relating to this). Engaging with relevant actors and local stakeholders can encourage and increase knowledge and appreciation of saltmarshes across Wales. This can also ensure that nature conservation objectives, such as those set out by the various protected area designations, are met. An additional aspect of this is the need to enhance access to saltmarshes. To achieve this, it is recommended that opportunities to increase access to saltmarshes

in ways that limit damage are explored, particularly given the high conservation status and value of these ecosystems (JNCC, 2008), including through the use of emerging technologies to facilitate virtual access to these otherwise hard to reach environments. Adopting virtual access approaches could help to enhance a sense of connection, create sustainable and managed access, and provide people with the opportunity to experience saltmarsh landscapes (Portman et al., 2015), without increasing risk to the ecosystem.

4.2. Improved monitoring of coastal grazing

As noted above, saltmarshes face a range of pressures and threats. Grazing is a specific pressure that needs to be carefully monitored and managed, particularly given its impact on biodiversity and the delivery of saltmarsh ecosystems services and benefits. Numerous authors have examined the positive and negative implications of agricultural grazing on saltmarsh ecosystems (see Hannaford et al., 2006; Davidson et al., 2017; and Pages et al., 2018), while others have recommended more careful monitoring is required to counteract recent, and indeed ongoing, global losses in saltmarsh extent (McOwen et al., 2017). In Wales, recent legislative changes have led to a shift towards natural resource management. This has included the application of the nine principles of Sustainable Management of Natural Resources (SMNR), as set out by the Environment (Wales) Act (2016). Of particular relevance for this work are the principles of 'Evidence' (i.e. the use of best available evidence and the importance of gathering diverse sets of evidence) and 'Multiple Benefits' (i.e. taking account of diverse and different values) (See National Assembly for Wales, 2019 for more information). SMNR principles now underpin all decision-making relating to Wales' natural environment and its management even though the SMNR approach to managing natural resources is relatively young and relevant authorities are still working to identify existing shortcomings, develop and implement a collaborative and integrative governance framework (Jenkins, 2018). In addition, it should be noted that the self-reported data collected on agricultural grazing on saltmarshes is not always in line with the findings of other work (see for example Davidson et al., 2020). We recommend that a regular monitoring programme (assessing impacts of farming and other activities) on saltmarsh environments is put in place to ground truth the findings from this study, and to also ensure carrying capacity is not breached and that uses are balanced. There are opportunities to build upon existing guidance from the Water Environment (Water Framework Directive (England and Wales) Regulations 2017 and the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019), as well as the recent Welsh Marine Area Statement (NRW, 2020), to support further assessment.

Crucially, this study highlights the strong emotional connection to the landscape expressed by saltmarsh farmers, mirroring similar notions of sense of place and connection voiced by local communities who 'know' saltmarshes (Roberts et al., 2020). These aspects are often derived from qualitative data collection processes, such as those grounded in the wider fields of conservation and marine social sciences (Bennett, 2016; McKinley et al., 2020), and are dimensions which have historically not been adequately considered within strategic management and decision-making processes. With this in mind, it is recommended that monitoring activities should move beyond traditional ecological monitoring approaches and should encompass social, cultural, and economic dimensions of saltmarsh environments and their role as coastal agricultural landscapes. This should include the relationship between the agricultural community and saltmarshes, including the implications of recreational disturbances on these environments.

4.3. Adopting an integrated management approach for saltmarshes

As discussed in the previous section, there is a need to better understand the full, true value of agricultural coastal grazing on saltmarshes, recognising that this may not be evident from traditional economic metrics alone, and should include the more intrinsic and relational nature of cultural and heritage values (as explored, for example, by Roberts et al., 2020). In addition, there is a need to balance grazing activity with other activities, and to understand the trade-offs that may take place between the various ecosystem services and benefits, and indeed disbenefits (Rendon et al., 2020), provided by saltmarshes under different grazing patterns and regimes. For example, livestock grazing can be beneficial for some other species, but may have implications for the structural integrity of floral community (Davidson et al., 2019), while other research has examined the inter-relationship between carbon storage and saltmarsh grazing, highlighting opportunities to develop PES schemes as a balancing mechanism for management (Muenzel and Martino, 2018).

