Research & Evidence

Reducing Greenhouse Gas Emissions from Conservation Grazing:

Exploring alternative grazing scenarios to reduce GHG emissions while maintaining nature conservation goals for six case study nature reserves in England

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Protecting **Wildlife** for the Future

This report presents an exploration of how conservation grazing regimes could be altered to reduce Greenhouse Gas (GHG) emissions while not compromising biodiversity conservation goals at six case study sites. GHG emissions from the large herbivores that are used to graze and browse nature reserves and other land managed by The Wildlife Trusts constitute approximately 68% of the Trusts' GHG emissions. Following a review of GHG emissions from large herbivores (Ramsay et al. 2023) and the creation of a new Conservation Livestock GHG Emissions Calculator (Doar et al. 2024) the following case studies document current conservation grazing regimes and compare them with a variety of alternative grazing scenarios that have the potential to reduce GHG emissions. The scenarios are focused on reducing stocking density, switching from high-emitting to low-emitting large herbivore species, using more targeted grazing with NoFence collars to reduce overall stocking densities, and considering the use of emission reducing feed supplements and technology. The potential to reduce emissions is weighed against the potential impact on biodiversity conservation goals and the barriers that could prevent switching the grazing regimes.

This report has explicitly considered the GHG emissions from conservation grazing used to deliver specified biodiversity conservation goals. These goals focus on maintaining habitats and features that support species of conservation importance. However, while these objectives are critical, the broader aspiration of rebuilding and sustaining landscape-scale functional and resilient ecosystems is another crucial consideration. Reviewing conservation grazing practices against broader nature recovery ambitions could result in changes in large herbivore assemblage and abundance, impacting GHG emissions.

To this end, estimations of natural wild herbivore biomass densities were considered for Hartington Meadows and Wheldrake Ings, along with the GHG emissions if this biomass density comprised entirely of wild deer. Although these natural large herbivore biomass density estimates are broad and derived from larger protected areas worldwide (controlled for net primary productivity), comparing these estimates of natural densities and GHG emissions to current conservation grazing sites indicates that conservation grazing densities and emissions are high.

This exploration of conservation grazing case studies suggests there are considerable opportunities to reduce GHG emissions while maintaining nature conservation goals. Implementation and testing of these alternatives are needed to confirm this potential.

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KEY INFORMATION

This paper is the result of work carried out in 2022, by Jennifer Ramsay and Dr Chris Sandom, from the Wild Business consultancy, under contract to the Royal Society of Wildlife Trusts (RSWT).

It sets out six case studies of conservation grazing operations in England and assesses the potential implications of different grazing regimes - for each site's conservation goals and for associated greenhouse gas emissions.

It has been published by The Wildlife Trusts as part of a strategic commitment to generate, share and use good evidence, and to be open about the data, evidence and reasoning that underpin the federation's decisions, policies and actions.

This paper has been published as part of a series launched in 2025, to fulfil a commitment made in The Wildlife Trusts' Collective Framework on Data, Research & Evidence, a copy of which can be obtained by e-mailing evidence@wildlifetrusts.org

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Find out more at: www.wildlifetrusts.org/

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1. Acronyms

AONB: Area of Outstanding Natural Beauty

BPS: Basic Payment Scheme

CO_2e: Carbon Dioxide Equivalent, allows for the conversion of other greenhouse gas emissions to the equivalent emissions of CO_2 (used in GWP100 and GWP20)

CO_2 w.e.: Carbon Dioxide Warming Equivalent, allows for the conversion of other greenhouse gas equivalent warming potential of CO_2 emissions (used in GWP*)

CSS: Countryside Stewardship Scheme

GHG: Greenhouse Gas

GWP*: Global Warming Potential Star, a model of the relative warming effect (radiative forcing) of GHG emissions over 100 years (measured in CO_2 warming equivalent). It is specifically intended for use in estimating the global warming impact of changes in the ongoing emission-rate of short-lived greenhouse gases such as methane. GWP* is a particularly important metric in circumstances when methane emissions are constant or decreasing over time. Because methane is a relatively short-lived GHG, declining emissions over time can result in negative warming potential over the 100 years to which conventional carbon accounting approaches based on GWP100 relate (Lynch et al. 2020). Under this scenario methane emissions fail to replace the methane that is naturally being lost from the atmosphere reducing total atmospheric methane concentrations.

GWP100: Global Warming Potential 100, a measurement of the relative warming effect (radiative forcing) of a quantity of GHG emissions over the following 100 years (measured in CO_2e)

GWP20: Global Warming Potential 20, a measurement of the relative warming effect (radiative forcing) of a quantity of GHG emissions over the following 20 years (measured in CO_2e)

HLS: Higher Level Stewardship

LIG: Low Input Grassland

LU: Livestock Units

LUY: Livestock Unit Years

NNR: National Nature Reserve

PRoW: Public Rights of Way

SAC: Special Area of Conservation

SFI: Sustainable Farming Initiative

SNCI: Site of Nature Conservation Importance

SPA: Special Protection Area

SSSI: Site of Special Scientific Interest

2. Introduction

This report presents an exploration of how conservation grazing regimes could be altered to reduce Greenhouse Gas (GHG) emissions while not compromising biodiversity conservation goals at six case study sites. GHG emissions from the large herbivores that are used to graze and browse nature reserves and other land managed by The Wildlife Trusts constitute approximately 68% of the Trusts' GHG emissions. Following a review of GHG emissions from large herbivores (Ramsay et al. 2023) and the creation of a new Conservation Livestock GHG Emissions Calculator (Doar et al. 2024) the following case studies document current conservation grazing regimes and compare them with a variety of alternative grazing scenarios that have the potential to reduce GHG emissions. The scenarios are focused on reducing stocking density, switching from high-emitting to low-emitting large herbivore species, using more targeted grazing with NoFence collars to reduce overall stocking densities, and considering the use of emission reducing feed supplements and technology. The potential to reduce emissions is weighed against the potential impact on biodiversity conservation goals and the barriers that could prevent switching the grazing regimes.

Organisation	Site Name	Key Habitats	Current grazing species
Dorset Wildlife Trust	Kingcombe Meadows	• Grasslands (81% of site): neutral, acid, calcareous, fen, purple moor-grass and rush • Woodland (12% of site) • Scrub (7% of site): gorse, hedgerow, native scrub thicket	Cattle (non-dairy), Sheep, Ponies
The Wildlife Trust for Lancashire Wildlife Trust Manchester & North Merseyside	Birkdale Sandhills	Coastal sand dunes, including: • fixed dune • dune grassland • dune slacks • dune scrub	Cattle (non-dairy)
Bedfordshire, Cambridgeshire and Northants Wildlife Trust	Old Sulehay	• Woodland (56% of site): includes SSSI ancient woodland (mix of broad-leaved species including small-leaved lime) • Grassland (38% of site): species-rich calcareous grasslands • Scrub and marsh (5% of site)	Cattle (non-dairy), Sheep
Derbyshire Wildlife Trust	Hartington Meadows	• Neutral and Calcareous grassland	Cattle (dairy), Sheep
Yorkshire Wildlife Trust	Wheldrake Ings	• Lowland meadow and pasture (78%) • Scrubland (16%) • Wetlands (6%)	Cattle (non-dairy), Sheep
Natural England	Gait Barrows	• Fen, marsh and swamp • Calcareous grassland • Broad-leaved, mixed and yew woodland • Neutral grassland • Scrubland	Cattle (non-dairy), Ponies

The case studies only focus on the emissions from large herbivores. Alternative management techniques such as mechanical cutting are not considered. Nor do they consider the carbon sequestration nature is likely to be delivering at these sites or the influence that different grazing regimes might exert on the quantity and quality of that sequestration. Both factors are vital for full carbon accounting but are beyond the scope of this report. **The goal for this report is to identify potential opportunities to minimise GHG emissions without putting biodiversity conservation goals at risk**. We are assuming that altering the grazing regime in the ways we are considering is unlikely to alter carbon sequestration potential substantially, however, this assumption needs further research.

The case studies come from across England and include both lowland and upland settings. The case studies examined consist of a range of habitats, with most primarily consisting of species-rich grasslands that are particularly supported by conservation grazing. Birkdale Sandhill is an exception as it is focused on a sand dune system. The current grazing on all the case study sites is primarily being delivered by cattle and sheep, reflecting the dominance of these species across all of the Trusts' landholdings. Some sites are already grazed by ponies as well, although in small numbers. The biodiversity conservation goals are focused on maintaining the richness and composition of species-rich grassland, creating and maintaining a diverse sward structure, and preventing the establishment or expansion of scrubland.

3. Summary results

At all six case study sites possible alternative grazing regimes were identified that could reduce GHG emissions with what were felt to be minimal risks to the nature conservation goals.

- The most favourable alternative grazing scenarios all included switching a proportion of the grazing from cattle and/or sheep over to horse/pony grazing.
- At all sites the view was that at least some cattle grazing should be maintained at the site because of the conservation benefits of cattle grazing. Namely creating a diverse sward structure and their dung helping to support a particularly diverse invertebrate community.
- The reported main perceived barriers to implementing alternative grazing scenarios include the need to develop the skills, experience, infrastructure, public awareness and processes for an increased use of pony grazing at conservation sites.
- For context, at two case study sites we compared reported conservation grazing stocking density to broad estimates of what might be considered a natural variation of large herbivore grazing densities. We found that conservation grazing densities at those sites are near to or above the 'very high' end of estimated natural stocking densities.
- **The average potential reduction of GHG emissions from the preferred alternative grazing scenarios across all the case studies sites is 42% (range 16-71%).**

Organisation	Site Name	Current Grazing regime	Proposed Best Alternative Grazing Regime	Reduction in GWP of switching to alternative grazing
Dorset Wildlife Trust	Kingcombe Meadows	Cattle, Sheep and Ponies (121 LUY; 0.61 LUY/ha)	**Mixed grazing with more Ponies, less Cattle and Sheep:** 50% of cattle and 50% sheep replaced by ponies at eq. LUs. (121 LUY; 0.61 LUY/ha)	↓ 40%
The Wildlife Trust for Lancashire Wildlife Trust Manchester & North Merseyside	Birkdale Sandhills	Cattle only (6.5 LUY; 0.024 LUY/ha)	**Mixed grazing with more Ponies, Goats, and Pigs, less Cattle**: 75% of cattle replaced by ponies, goats and pigs and 25% reduction in remaining cattle. (6.0 LUY; 0.022 LUY/ha)	↓ 67%
Bedfordshire, Cambridgeshire and Northants Wildlife Trust	Old Sulehay	Cattle, Sheep and Ponies. (7.8 LUY; 0.09 LUY/ha)	**Mixed grazing with more Ponies, less Cattle and Sheep**: 50% of cattle and 50% sheep replaced by ponies at eq. LUs. (7.8 LUY; 0.09 LUY/ha)	↓ 41%
Derbyshire Wildlife Trust	Hartington Meadows	Cattle and Sheep (10.9 LUY; 0.42 LUY/ha)	**Combination of Scenarios:** Reduce cattle stocking density to 50% (through reduced stocking rate and targeted grazing) and replace sheep with horse at eq. LUs. (5.45 LUY; 0.21 LUY/ha)	↓ 71%
Yorkshire Wildlife Trust	Wheldrake Ings	Cattle and Sheep (14.21 LUY; 0.14 LUY/ha)	**Mixed grazing with more Ponies and less Cattle and Sheep**: 50% of cattle & sheep replaced by ponies at eq. LUs (14.21 LU yrs; 0.14 LUY/ha)	↓ 40%
Natural England	Gait Barrows	Cattle and Ponies (5.2 LUY; 0.12 LUY/ha)	**Mixed grazing with more Ponies and less Cattle:** 20% of cattle replaced by ponies at eq. LUs. (5.2 LU yrs; 0.12 LUY/ha)	↓ 17%

4. Methods

The locations for the six case studies were selected based on the following criteria:

- Conservation grazing is currently practiced on the site and is important for the attainment of nature conservation goals.
- Relevant staff (with at least two years of experience in conservation grazing) were available to take part in interviews.
- Detailed grazing data, management goals, and maps were readily available.
- A variety of different habitats typical of those grazed by nature conservation organisations in the UK was present across the case study sites selected.

For each site, details of the current grazing regime were provided by staff, along with details of key habitats and conservation goals for grazing on the site. Interviews were conducted with an experienced member of staff for each site to identify options for grazing scenarios that would be likely to reduce GHG emissions whilst contributing effectively to the broad ecological goals for the site. These interviews also identified practical barriers and challenges that could impede the implementation of these scenarios in practice.

The alternative grazing scenarios discussed at the interviews were based on 'levers of change' to reduce GHG emissions from grazing, as identified in Ramsay et al. (2023). The key 'levers of change' discussed in staff interviews were:

1. replacing cattle and sheep with ponies and/or pigs (either entirely or partially)
2. reducing cattle and sheep numbers with a more targeted approach to grazing
3. the use of methane-reducing supplements or technologies

Based on interview responses and site data, appropriate alternative scenarios were selected to reflect site conditions and ecological requirements.

For each alternative scenario, GHG emissions were calculated using a bespoke calculator created by the Royal Society of Wildlife Trusts (Nigel Doar et al. 2024). CO_2 equivalent (CO_2e) values are presented for Global Warming Potential 100 and 20 (GWP100, GWP20 respectively), while CO_2 warming equivalent (CO_2 w.e.) is reported for GWP*. The different GWP metrics are provided because they reflect different ways of accounting for the life-time of methane in the atmosphere (~20 years). GWP100 and GWP20 are static metrics that provide a measure of warming potential of an equivalent one-off emission of CO_2. GWP100 is international standard. However, GWP100 and GWP20 fail to effectively account for methane's shorter natural life in the atmosphere (Lynch et al. 2020). GWP* is a model of warming potential that takes into account the natural loss of methane from the atmosphere, comparing current emission rates with those of 20 years ago. This is important because decreasing emissions of methane over time can result in negative warming potential. In our calculations of GWP* we have assumed current emissions estimates from the current conservation grazing regime were the same 20 years ago, and that the emissions associated with alternative scenarios will continue at the same rate into the future.

The GHG emissions calculated are those arising directly from grazing animals (methane and nitrous oxide emissions from enteric digestion, manure and urine) and do not include emissions from machinery, vehicles, fencing, farm buildings, supplementary feed or any equipment associated with livestock handling. They also do not include potential removal of carbon from the air by habitats (due to the high uncertainty in estimating carbon sequestration in different habitats). Reducing grazing intensity has the potential to increase carbon sequestration where succession occurs to create scrubland and woodland habitats on appropriate soils. A potentially important unknown is whether different livestock species influence soil carbon sequestration differently. For example, a key emission reduction scenario considered is switching from high emitting cattle to low emitting horse or ponies. While this change in grazing has the potential to reduce GHG emissions arising directly from the animals and their waste products, if less carbon is sequestered on ground grazed by horses compared to cattle (as a result of their differing biology and the responses of plants, invertebrates, fungi and soils to it), some of these benefits may be erased. Equally, a change in grazing regime away from cows and/or sheep may result in more sequestration (at least in the short term). In which case, the benefits of reduced emissions may be accompanied by additional benefits from increased sequestration. We have made no assumptions about this aspect of the grazing ecosystem, given the complexity and uncertainty associated with this.

For two case study sites we made broad estimates of the emissions associated with estimated natural densities of wild large herbivores. Wild large herbivorous mammals are a natural part of most ecosystems and, until relatively recently, have had a largely ubiquitous presence over the last 40 million years on all continents except Antarctica. However, as a result of the Pleistocene megafauna extinction and subsequent dramatic decline in the remaining wild large herbivores, Britain has a considerably impoverished wild large herbivore assemblage. Deer species, including some introduced species, are essentially all that remain.

With no part of Britain unimpacted by people, it is difficult to assess what could be considered a natural assemblage and density of large herbivores. Making such an assessment would allow comparisons of GHG emissions from conservation grazing as a management approach with emissions associated

with naturally occurring large herbivores. As a way of offering a broad comparison, we have compared the current conservation grazing scenario with the emissions estimates from the range of large herbivore biomass densities that have been calculated for the Net Primary Productivity of the site based on data recorded from large, protected areas around the world (Fløjgaard et al., 2021). These are presented as very low, average and very high natural biomass density estimates. We then calculate the emissions if this biomass density was entirely made up of deer. It is important to note that the natural density estimates are taken over large spatial scales. Density estimates are likely to have a much broader range of densities within them when considering smaller spatial scales. These estimates are provided as a very broad comparison to consider and reflect upon in the knowledge of the considerable uncertainty and limitations in these data.

4.1. Rating of Scenarios

Each scenario for all case studies is given ratings for Nature Conservation Outcomes, Carbon Reduction, and Feasibility. These are combined into an Overall Rating for each scenario. The ratings involve some subjective assessments based on interview responses and likely conservation outcomes and feasibility of implementation. They are therefore indicative of comparative impacts rather than precise ratings.

Nature Conservation Outcomes:

- Low (likely to be detrimental to stated conservation goals)
- Medium (likely to help deliver the conservation goals, and unlikely to be detrimental)
- High (very likely to help deliver stated conservation goals)

Carbon Reduction:

- Low (less than 15% reduction)
- Medium (15 – 29% reduction)
- High (30 – 49% reduction)
- Very High (50% and above)

Feasibility:

- Low (one or more barriers are likely to be insurmountable in the immediate future)
- Medium (one or more barriers will require solving but are not likely to be insurmountable)
- High (no major barriers are envisioned for implementing this scenario)

Overall Scenario Rating:

This combines the Biodiversity, Carbon and Feasibility ratings to give an overall rating as follows:

	Unfavourable (Stop)	Two or more ratings are Low; OR Nature Conservation Outcomes are assessed to be Low.
	Acceptable (Consider)	Two or more ratings are Medium or better (or one Medium/one High; or two Highs/one Low)
	Good (Recommended)	Two or more ratings are High, and none are Low

4.2. Barriers to alternative grazing scenarios

The main barriers to alternative scenarios were identified in staff interviews and are summarised in **Table 1.**

Some of the barriers could be addressed through knowledge exchange with other sites (for example, where larger pony herds or pigs are already used), with other organisations (especially those that are also prioritising effort to address the climate impacts of their conservation land management), and through staff training. A gradual approach to changing grazing regimes may also be more beneficial than sudden large-scale changes (allowing staff and site adjustments and progressive learning and adaptation). More detailed suggestions for overcoming barriers (outlined in **Table 1**) could be enhanced with staff forums, workshops and guidelines.

Site designations (such as SSSI) and agri-environment schemes were not viewed by the staff interviewed as specific barriers to alternative grazing regimes. However, it was recognised that discussions with Natural England or the Rural Payments Agency would be required to obtain permission for any substantial changes to livestock type or numbers that deviated from existing agreements.

Working in partnership with other land management organisations (e.g. National Trust, RSPB, Natural England) was identified as a potential mechanism to reduce overall livestock numbers required across a geographical region (and therefore to reduce overall GHG emissions). This could be achieved by sharing livestock between organisations and sites within a geographical area (rather than each organisation having their own livestock year-round). This could also provide access to a more varied mix of livestock types at the times required.

Table 1: Barriers to alternative grazing scenarios and potential strategies to address them.

Organisation	Site Name Current Grazing regime	Proposed Best Alternative Grazing Regime Reduction in GWP of switching to alternative grazing
Barrier A: Staff less experienced with ponies	Staff lack experience with managing ponies (or large herds of ponies).	**Staff training and experience:** • Specific training for pony herd management • Knowledge exchange and visits to sites with larger pony herds • Online forums for advice and information sharing
Barrier B: Herd size management (for breeding herd of ponies)	The size of breeding herds of cattle and sheep can be managed by selling individuals when herd size becomes too large. There is no current meat market for ponies, so sensitive alternative options would have to be identified.	**Knowledge exchange:** • How do existing sites with large breeding herds of ponies manage this issue? • How big an issue is it likely to be? **Developing options:** • If more sites are using ponies, could options be developed for exchanging ponies between sites? • Could options be developed for off-site homes for excess ponies? • What are the opportunities for large non-breeding herds?
Barrier C: Possible loss of some ecological benefits of cattle	Cattle may bring some specific ecological benefits that are not provided by ponies. Differences in grazing style, size, behaviour and dung may have benefits for habitat heterogeneity and creation of micro-habitats.	**More research:** • More research into the differing ecological impacts of ponies and cattle (at varying scales) would allow a more robust assessment of situations where cattle would be strongly preferable to ponies. **Retain some cattle:** • Where cattle are considered more suitable than ponies for specific conservation goals then some cattle could be retained (at the minimum herd size required for those purposes).
Barrier D: Possible difficulties with using ponies on steep slopes (sheep more suited).	The small size, weight and agility of sheep make them suitable for grazing steep slopes. It may be possible for ponies to graze the steep slopes, but there could be impacts from their weight and they might avoid steep slopes unless contained there.	**Research and knowledge exchange:** • Are there existing sites where ponies are used for grazing steep slopes? • What can be learned from these sites? **Experimental approaches:** • Experimental trials would be beneficial to assess the suitability of ponies for steep slopes and the impacts on soil and vegetation compared to sheep. **Retain some sheep**: • If ponies are considered unsuitable for steep slopes, some sheep could be retained for the specific purpose of grazing the slopes (at the minimum herd size required).
Barrier E: Possible negative visitor perceptions if cattle removed.	Many regular visitors and local residents are fond of the cattle and enjoy seeing them when they visit. There could be a backlash if cattle were completely removed from the site.	**Gradual approach, retaining some cattle:** • A proportion of cattle could be retained to minimise negative visitor perceptions • Reductions in cattle could be made gradually to avoid sudden changes to the visitor experience **Visitor education:** • Informing visitors of the reasons why cattle numbers are being reduced could assuage negative perceptions
Barrier F: Cost of using NF collars for large number of cattle and sheep.	NoFence collars can be expensive to purchase and maintain for large herds.	**External funding:** • Using NF collars for the purposes of reducing GHG emissions could open more sources of grant funding
Barrier G: Uncertainty in % herd reduction possible without detrimental ecological impacts.	It is difficult to quantify the maximum reduction of herd size that would be possible whilst maintaining conservation goals.	**Research and knowledge exchange:** • Synthesise the existing research on stocking rates and conservation impacts • Facilitate knowledge exchange between sites to discuss and share experiences on stocking rates **Experimental approaches:** • Reduce herd size gradually to assess and adapt • Where possible, experiment with different herd sizes and monitor impacts

Organisation	Site Name Current Grazing regime	Proposed Best Alternative Grazing Regime Reduction in GWP of switching to alternative grazing
Barrier H: Seasonal changes in livestock numbers required to achieve conservation goals.	Livestock numbers required for conservation grazing vary seasonally. When animals are not grazing the site, they still need to be somewhere and are continuing to emit GHGs.	**Calculating off-site emissions:** • The WT carbon calculator should account for off-site emissions when animals are not on site (this should be done in a way that ensures there is no double-counting when animals are at another WT site) **Maximising conservation benefits when off-site:** • Where possible, when animals are off-site they should be conservation grazing at another site **Collaboration with other conservation bodies:** • Overall livestock numbers could be reduced through landscape-scale approaches that collaborate with other NGOs or land managers to share conservation livestock
Barrier I: Livestock shared across sites.	Livestock may be moved between different sites seasonally. The minimum number of livestock required therefore needs to suit all sites, not just one site.	**Multi-site planning:** • Where livestock are shared and moved across multiple sites, planning for alternative grazing regimes will need to take a holistic view of the requirements of all sites
Barrier J: Difficulty obtaining the desired livestock from graziers.	Some types of livestock are more difficult to obtain from local graziers (e.g. ponies, goats and pigs can be more difficult to obtain than cattle and sheep) particularly during the time/season required.	**Communication and planning with graziers and other organisations:** • A livestock 'dating app' was suggested – allowing sites and graziers to match up and plan ahead • Partnership working with other organisations who could use the same grazing livestock e.g. National Trust, RSPB, Natural England
Barrier K: Possible problems with livestock-visitor interactions.	Some types of livestock are considered more risky around visitors e.g. ponies and goats.	**Visitor education and communication:** • Signage and information for visitors (discouraging interactions with livestock) **Use of trained livestock:** • Where possible, choose livestock that have learned to avoid approaching visitors
Barrier L: Lack of housing or farm base for livestock when not grazing the site.	Seasonal use of different types of grazing animals may require housing or a farm base for those animals when not grazing the site. This would have cost and staffing implications.	**Funding and creation of farm base for livestock:** • Seek funding to create and manage a farm base with housing for a variety of livestock types • Partnership working with other organisations who could use the same grazing livestock e.g. National Trust, RSPB, Natural England OR use local graziers (but see Barrier J)
Barrier M: Pigs can be more prone to escaping.	Pigs are considered to escape more easily. Staff would require training and experience.	**NoFence collars for pigs:** • The manufacturers have indicated they may develop pig collars. **Staff training and experience:** • Specific training for pig management • Knowledge exchange and visits to sites with pigs • Online forums for advice and information sharing
Barrier N: Managing latrines created by ponies/horses	There is concern that the latrines created by ponies/horses take longer to decompose and so increase the likelihood of dung getting collected during the hay cut	**Research and knowledge exchange:** • Share knowledge from Trusts already managing this problem • Research to find mitigating strategies
Barrier O: Need for new permanent infrastructure (e.g. fencing and providing water)	Sheep are a low maintenance species in that they can be retained with electric fencing and generally have lower water requirements. Replacing them with horses can increase the need for permanent fencing and providing water.	**Funding** • Seek funding to pay for infrastructure
Barrier P: Rooting is a threat to the features of this highly designated site	Rooting by pigs can be a threat to species of conservation concern, especially if present at low abundance.	**Research and knowledge exchange**: • Share knowledge from Trusts already managing this problem • Research to find mitigating strategies where possible
Barrier Q: Managing animal welfare	There was a concern that pigs would require extra levels of management to ensure animal welfare standards are met.	**Research and knowledge exchange:** • Share knowledge from Trusts already managing this problem • Research to find mitigating strategies where possible