Developing a more comprehensive understanding of historical uses of saltmarshes, and historical grazing practices and intensity, would provide valuable insights relating to saltmarsh functionality and capacity to maintain ecosystem service provision, actively contributing to contemporary coastal and land use management for saltmarshes. Furthermore, drawing on aerial photography, historical mapping and archived information about land use practices from within the agricultural community, and seeking existing data from organisations involved in ecosystem monitoring (e.g. Natural Resources Wales in a Welsh context) would contribute to a deeper understanding of the carrying capacity of these often peripheral and forgotten systems. This would ensure that management decisions are made with best available information and an understanding of historical uses and how these may have accumulated to impact a system's capacity to deliver ecosystem services in the present day.

Finally, in coastal fringe environments, like saltmarshes, there are likely to be multiple uses, activities, and stakeholder groups - a recent study by McKinley et al.(2020b) explores this variation on a global scale and highlights the importance of integrated management. All these must be taken into account to avert conflicting management approaches being implemented. While it is evident that there are tensions between different policy areas, user needs and ecosystem service provision at different spatial scales – the adoption of more integrated approaches to decision-making should mean that future management interventions (e.g. creation of saltmarsh habitat through managed realignment programmes) provide not only local benefits for farmers, but also contribute to wider gains (e.g. carbon storage, coastal protection) some of which may be of national significance. This is particularly timely given a growing focus on 'working with nature' and habitat creation/ restoration programmes within coastal management and climate adaptation – projects such as Steart Marshes, Somerset, UK, or Cwm Ivy, Wales, UK, may provide valuable insight and lessons in this context.

5. Conclusions and Recommendations

This paper presents an integrated approach to mapping and understanding coastal grazing on saltmarshes and the potential trade-offs between uses that may need to be taken account of for future management. However, the data presented here is not a complete dataset and is based, for the most part, on self-reported data collected from the farming community through interview processes. It is recommended that additional research be undertaken to ground-truth and to add to our dataset. More broadly, it is recommended that integrated approaches to assessing environmental value of coastal fringe systems are mainstreamed, ensuring a greater understanding of the social and cultural

values associated with coastal ecosystems. Importantly, this should be undertaken as part of a regular programme of monitoring, which can identify the transient nature and associated spatial and temporal variations in values, services and benefits attributed to these different ecosystems. This call for integrated monitoring and interdisciplinary research agenda echoes the recommendations set out in a recent paper by McKinley et al. (2020) which explores global management of saltmarshes and their ecosystem services and benefits.

As efforts continue to move towards successful implementation of sustainable management of natural resources on a global scale, there needs to be an improved understanding of how the cumulative effects of multiple uses and activities can impact current ecosystem functionality and carrying capacity. There is therefore a need for consideration of how both current and longer-term trends of use of coastal fringe environments, such as saltmarshes, could be incorporated into wider coastal management and decision-making processes. This partly re-echoes calls for Integrated Coastal Management, approaches which have somewhat dwindled over the last decade since the introduction and focus on marine planning. Improved understanding from such approaches could help deliver sustainable management in future.

Furthermore, coastal fringe environments such as saltmarshes, can act a valuable lens to explore the complex network of coastal users, governance and management and their ecosystem services. Additionally, as these environments generally occur in relatively less developed and more rural coastal areas, they could act as valuable test sites for developing integrated monitoring programmes, taking account of diverse values (ecological, economic, social, and cultural). These could track how such values change over time, across marine and coastal systems globally, resulting in improved integration between land and marine planning.

Finally, this study further emphasises the importance of recognising, valuing, and incorporating the different knowledges and values held by different communities of practice within research and management – by working closely with stakeholders from across the agricultural community, this study gathered multiple insights into the spread, scale, and intensity of grazing activity across coastal saltmarshes. There is a clear opportunity for improved stakeholder and community engagement within coastal management and decision-making, and the value of local environmental knowledge and values should not be under-estimated within these processes.

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Declaration of interests

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