5. Case Study 1: Kingcombe Meadows

5.1. Background

Kingcombe Meadows is a 200-hectare nature reserve managed by Dorset Wildlife Trust (DWT). Conservation grazing is used to maintain the species-rich unimproved grassland habitats, that are protected as SSSI, SNCI, SAC, and NNR. Grazing is used to maintain suitable sward height, control scrub, and reduce competitive grasses to maintain floristic diversity. It is currently grazed by cattle, sheep, and a small number of Exmoor ponies.

This case study compares Greenhouse Gas (GHG) emissions from eight grazing scenarios (the current grazing regime and seven potential alternatives). The alternative grazing options are based on using a higher proportion of lower-emitting grazing animals (in this case more ponies and fewer cattle and sheep) or reducing the number of grazing animals through more targeted grazing. The scenarios represent options that would reduce GHG emissions whilst maintaining overarching conservation goals for the site. Scenarios unlikely to achieve these goals are excluded (see **Appendix 1a**). The case study also considers practical barriers to alternative grazing regimes, which were identified through interviews with DWT staff.

5.2. Summary of outcomes

- The case study found that the **highest reductions in GHG emissions (81% reduction) could be achieved by replacing all cattle and sheep with ponies**. However, this was not considered the most ecologically desirable scenario due to the loss of some specific ecological benefits of cattle-grazing.
- Of the alternative options explored, **the most ecologically acceptable was a mixed grazing scenario involving smaller numbers of cattle and sheep, with proportionately more ponies (achieving a 40% reduction in GHG emissions).**
- We conclude that substantial reductions in GHG emissions are feasible whilst maintaining the key conservation goals of the site.

5.3. Site details

Site Name	Kingcombe Meadows
Site Management Organisation	Dorset Wildlife Trust
Site owner	Dorset Wildlife Trust
Address	Kingcombe Meadows, Toller Porcorum, Maiden Newton, Dorset, DT2 0EQ
OS Map Reference	SY 55425 99059
Site Size	199.5 ha
Site Description	"The nature reserve is managed as a working farm, grazed by cows, sheep and Exmoor ponies, without the use of pesticides, artificial fertilisers and other modern agricultural practices. The result is a patchwork of fields of unimproved flower-rich grassland, broken up by thick hedges, streams, ponds, ancient green lanes and wooded areas spreading up the valley either side of the River Hooke. This mosaic of habitats supports a wide range of wildlife." – from Dorset Wildlife Trust website: https://www.dorsetwildlifetrust.org.uk/nature-reserves/kingcombe-meadows
Website	https://www.dorsetwildlifetrust.org.uk/nature-reserves/kingcombe-meadows
Site Leaflet and Map	https://www.dorsetwildlifetrust.org.uk/sites/default/files/2023-02/Kingcombe-Leaflet-2022-FINAL.pdf
Key habitats	• Grasslands (81% of site): neutral, acid, calcareous, fen, purple moor-grass and rush • Woodland (12% of site) • Scrub (7% of site): gorse, hedgerow, native scrub thicket
Designations	• National Nature Reserve (NNR) • Special Area of Conservation (SAC) • Site of Nature Conservation Importance (SNCI) • Site of Special Scientific Interest (SSSI)
Agri-environment funding	The site is currently in a Higher Level Stewardship (HLS) agreement and will soon be entering a new Countryside Stewardship (CS) scheme.
Site access	Public access site with Visitor Centre. There are public footpaths and a bridleway crossing the site, as well as visitor trails within the site (see link to 'Site Leaflet and Map' above). The nearest village is Maiden Newton (4 miles), and the nearest town is Dorchester (11 miles).

5.3.1. Conservation goals for grazing

The key conservation goals for grazing are to maintain the grassland habitats, enhance floristic diversity and prevent scrub encroachment. Specific conservation goals are:

Goal 1	**Scrub control:** Grazing is used to prevent scrub encroachment in the grassland.
Goal 2	**Reduce competitive grass:** Grazing maintains and enhances floristic diversity by reducing dominant grasses and allowing less competitive species to thrive.
Goal 3	**Maintain suitable sward height:** Grazing maintains sward height within the levels required for favourable condition and plant diversity.
Goal 4	**Enhance grassland biodiversity:** Grazing creates a variety of micro-habitats through structural diversity of sward height, creation of bare patches, and presence of dung.

5.3.2. Current grazing animals

Species	Breeds	Number (max. herd size)	Ownership
Cattle (non-dairy)	Angus & Shorthorn	160 (but varies seasonally; down to 90 in winter)	DWT
Sheep	"Easy Care"	160 (but varies seasonally)	DWT
Ponies	Exmoor	12	Exmoor Pony Society (on long-term loan to DWT)

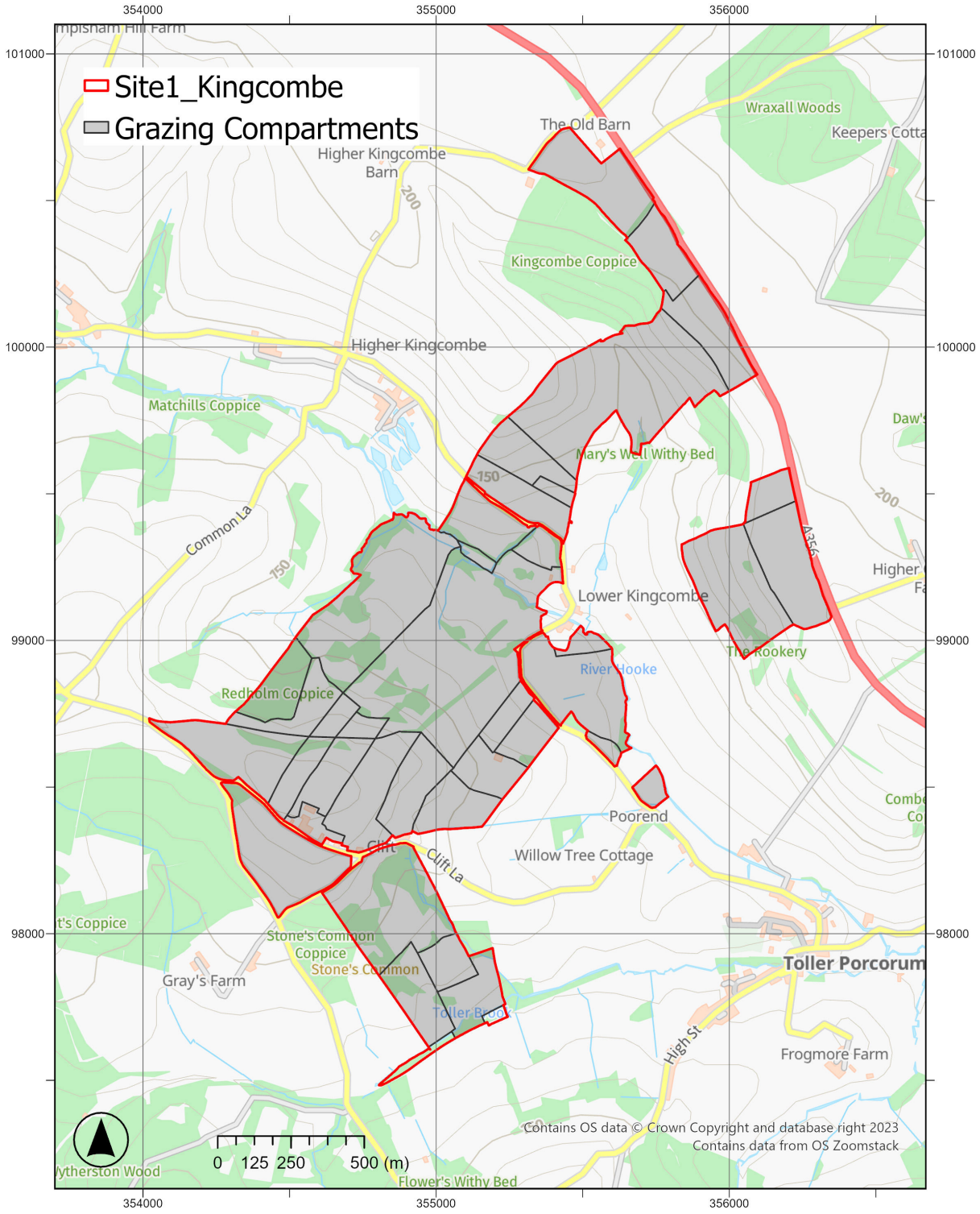

Figure 1: Map of Grazing Compartments at Kingcombe Meadows. Map provided by Dorset Wildlife Trust and presented here with permission.

5.4. Comparison of Grazing Scenarios

Scenario	Annual Grazing Activity (Animal Yrs / Livestock Unit Yrs)	Emissions (t CO_2e / year)		Reduction (vs. current scenario)	Modelled change in warming potential using GWP* (t CO_2we)	Barriers	Scenario Rating
		GWP_{20}	GWP_{100}				
A. Current grazing regime: current numbers of cattle, sheep and ponies.	280.5 animal years 121 LUY (0.61 LU/yr/ha)	963.9	341.2	NA	113.75	NA	**Biodiversity Rating**: High **Carbon Reduction Rating:** Low **Feasibility Rating**: High **Overall Rating:** Acceptable
B1. All ponies: All sheep and cattle replaced by ponies at equivalent Lus.	124 animal years 121 LUY	185.8	71.1	↓ 81%	-1,066.28	Barriers: A, B, C, D, E	**Biodiversity Benefit:** Medium **Carbon Reduction:** Very High **Feasibility:** Medium **Overall:** Acceptable
B2. Ponies for sheep: All sheep replaced by ponies at eq LUs. Cattle unchanged.	165.4 animal years 121 LUY	903.0	319.9	↓ 6%	21.62	Barriers: A, B, D	**Biodiversity:** High **Carbon Reduction**: Low **Feasibility**: Medium **Overall**: Acceptable
B3. Ponies for cattle: All cattle replaced by ponies at eq. Lus. Sheep unchanged.	239.4 animal years 121 LUY	246.7.0	92.5	↓ 74%	-974.15	Barriers: A, B, C, E	**Biodiversity:** Medium **Carbon Reduction:** Very High **Feasibility**: Medium **Overall**: Acceptable
B4. Mixed grazing with more ponies less cattle: 50% of cattle replaced by ponies at eq. LUs. Sheep unchanged.	256.0 animal years 121 LUY	605.3	216.9	↓ 37%	-430.20	Barriers: A, B	**Biodiversity**: High **Carbon Reduction**: High **Feasibility:** High **Overall**: Good
B5. Mixed grazing with more ponies, less cattle and sheep: 50% of cattle and 50% sheep replaced by ponies at eq. LUs.	202.4 animal years 121 LUY	574.8	206.2	↓ 40%	-476.26	Barriers: A, B	**Biodiversity:** High **Carbon Reduction:** High **Feasibility:** High **Overall:** Good
C1. Targeted grazing 10%: Current regime with 10% reduction in cattle and sheep (targeted grazing with collars).	253.7 animal years 110 LUY	869.3	307.8	↓ 10%	-29.14	Barriers: F, G, H	**Biodiversity:** Medium **Carbon Reduction:** Low **Feasibility:** Medium **Overall:** Acceptable
C2. Targeted grazing 20%: Current regime with 20% reduction in cattle and sheep (targeted grazing with collars).	226.8 animal years 99 LUY	774.8	274.4	↓ 20%	-172.02	Barriers: F, G, H	**Biodiversity:** Low **Carbon Reduction**: Medium **Feasibility**: Medium **Overall:** Unfavourable

5.5. Scenario Descriptions

5.5.1. Scenario A (current grazing regime)

Conservation grazing on the site is currently achieved by mixed herds of non-dairy cattle, sheep and ponies. Most of the animals are cattle and sheep (herd sizes of up to 160 of each, with numbers varying seasonally). There are only 12 ponies on site (all Exmoor ponies). The cattle are mixed breeds (predominantly Angus and Shorthorns), and sheep are 'Easy Care' (a Wiltshire cross-breed).

5.5.2. Scenario B1 – B5 (replacing cattle and/or sheep with ponies)

Scenarios B1 to B5 all involve replacing cattle and/or sheep with ponies to varying degrees. The greatest reduction in GHG emissions (81% lower than the current regime) would be achieved by Scenario B1 - replacing all cattle and sheep with ponies of equivalent Livestock Units (LUs). Scenarios B2-B5 involve mixed herds which retain some cattle and/or sheep for their ecological benefits, whilst increasing the proportion of ponies. These scenarios would require around 120 to 240 ponies on the site (depending on the proportional replacement of cattle and sheep).

The main practical barriers to increasing the proportion of ponies on site are:

- Site staff have less experience with ponies compared to cattle and sheep, so there is less understanding of herd behaviour and how large herds of ponies would be managed.
- The difficulty of managing herd size for breeding ponies, particularly as there is no meat market for ponies if numbers become too large.
- The likelihood of very negative public perceptions of culling ponies if that was required.

The main ecological and practical barriers to removing cattle or sheep are:

- The possible loss of some ecological benefits of cattle, due to differences in feeding behaviour, size and dung (which contribute to habitat heterogeneity and micro-habitats).
- Potentially negative visitor reactions to the loss of cattle from the site, as visitors particularly enjoy seeing the cattle.
- The possibility that sheep are better than ponies at grazing steep slopes (due to being lighter on foot and less likely to avoid steep slopes).

The staff member interviewed felt that there would be some ecological consequences from replacing cattle and sheep with ponies, but that the overarching conservation goals of the site might not be detrimentally affected. The creation of latrine areas and grazed lawns by ponies would need to be considered, but these could have both positive and negative impacts.

5.5.3. Scenario C1 and C2 (targeted grazing – reduced cattle and sheep numbers)

Scenarios C1 and C2 involve the use of NoFence collars or other measures to achieve targeted grazing with lower livestock numbers. This could involve spatial targeting of areas most requiring grazing and/or temporal targeting to reduce livestock numbers at times when less grazing is required.

These scenarios are based on the current grazing regime, but with cattle and sheep numbers both reduced by 10% (C1) or 20% (C2). These scenarios allow the ecological benefits of cattle and sheep to be retained, whilst reducing GHG emissions by 10% and 20% respectively.

The main barriers to these scenarios were identified as:

- The high cost of purchasing NoFence collars for large numbers of cattle and sheep (around £200 to £300 per animal plus ongoing subscription and maintenance costs).
- Uncertainty over the extent to which herd reductions would be possible without significant impacts on ecology. 10% reduction was considered achievable, but more substantial reductions were considered unlikely to achieve the desired conservation goals.

Staff also mentioned that seasonal changes in livestock numbers are required to achieve conservation goals. When animals are not grazing the site, they still need to be somewhere and are continuing to emit GHGs. This is not necessarily a barrier to reducing herd size but is a consideration in carbon accounting.

Note: NoFence collars are available for cattle, sheep and goats, but the manufacturer currently has no plans to develop them for horses and ponies.

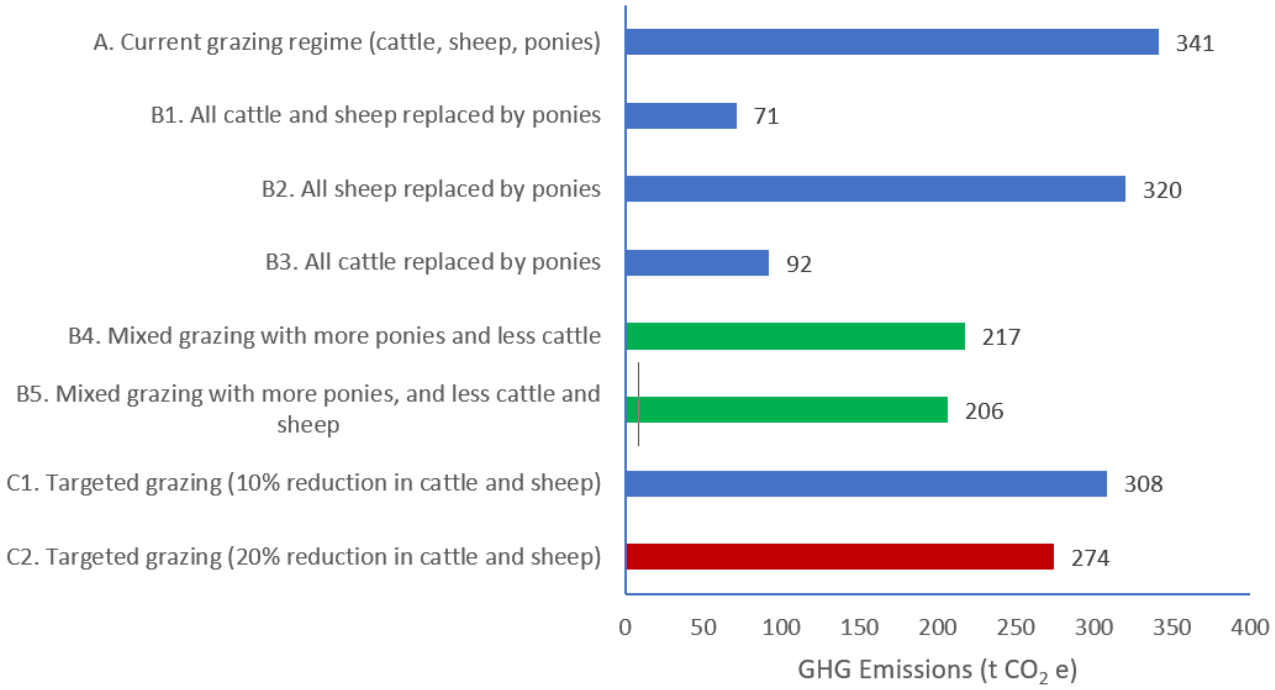

Figure 2: Annual GHG Emissions (t We) from current grazing regime and alternative grazing scenarios at Kingcombe Meadows (using GWP100). Green bars indicate Overall Scenario Rating of 'Good'; blue bars indicate 'Acceptable'; red bars indicate 'Unfavourable''.

5.6. Recommendations

Based on the estimated reductions in GHG emissions, low adverse ecological impacts, and practical feasibility, **Scenarios B4 and B5** are considered the most feasible and desirable of the alternative options. Both scenarios involve increasing the number of ponies and reducing the number of cattle. Both scenarios are likely to cut GHG emissions by around one-third, whilst retaining the ecological benefits of mixed grazing with ponies, cattle and sheep.

If implemented as a long-term change in the ongoing grazing regime at the site, over the next 100 years, these scenarios would deliver an equivalent impact on overall global warming equivalent to removing between 430 and 476 tonnes of CO_2 from the atmosphere during the year in which they were implemented (see 'comparison of grazing scenarios', above).

A gradual and experimental approach would help to overcome the barriers identified, allowing staff to build up their experience whilst assessing ecological impacts and adjusting proportions as required. Such an approach could also incorporate other species of grazing and browsing animals (e.g., goats, water buffalo, traditional pigs, wild boar, deer, bison) that are not specifically considered in the case study scenarios presented here, but which could potentially provide diverse ecological benefits (see **Appendix 1a**).

Appendix 1a

Alternative scenarios not included.

Pigs: The use of pigs for conservation management was discussed in the staff interviews (both wild boar and traditional breeds of domestic pig). Pigs have low methane emissions and can provide a range of ecological benefits (Ramsay et al. 2023). In the staff interviews, wild boar and traditional pig breeds were considered to be potentially beneficial due to their rooting activities. However, this was dependent on the number of pigs and the habitat-specific context. Their potential ecological impacts on grasslands were not sufficiently understood by staff to consider them as replacements to grazing cattle or sheep. However, the staff member interviewed was keen to explore the possibilities for including wild boar and/or traditional pig breeds as part of a more naturalistic mixed grazing approach.

Goats, European bison and water buffalo: The use of alternative species, including goats, bison and water buffalo, was discussed in the staff interviews. They are not included in the case study scenarios as their methane emissions are not likely to be significantly lower than those of sheep and cattle. The staff member interviewed was keen to consider all of these species in the wider context of more naturalistic mixed grazing regimes, and the diverse ecological benefits from a range of grazing animals of differing size, behaviour and styles of grazing and browsing. In terms of GHG emissions, they could potentially play a role in reducing emissions if a mixed herd of diverse grazers and browsers allowed overall stocking density to be reduced. This would require a gradual experimental approach to assess both ecological and GHG impacts of different mixed herd combinations.

Machinery: The use of machinery as an alternative to grazing was discussed in the staff interviews. Machinery was not explored in the case study scenarios as details of GHG emissions from machinery and staff travel are not readily available. The staff member interviewed also expressed the view that entirely replacing grazing animals with machinery would lead to loss of some ecological benefits of large herbivores (such as habitat heterogeneity and micro-habitats created from the variability of animal behaviour, herd movements and dung).

Stop grazing: The option of ceasing grazing and allowing natural succession to occur was not considered as an alternative scenario. This option could be considered in wider ecological and philosophical questions around the ultimate goals of conservation management. However, the specific focus of this case study was to explore alternative scenarios that could achieve similar ecological and biodiversity goals to those of the current management regime. The option to stop grazing entirely was considered to result in ecological outcomes that would be incompatible with current conservation goals.

6. Case Study 2: Birkdale Sandhills

6.1. Background

Birkdale Sandhills is part of 'The Ainsdale and Birkdale Sandhills Local Nature Reserve' in Southport – one of the largest remaining wild dune systems in the UK. The site is particularly important for breeding Natterjack Toads, Sand Lizards, and a variety of scarce plants, including the nationally rare Dune Helleborine. The land is owned by Sefton Council and managed by the Lancashire Wildlife Trust (LWT). The site is composed of 274 hectares of coastal sand dunes (including fixed dunes, dune slacks, dune grassland and scrub). It is a designated Site of Special Scientific Interest (SSSI) and is managed by grazing with English longhorn cattle (from October to April). Grazing is used to reduce scrub and maintain areas of open sand, with the aim of achieving favourable condition.

This case study compares Greenhouse Gas (GHG) emissions from seven grazing scenarios (the current grazing regime and six potential alternatives). The alternative grazing options are based on using a higher proportion of lower-emitting grazing animals (in this case more ponies and pigs and fewer cattle) or reducing the number of cattle through more targeted grazing. The scenarios are based on discussions with LWT staff to identify plausible options. Some options were discussed but not included in the scenarios as they were considered unrealistic for the site conditions and conservation goals (see **Appendix 1b**). The case study also considers practical barriers to alternative grazing scenarios, which were identified through staff interviews.

6.2. Summary of outcomes

- The case study found that the **highest reductions in GHG emissions (86% reduction) could be achieved by replacing all cattle with ponies.** However, this was not considered to be the most ecologically desirable scenario due to the loss of some specific ecological benefits of cattle.
- Of the alternative options explored, **the most ecologically acceptable was a mixed grazing scenario involving smaller numbers of cattle, with proportionately more ponies, pigs and goats (achieving approximately 60% reduction in GHG emissions).**
- Combining this with more targeted grazing could achieve around 67% reduction in GHG emissions.

We conclude that substantial reductions in GHG emissions are feasible whilst maintaining the key conservation goals of the site.

6.3. Site details

Site Name	Birkdale Sandhills
Site Management Organisation	The Wildlife Trust for Lancashire, Manchester & North Merseyside (Lancashire Wildlife Trust)
Site owner	Sefton Council
Address	Birkdale Sandhills, Off Coastal Road, Birkdale, Southport, PR8 2JA
OS Map Reference	SD 31928 15894
Site Size	274 ha
Site Description	"The Ainsdale and Birkdale Sandhills Local Nature Reserve is one of the largest areas of wild dune land left in Britain. It is typical of most sand dune systems with high dune ridges and dune valleys containing slack. Some slacks provide ideal breeding pools for Natterjacks. The reserve is rich in plant life. During the summer months damp slacks are carpeted with flowers including Early-marsh Orchid, Marsh Helleborine and Grass of Parnassus. In drier slacks the Round-leaved Wintergreen and nationally rare Dune Helleborine can be found." – from Sefton Council website: https://www.sefton.gov.uk/around-sefton/coast-countryside/ainsdale-and-birkdale-sandhills-local-nature-reserve.aspx
Website	Ainsdale and Birkdale Sandhills Local Nature Reserve (sefton.gov.uk)
Key habitats	Coastal sand dunes, including: • fixed dune • dune grassland • dune slacks • dune scrub
Designations	• Site of Special Scientific Interest (SSSI)
Agri-environment funding	The site is under a Higher Level Stewardship (HLS) agreement, but this does not restrict livestock choices.
Site access	Public access site with public footpaths. It is adjacent to the seaside town of Southport.

6.3.1. Conservation goals for grazing

Overgrowth of scrub has resulted in the site being in unfavourable condition. Conservation grazing is the primary tool to reduce scrub with the aim of achieving favourable condition for the SSSI. Through direct grazing, animal movements and ground disturbance, the specific goals of conservation grazing are:

Goal 1	**Scrub reduction and control:** The site is already overgrown with scrub. Grazing is used to reduce existing scrub and prevent further scrub encroachment.
Goal 2	**Maintain open sand habitats:** Grazing and trampling by cattle help to maintain and expand areas of open, bare sand. Bare sand habitats are important for a range of species, including burrowing insects, reptiles, amphibians and specialist plants and fungi.
Goal 3	**Reduce above-ground biomass:** Grazing reduces above-ground vegetation allowing more light and space for less competitive dune species.
Goal 4	**Nutrient reduction:** By removing vegetation, grazing helps to reduce soil nutrients. This enhances plant diversity by reducing the dominance of fast-growing competitive species.

6.3.2. Current grazing animals

Species	Breeds	Number (max. herd size)	Ownership
Cattle (non-dairy)	English Longhorn	16 (Oct – April only)	Lancashire Wildlife Trust

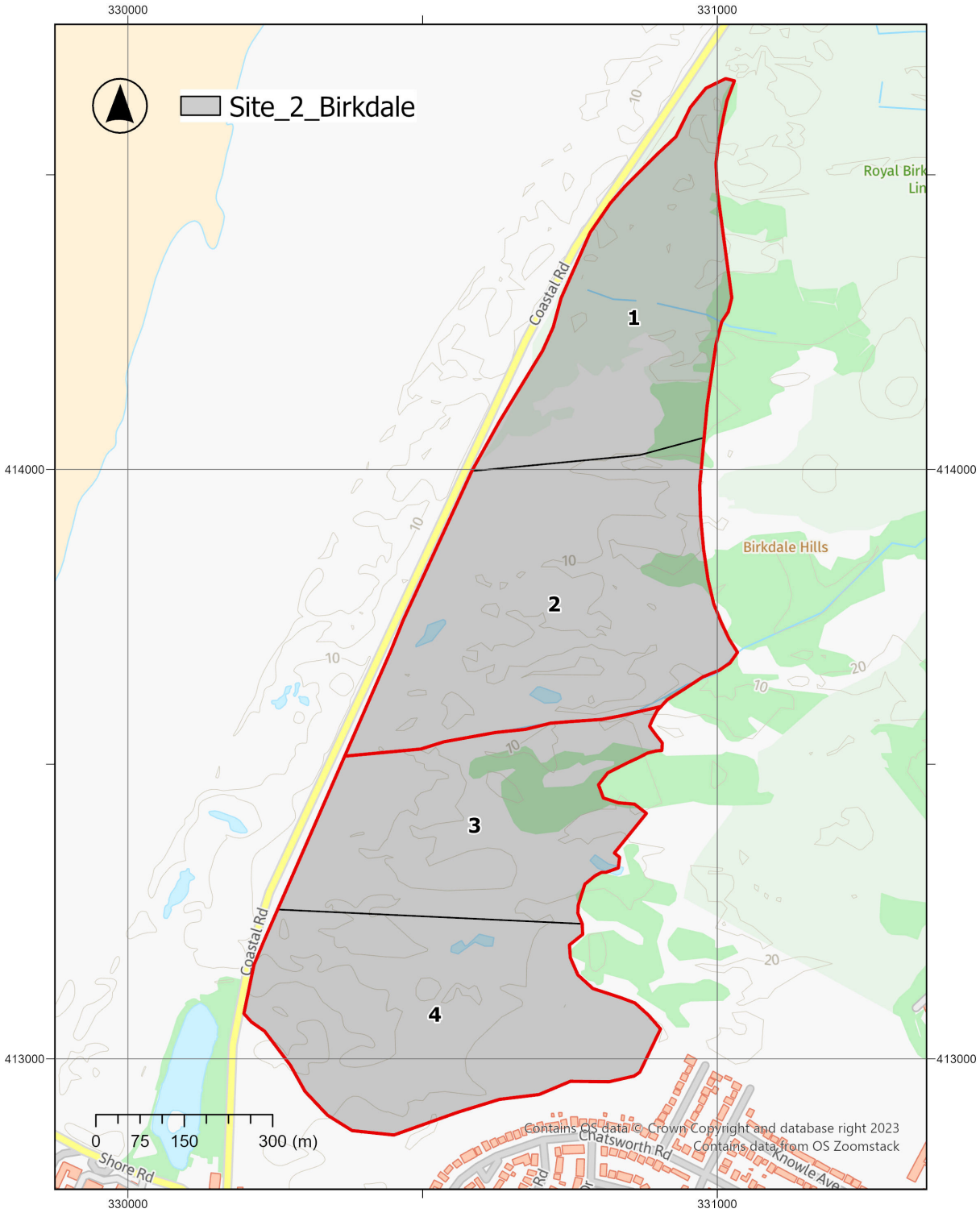

Figure 3: Map of Grazing Compartments at Birkdale Sandhills. Map provided by Lancashire Wildlife Trust and presented here with permission.

6.4. Comparison of Grazing Scenarios

Scenario	Annual Grazing Activity (Animal Yrs / Livestock Unit Yrs)	Emissions (t CO_2e / year)		Reduction (vs. current scenario)	Modelled change in warming potential using GWP* (t CO_2we)	Barriers	Scenario Rating
		GWP_{20}	GWP_{100}				
A. Current grazing regime: (cattle only; 16 longhorn cattle, winter grazing)	9.3 animal years 6.5 LUY (0.02 LU yrs/ha)	58.5	20.7	NA	6.8	NA	**Biodiversity Rating**: High **Carbon Reduction Rating:** Low **Feasibility Rating**: High **Overall Rating:** Acceptable
B1. All ponies: All cattle replaced by ponies at equivalent LUs e.g. 14 ponies	8.1 animal years 6.5 LUY	8.4	3.2	↓ 86%	-69.09	Barriers: A, C, G, K, L	**Biodiversity Benefit:** Low **Carbon Reduction:** Very High **Feasibility:** Medium **Overall:** Unacceptable
B2. Ponies for sheep: All cattle replaced by ponies and goats at eq LUs e.g. 12 ponies, 14 goats	15 animal years 6.5 LUY	13.2	4.8	↓ 77%	-61.82	Barriers: A, C, G, K, L	**Biodiversity:** Medium **Carbon Reduction**: Very High **Feasibility**: Medium **Overall**: Good
B3. Ponies for cattle: All cattle replaced by ponies, goats and pigs at eq. Lus e.g. 11 ponies, 12 goats, 2 pigs	15 animal years 6.5 LUY	11.9	4.4	↓ 80%	-63.75	Barriers: A, C, G, K, L, M	**Biodiversity:** Medium **Carbon Reduction:** Very High **Feasibility**: Low **Overall**: Good
B4. Mixed grazing with more ponies less cattle: 75% of cattle replaced by ponies, goats and pigs at eq. LUs e.g. 4 cattle, 8 ponies, 8 goats, 2 pigs	12.7 animal years 6.5 LUY	23.0	8.3	↓61%	-46.91	Barriers: A, G, K, L, M	**Biodiversity**: High **Carbon Reduction**: Very High **Feasibility:** Medium **Overall**: Good
C1. Targeted grazing 10%: Current regime with 25% reduction in cattle (targeted grazing with NF collars) e.g. 12 cattle	6.9 animal years 4.9 LUY	43.9	15.5	↓ 25%	-15.30	Barriers: G, H	**Biodiversity:** Low **Carbon Reduction:** Medium **Feasibility:** High **Overall:** Unfavourable
C2. Targeted grazing 20%: Mixed grazing (scenario B4) plus 25% reduction in cattle (Scenario C1) e.g. 3 cattle, 8 ponies, 8 goats, 2 pigs	12.1 animal years 6.0 LUY	19.4	7.0	↓ 67%	-52.44	Barriers: A, G, K, L, M	**Biodiversity:** High **Carbon Reduction**: Very High **Feasibility**: Medium **Overall:** Good

6.5. Scenario Descriptions

6.5.1. Scenario A (current grazing regime)

Conservation grazing on the site is currently achieved by a small herd of 16 non-dairy cattle (English Longhorns). They graze Birkdale Sandhills in winter (October to April) and spend the summer grazing other sites.

6.5.2. Scenario B1 – B5 (replacing cattle with ponies, goats and pigs)

Scenarios B1 to B5 all involve replacing some or all cattle with lower-emitting livestock (ponies and pigs). The greatest reduction in GHG emissions (86% lower than the current regime) is achieved by Scenario B1 - replacing all cattle with horses or ponies of equivalent Livestock Units (LUs). Using equivalent LUs, 16 medium beef cattle could be replaced with 14 ponies or 11 medium horses. Scenarios B2 to B4 are mixed herd scenarios involving ponies, goats, pigs and cattle.

The main benefits of mixed grazing were identified as:

- Goats would be particularly beneficial on this site due to their browsing of woody vegetation. However, their GHG emissions are not much lower than cattle. Including pigs and ponies would help to substantially reduce GHG emissions whilst providing some of the ecological benefits of cattle.
- Pigs could provide ground disturbance that would help to create and maintain bare sand.
- Ponies could help to prevent scrub encroachment and maintain bare sand by grazing close to the ground and generating ground disturbance.

The main ecological and practical barriers to replacing cattle with ponies, goats or pigs are:

- Site staff who are less experienced with ponies and pigs compared to cattle, so have less understanding of how these species would be managed.
- Potential difficulties arising from the interaction of ponies, goats and pigs with visitors to the site, and how this could be managed by staff. Use of NoFence collars on goats could help with this, but collars are currently unavailable for ponies and pigs.
- The current absence of farm housing for livestock. Animals are rotated around different sites throughout the year. Housing (or alternative sites) would need to be provided for the ponies, goats and pigs, which could be logistically and financially challenging and cause an increase GHG emission estimates. Alternatively, local graziers could provide the animals at the time needed, but it is more difficult to find local graziers with ponies, pigs and goats.
- The potential for pony latrines to be an ecological problem if they create areas of nutrient enrichment.
- The potential for rooting activity by pigs to interfere with hibernation sites of Natterjack toads and sand lizards – this would need to be researched and managed.

The main ecological and practical barriers to removing cattle are:

- The possible loss of some ecological benefits of cattle, due to differences in feeding behaviour, size and dung (which contribute to habitat heterogeneity and micro-habitats).
- The need for large, heavy grazing animals (currently cattle) to churn up the ground and trample vegetation to create and maintain patches of bare sand (which are particularly beneficial within the dune system). Goats were considered too light to provide sufficient ground disturbance.
- The potential for the sward structure to become more even (less varied) if cattle are replaced with ponies (which are more likely to nibble close to the ground).

6.5.3. Scenario C1 and C2 (targeted grazing – reduced cattle and sheep numbers)

Scenarios C1 and C2 involve the use of NoFence collars or other measures to achieve targeted grazing with lower livestock numbers. This could involve spatial targeting of areas most requiring grazing.

Scenario C1 is based on the current grazing regime, but with cattle reduced by 25%, thus achieving 25% reduction in GHG emissions. Scenario C2 combines Scenario C1 (targeted grazing) with Scenario B4 (mixed grazing with cattle, ponies, goats and pigs). This achieves a 67% reduction in GHG emissions compared to the current grazing regime. Scenarios C2 allows the ecological benefits of cattle to be retained, whilst substantially reducing GHG emissions.

The main barrier to these scenarios were identified as:

- Uncertainty over the extent of herd reduction possible without significant impacts on ecology. The site is already considered 'under-grazed' and is in unfavourable condition. Reducing livestock numbers would require careful targeting where grazing is most needed.
- NoFence collars are more easily broken when worn by horned cattle. Longhorn cattle tend to tussle each other with their horns and the horns can snag and break the bracket of the collars. A supply of spare brackets would be needed for quick replacement when this happens.

Note: NoFence collars are available for cattle, sheep and goats, but the manufacturer currently has no plans to develop them for horses and ponies. The manufacturer has indicated they may develop them for pigs.

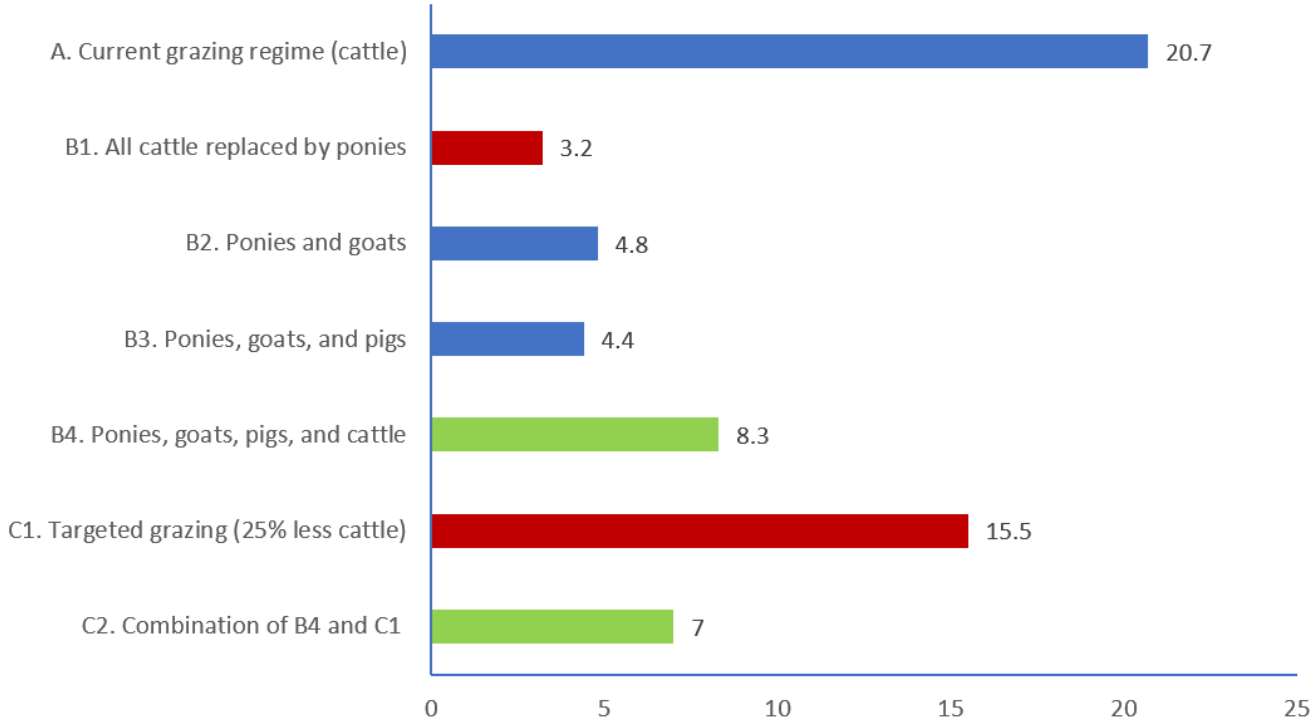

Figure 4: Annual GHG Emissions (t CO_2e) from current grazing regime and alternative grazing scenarios at Birkdale Sandhills (using GWP100). Green bars indicate Overall Scenario Rating of 'Good'; blue bars indicate 'Acceptable'; red bars indicate 'Unfavourable'.

6.6. Recommendations

Based on the estimated reductions in GHG emissions and ecological benefits, **Scenarios B4 and C2** are considered the most desirable of the alternative options. Both scenarios involve reducing the number of cattle and providing a diversity of ecological benefits from a mixed herd of ponies, cattle, pigs and goats. Both scenarios could cut GHG emissions by more than 60%, whilst retaining the processes of grazing, browsing and ground disturbance that are central to achieving the conservation goals of this site.

Managing a mixed herd presents more challenges for staff and visitor interactions. A gradual and experimental approach would help to overcome the barriers identified, allowing staff to build up their experience whilst assessing ecological impacts and adjusting livestock numbers as required. Investment may also be required to provide appropriate animal housing and infrastructure.

Appendix 1b

Alternative scenarios not included in the Birkdale Sandhills Case Study:

European bison: European bison could potentially have ecological benefits in sand dune systems (see https://liferedune.it/2020/04/05/reconstructing-the-dutch-dunes-with-the-european-bison/?lang=). They are not included in the case study scenarios as their methane emissions are not significantly lower than those of cattle. However, it's possible that fewer bison could be required than cattle due to their larger size (this would require further consideration). They would also require extra measures to ensure visitor safety (which could be based on measures already implemented at other European sites with bison).

Machinery: The use of machinery as an alternative to grazing was discussed in the staff interviews. It was felt that machinery would be difficult to use (and easily damaged) on the uneven terrain of a sand dune system and would be unable to access many areas that grazing animals can access. Machinery was also not explored in the case study scenarios as details of GHG emissions from machinery and staff travel are not readily available.

Stop grazing: The option of ceasing grazing and allowing natural succession to occur was not considered as an alternative scenario. The option to stop grazing entirely would be incompatible with conservation goals to restore and maintain the open habitat of the sand dunes.

Methane-reducing Supplements: There was discussion of how supplements could potentially be administered to cattle. Mineral licks are currently provided and could be a potential mechanism for including small-dose supplements such as Bovaer. However, it would be difficult to ascertain how much each cow was consuming, so estimating the impacts on methane emissions would be difficult.

Methane-reducing Masks: The staff member interviewed would consider the possibility of using these masks and would be willing to trial them. They were considered potentially problematic if they could snag on trees and bushes. They might also be broken when longhorn cattle tussle each other with their horns. There was also concern that wearing masks and NoFence collars together could be cumbersome for the cattle and increase risks of snagging.

7. Case Study 3: Old Sulehay

7.1. Background

Old Sulehay nature reserve is composed of 85 hectares of broadleaf woodlands and calcareous grasslands. It is owned and managed by Bedfordshire, Cambridgeshire & Northamptonshire Wildlife Trust (BCNWT). Conservation grazing is focused on the species-rich grasslands, with the key goals of maintaining the grass sward at a suitable height for floristic diversity, maintaining low soil fertility, and preventing scrub encroachment. It is currently grazed by sheep and cattle. Grazing is predominantly in winter (cattle and sheep), but with a lower number of sheep grazing year-round.

This case study compares Greenhouse Gas (GHG) emissions from eight grazing scenarios (the current grazing regime and seven potential alternatives). The alternative grazing options examined are based on using a higher proportion of lower-emitting grazing animals (in this case more ponies and fewer cattle and sheep) or reducing the number of grazing animals through more targeted grazing. The scenarios represent options that would reduce GHG emissions whilst maintaining overarching biodiversity conservation goals for the site. Scenarios likely to fail to achieve these goals are excluded **(see Appendix 1c)**. The case study also considers the practical barriers to alternative grazing scenarios, which were identified through interviews with site staff.

7.2. Summary of outcomes

- The case study found that the **highest reductions in GHG emissions (82% reduction) could be achieved by replacing all cattle and sheep with ponies**. However, this was not considered to be the most ecologically desirable option due to the loss of specific ecological benefits of cattle.
- Of the alternative options explored, **the most ecologically acceptable was a mixed grazing scenario involving smaller numbers of cattle and sheep, with proportionately more ponies (achieving 41% reduction in GHG emissions).**
- Combining this option with targeted grazing (using NoFence collars) to reduce sheep and cattle numbers would probably achieve even greater reductions. We conclude that substantial reductions in GHG emissions are feasible whilst maintaining the key conservation goals of the site.

7.3. Site details

Site Name	Old Sulehay Nature Reserve
Site Management Organisation	BCN Wildlife Trust (Bedfordshire, Cambridgeshire and Northants)
Site owner	BCN Wildlife Trust
Address	Old Sulehay Nature Reserve, Sulehay Road, Yarwell, Northamptonshire, PE8 6PA
OS Map Reference	TL 054 980
Site Size	85 ha
Site Description	"Old Sulehay Forest is a fragment of the ancient Rockingham Forest... Many wild-flowers found here are rare in Northamptonshire, including ploughman's-spikenard, wild thyme, viper's bugloss, common cudweed and yellow-wort. These attract a wide range of butterflies, such as common blue, brown argus and dingy skipper... To maintain the varied habitat structure most of the grassland is grazed with rare-breed sheep and cattle to maintain low soil fertility... It now boasts a variety of native flowers, including cowslips, bird's-foot trefoil, knapweed broomrape and pyramidal orchids." – BCN Wildlife Trust: https://www.wildlifebcn.org/nature-reserves/old-sulehay
Website	https://www.wildlifebcn.org/nature-reserves/old-sulehay
Site Leaflet and Map	https://www.wildlifebcn.org/sites/default/files/2018-05/Old%20Sulehay%20Leaflet.pdf
Key habitats	• Woodland (56% of site): includes SSSI ancient woodland (mix of broad-leaved species including small-leaved lime) • Grassland (38% of site): species-rich calcareous grasslands • Scrub and marsh (5% of site):
Designations	• Site of Special Scientific Interest (SSSI) – the ancient woodland is SSSI.
Agri-environment funding	Higher Level Stewardship (HLS): HK7 (restoration of species-rich, semi-natural grassland), HK16 (restoration of grassland for target species), HLS funding requires the grassland to be managed by grazing to maintain a sward height between 5cm and 15cm during April, May and November.
Site access	Public access. No visitor centre or entry charge. There are public footpaths and a bridleway crossing the site, as well as visitor trails within the site. Dogs are permitted (on leads). The nearest large population centre is Peterborough (10 miles). Visitor numbers are approximately a few thousand per year.

7.3.1. Conservation goals for grazing

The key conservation goals for grazing are to maintain the unimproved grassland habitats, enhance floristic diversity, and prevent scrub encroachment. Specific conservation goals are:

Goal 1	**Scrub control:** Grazing is used to prevent scrub encroachment in the grassland.
Goal 2	**Reduce soil nutrients:** Grazing helps to prevent over-enrichment of soil nutrients, allowing less competitive plants (adapted to low nutrient conditions) to thrive.
Goal 3	**Maintain suitable sward height:** Grazing maintains sward height within the levels required for favourable condition and plant diversity. HLS funding requires specific sward height (between 5cm and 15cm in April, May and November).

7.3.2. Current grazing animals

Species	Breeds	Number (max. herd size)	Ownership
Cattle (non-dairy)	Highland cattle	22 (but varies seasonally)	BCN Wildlife Trust
Sheep	Hebridean Lleyn Mouflon (recently acquired	150 (but varies seasonally)	BCN Wildlife Trust

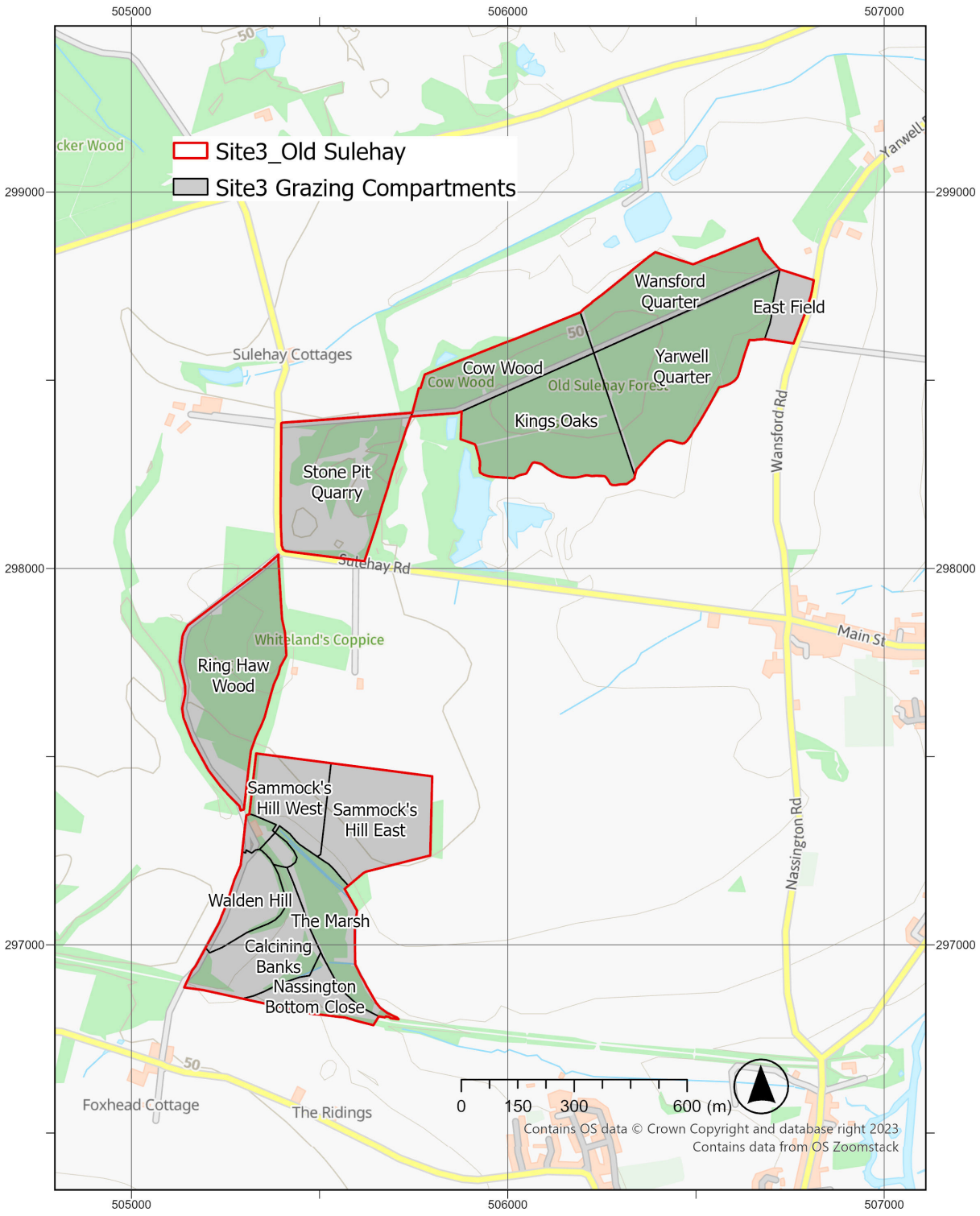

Figure 5: Map of Grazing Compartments at Old Sulehay. Map provided by BCN Wildlife Trust and presented here with permission.

Compartment Grazed	Conservation Goal
Sammocks East	Remove years growth and prevent scrub encroachment of developing limestone grassland.
Sammocks West	Remove years growth and prevent scrub encroachment of developing limestone grassland.
The Marsh	Prevent ragwort, bramble and scrub encroachment
Calcining banks	Remove years growth and prevent scrub encroachment of limestone grassland.
Waldens Hill	Remove years growth and prevent scrub encroachment of developing limestone grassland.
Nassington Bottom Close	Remove years growth and prevent scrub encroachment of limestone grassland.
Stone Pit	Prevent scrub, bramble and clematis developing.
East Field	Control ragwort and scrub.

7.4. Comparison of Grazing Scenarios

Scenario	Annual Grazing Activity (Animal Yrs / Livestock Unit Yrs)	Emissions (t CO_2e / year)		Reduction (vs. current scenario)	Modelled change in warming potential using GWP* (t CO_2we)	Barriers	Scenario Rating
		GWP_{20}	GWP_{100}				
A. Current grazing regime: current numbers of cattle, sheep and ponies.	47.9 animal years 7.8 LUY (7.8 LU yrs/ha)	55.6	19.7	NA	6.64	NA	**Biodiversity Rating**: High **Carbon Reduction Rating:** Low **Feasibility Rating**: High **Overall Rating:** Acceptable
B1. All ponies: All sheep and cattle replaced by ponies at equivalent Lus.	9.77 animal years 7.8 LUY	10.1	3.9	↓ 82%	-62.12	Barriers: A, B, C, D, E	**Biodiversity Benefit:** Medium **Carbon Reduction:** Very High **Feasibility:** Medium **Overall:** Acceptable
B2. Ponies for sheep: All sheep replaced by ponies at eq LUs. Cattle unchanged.	11.4 animal years 7.8 LUY	37.9	13.5	↓ 32%	-20.04	Barriers: A, B, D	**Biodiversity:** High **Carbon Reduction**: High **Feasibility**: Medium **Overall**: Good
B3. Ponies for cattle: All cattle replaced by ponies at eq. LUs. Sheep unchanged.	46.2 animal years 7.8 LUY	27.8	10.1	↓ 50%	-35.44	Barriers: A, B, C, E	**Biodiversity:** Medium **Carbon Reduction:** Very High **Feasibility**: Medium **Overall**: Acceptable
B4. Mixed grazing with more ponies less cattle: 50% of cattle and 50% sheep replaced by ponies at eq. LUs.	28.8 animal years 7.8 LUY	32.9	11.8	↓41%	-27.74	Barriers: A, B	**Biodiversity**: High **Carbon Reduction**: High **Feasibility:** High **Overall**: Good
C1. Targeted grazing 10%: Current regime with 10% reduction in cattle and sheep (targeted grazing with collars).	43.1 animal years 7.0 LUY	50.0	17.8	↓ 10%	-1.75	Barriers: F, G, H, I	**Biodiversity:** Medium **Carbon Reduction:** Low **Feasibility:** Medium **Overall:** Acceptable
C2. Targeted grazing 20%: Current regime with 20% reduction in cattle and sheep (targeted grazing with collars).	38.3 animal years 6.3 LUY	44.5	15.8	↓ 20%	-10.15	Barriers: F, G, H, I	**Biodiversity:** Medium **Carbon Reduction**: Medium **Feasibility**: Medium **Overall:** Good
D. Methane-reducing masks: current regime, but with cattle wearing Zelp masks.	47.9 animal years 7.8 LUY	39.1	13.9	↓ 30%	-18.29	Barriers: to be trialled	**Biodiversity**: High **Carbon Reduction**: High **Feasibility**: Medium **Overall**: Good

7.5. Scenario Descriptions

7.5.1. Scenario A (current grazing regime)

Conservation grazing on the site is currently achieved by Highland cattle and sheep (Hebridean, Lleyn and recently acquired Mouflon). Herd sizes are up to 22 cattle and 150 sheep, but with precise numbers varying seasonally. Grazing is predominantly in winter, with most animals grazing a different site in summer (though there is some year-round sheep grazing).

7.5.2. Scenario B1 – B4 (replacing cattle and/or sheep with ponies)

Scenarios B1 to B5 all involve replacing cattle and/or sheep with ponies to varying degrees. The greatest reduction in GHG emissions (82% lower than the current regime) is achieved by Scenario B1 - replacing all cattle and sheep with ponies of equivalent Livestock Units (LUs). Scenarios B2-B4 involve mixed herds which retain some cattle and/or sheep for their ecological benefits, whilst increasing the proportion of ponies.

The main practical barriers to increasing the proportion of ponies on site are:

- Site staff who are less experienced with ponies compared to cattle and sheep, so have less understanding of herd behaviour and how large herds of ponies would be managed.
- The difficulty of managing herd size for breeding ponies, particularly as there is no meat market for ponies if numbers become too large.
- The likelihood of very negative public perceptions of culling ponies if that was required.

The main ecological and practical barriers to removing cattle or sheep are:

- The possible loss of some ecological benefits of cattle, due to differences in feeding behaviour, size and dung (which contribute to habitat heterogeneity and micro-habitats).
- The possibility that sheep are better than ponies at grazing steep slopes (due to being lighter on foot and less likely to avoid steep slopes).
- The staff member interviewed felt that there would be some ecological consequences from replacing cattle and sheep with ponies, but that the overarching conservation goals of the site might not be detrimentally affected. The creation of latrine areas by ponies would need to be considered, but this could have both positive and negative impacts.

7.5.3. Scenario C1 and C2 (targeted grazing – reduced cattle and sheep numbers)

Scenarios C1 and C2 involve the use of NoFence collars or other measures to achieve targeted grazing with lower livestock numbers. This could involve spatial targeting of areas most requiring grazing.

Scenarios C1 and C2 involve the use of NoFence collars or other measures to achieve targeted grazing with lower livestock numbers. This could involve spatial targeting of areas most requiring grazing and/or temporal targeting to reduce livestock numbers at times when they are less required for grazing.

Scenarios C1 and C2 are based on the current grazing regime, but with cattle and sheep numbers both reduced by 10% and 20% for C1 and C2 respectively. These scenarios allow the ecological benefits of cattle and sheep to be retained, whilst reducing GHG emissions.

The main barriers to these scenarios were identified as:

- The requirement to use livestock at other sites when they are not grazing at Old Sulehay. The minimum herd size needs to be suited to the grazing requirements of other sites that are grazed by the same herds in summer.
- Uncertainty over the extent to which herd reductions would be possible without significant impacts on ecology. Staff felt that herd size could be substantially reduce by targeting specific areas, but quantifying the reduction possible is tricky and would require some trials.

Note: NoFence collars are available for cattle, sheep and goats, but the manufacturer currently has no plans to develop them for horses and ponies.

7.5.4. Scenario D (methane-reducing cattle masks)

Zelp masks are a fairly new invention designed to reduce methane emissions from cattle (by around 50%). The site staff were interested in a trial of these masks. Scenario D has therefore been included as an illustration of how using the masks would affect emissions when used on cattle for the current grazing regime. Practical barriers to the use of the masks have not yet been identified, but staff discussed whether the masks might affect grazing behaviour. There is also uncertainty around the potential embodied GHG emissions associated with production and transport of the masks.

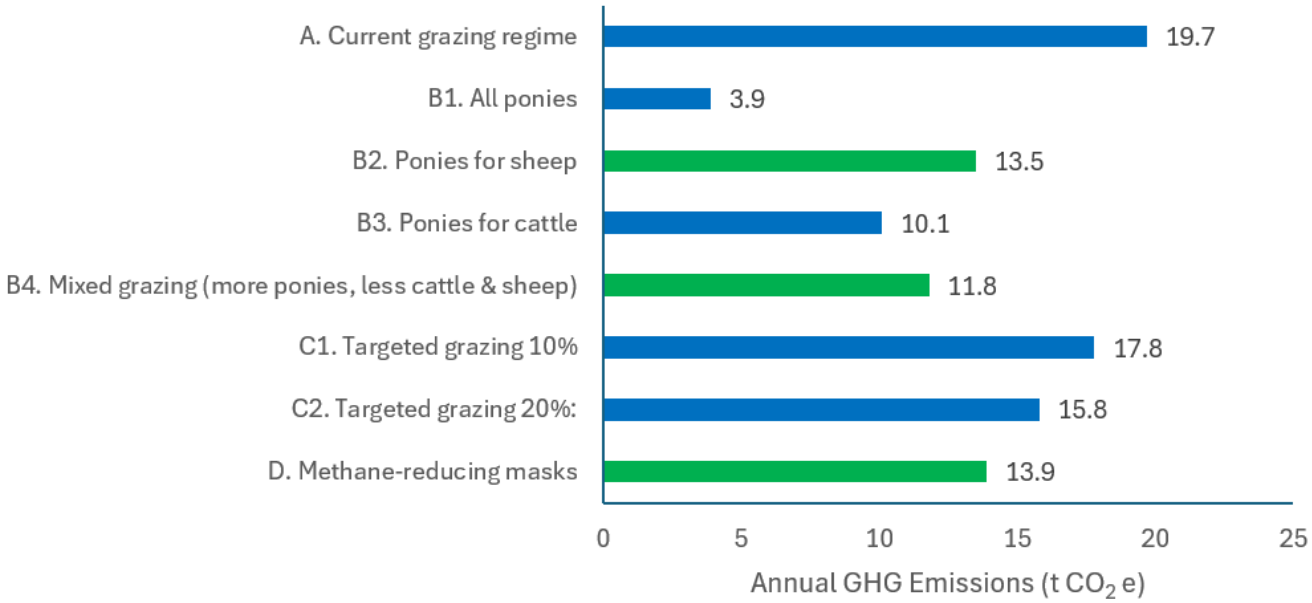

Figure 6: Annual GHG Emissions (t CO_2e) from current grazing regime and alternative grazing scenarios at Old Sulehay (using GWP100). Green bars indicate Overall Scenario Rating of 'Good'; blue bars indicate 'Acceptable'.

7.6. Recommendations

Based on the estimated reductions in GHG emissions and ecological benefits, **Scenarios B2 and B4** are considered the most desirable of the alternative options. Both scenarios involve reducing the number of high-emitting livestock (cattle and/or sheep) and providing a diversity of ecological benefits from a mixed herd of ponies and cattle (with or without sheep). Of these two options, **Scenario B4** would achieve the greatest reduction in GHG emissions (around 40%), whilst retaining the processes of grazing, browsing and ground disturbance that are provided by a mixed herd of cattle, ponies and sheep.

Even greater GHG reductions could be achieved by combining Scenario B4 with targeted grazing (Scenarios C1 and C2) and/or with the use of Zelp masks. A gradual approach, combined with additional staff training, could help to overcome the barriers identified.

Appendix 1c

Alternative scenarios not included in the Old Sulehay Case Study:

Goats, Pigs and European bison: Goats and European bison were not included in the scenarios as their emissions are not much lower than cattle. The option of using pigs was discussed with site staff, but pigs were not considered to be appropriate for the conservation goals of the Old Sulehay grassland habitats. They were, however, being considered for a different nature reserve where pigs were likely to be more suited to the habitats and conservation goals.

Machinery: The use of machinery as an alternative to grazing was discussed in the staff interviews. It was felt that machinery would be unlikely to provide the diverse ecological benefits of grazing animals. Machinery was also not explored in the case study scenarios as details of GHG emissions from machinery and staff travel are not readily available.

Stop grazing: The option of ceasing grazing and allowing natural succession to occur was not considered as an alternative scenario. The option to stop grazing entirely would be incompatible with conservation goals to maintain the grasslands in favourable condition.

Methane-reducing Supplements: There was discussion of how supplements (such as Bovaer) could potentially be administered to cattle. It was considered that this would currently be difficult to administer in the context of free-roaming animals and it would be difficult to ascertain how much each cow was consuming.

8. Case Study 4: Hartington Meadows

8.1. Background

Hartington Meadows is a 33-hectare Derbyshire Wildlife Trust Nature Reserve situated two kilometres from Hartington village, inside in the Peak District National Park. The site is primarily upland unimproved neutral and calcareous grassland. It also includes three disused quarries that have a full representations of successional vegetation communities including bare ground, grassland, scrubland and woodland. Other than being situated within the National Park, the site is not designated. It is an important site for supporting a variety of species of conservation importance, including Biodiversity Action Plan (BAP) species Frog Orchid, Small Heath, Dingy Skipper, Skylark, Bullfinch, Song Thrush and Common Toad. The conservation goals are focused on maintaining the species rich grassland composition, ensuring a diverse sward structure, preventing scrub expanding into grassland, and ensuring food webs associated with the grassland and grazers are maintained. The site is grazed with cattle and sheep in the latter half of the year by a grazier.

The Derbyshire Wildlife Trust are looking to take the grazing of the site back in house. They are revising the grazing regime to better reflect natural processes. In this case study, we explore the Greenhouse Gas (GHG) emissions from eleven grazing scenarios (the current grazing regime and ten potential alternatives). The grazing options explore switching from dairy (Holstein Friesian) to beef (Highland) cattle, reduced stocking rates, switching to lower-emitting large herbivores (Exmoor ponies), reducing the number of cattle stocked by targeting grazing, and combining scenarios.

8.2. Summary of outcomes

- The current stocking densities, set by a grazier but within limits agreed with the Trust, are thought to be higher than needed to achieve the conservation goals.
- It was assessed that **by employing a rotational stocking regime, cattle grazing could be reduced to ~60% of current levels without having a negative impact on the conservation goals**. Cattle would be stocked at approximately half the current stocking density for four years in five and returned to higher stocking levels for the other year. There is a preference to cease sheep grazing altogether. In combination with the switch to Highland cattle, these changes are estimated to reduce GHG emissions by 57%.
- However, **a preferable grazing regime that could reduce emissions by 71% is to reduce cattle grazing to 50% of the current stocking density,** using rotational and targeted grazing, and replace the sheep with pony grazing at eq. LU.
- The scenario with the potential for biggest reduction in emissions (86%) **is to replace all grazing by cattle and sheep with ponies,** but this could have negative outcomes for the conservation goals for the site.

We conclude that substantial reductions in GHG emissions are possible (~71%) while still achieving the nature conservation goals.

8.3. Site details

Site Name	Hartington Meadows
Site Management Organisation	Derbyshire Wildlife Trust
Address	Hartington, near Ashbourne, Derbyshire, SK17 0AZ
OS Map Reference	SK156211
Site Size	Total size: 33 ha Grazed area: 26 ha
Site Description	"Hartington Meadows is bursting with the colour of wild flowers through the summer. The grassland is managed as part of a working farm, and is cut for hay in mid-July - this encourages meadow flowers such as hay rattle and meadow vetchling. Different flowers grow on the rock outcrops - among them are clustered bellflower and dropwort. The rough grassland also provides breeding sites for skylark and ground-nesting birds. Various orchids and other limestone flowers thrive in and around the disused limestone quarry, while its faces provide breeding sites for cliff-nesting birds such as kestrel and jackdaw"
Website	https://www.derbyshirewildlifetrust.org.uk/nature-reserves/hartington-meadows
Key habitats	• Neutral grassland • Calcareous grassland
Designations	• None
Agri-environment funding	High Level Stewardship
Site access	Public footpaths across it. Tissington Trail – multi-use.

8.3.1. Conservation goals for grazing

The underlying rock is primarily carboniferous limestone, but there is also deposited sand, silt and clay. The site is primarily important for its neutral and calcareous grassland community. Part of the site is an old mine where the soil was cleared and left, creating low nutrient conditions that are supporting species rich grassland. The surrounding area is primarily used for dairy farming. The site has been well surveyed for vascular plants, birds, amphibians, and Lepidoptera, but non-vascular plants, small mammals, reptiles, fungi and other invertebrates have not been extensively surveyed. Frog Orchid, Small Heath, Dingy Skipper, Skylark, Bullfinch, Song Thrush and Common Toad are BAP species that have been recorded on the site. Frogs, smooth newts and great crested newts are also present in good numbers and a conservation consideration.

Goal 1	**Maintain grassland species richness and composition:** The site is of conservation importance for its unimproved meadow grassland, supporting species such as Adder's Tongue, Dropwort, Fragrant Orchid and Frog Orchid. Grazing is used to help maintain floral and associated species richness and composition and avoid rank sward becoming dominant.
Goal 2	**Maintain a diverse sward structure:** Grazing is used to create patches of closely cropped grassland along with areas of tufted grassland that is important for sheltering species such as great crested newt.
Goal 3	**Prevent scrub from establishing:** Prevent scrub establishing on the unimproved grassland.
Goal 4	**Maintain food webs:** Ensure food-web associated with dung are maintained, particularly from cattle.

8.3.2. Current grazing animals

A grazier grazes the site between the 15th of June and the 31st of December. The grazing agreement requires at least 10 cattle to be grazed, and up to 20 cattle and 40 sheep. The cattle are 2-3 year-old Holstein Friesian that will be used for diary production. The Sheep are a Texel x Swaledale mule. The grazier typically grazes at or close to the maximum allowance.

Species	Breeds	Number (max. herd size)	Ownership
Cattle (Pre-Dairy)	Holstein Friesian	20	Grazier
Sheep	Texel x Swaledale	40	Grazier

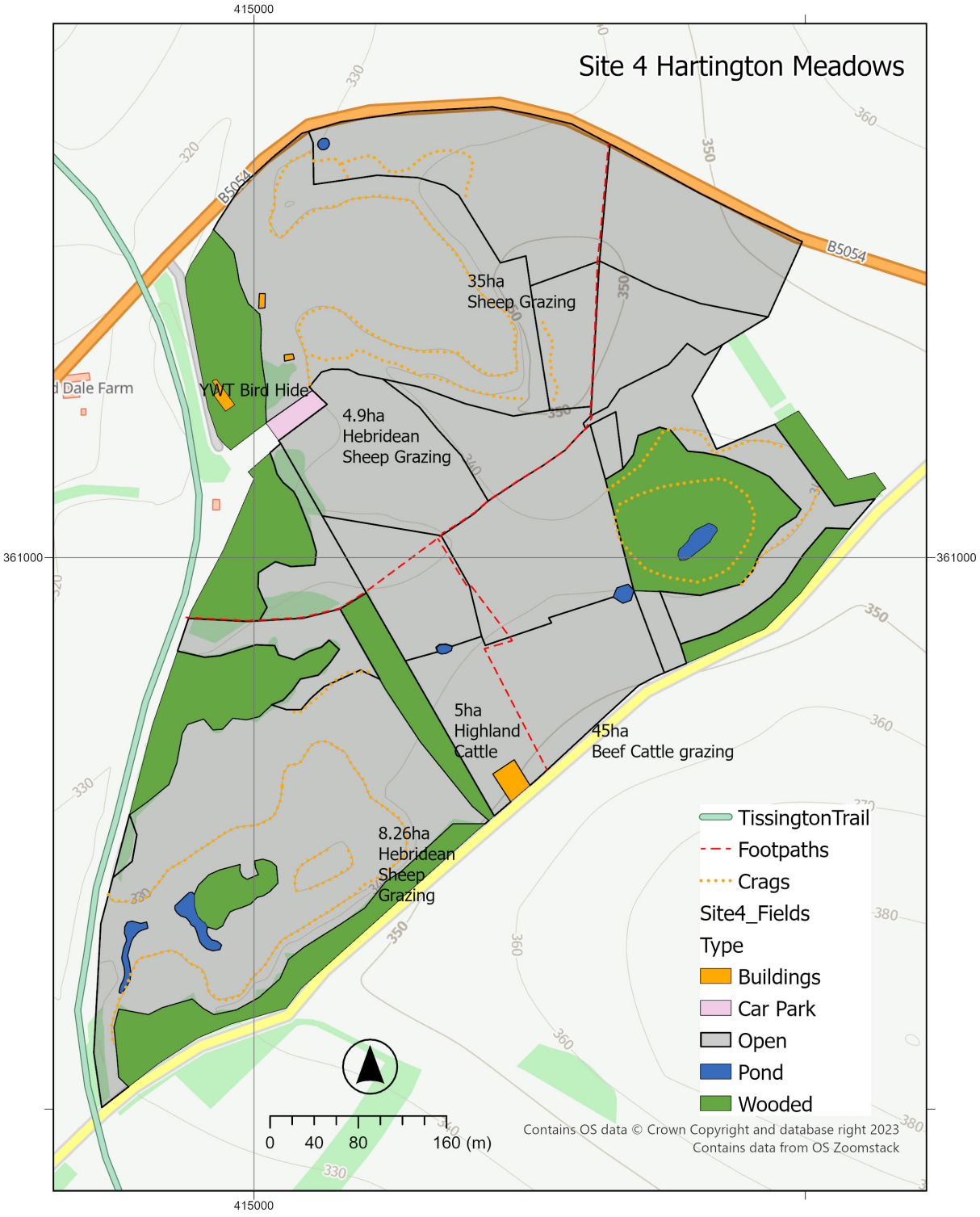

Figure 7: Map of Hartington Meadows. Map provided by Derbyshire Wildlife Trust and presented here with permission.

8.4. Comparison of Grazing Scenarios

Scenario	Annual Grazing Activity (Animal Yrs / Livestock Unit Yrs)	Emissions (t CO_2e / year)		Reduction (vs. current scenario)	Modelled change in warming potential using GWP* (t CO_2we)	Barriers	Scenario Rating
		GWP_{20}	GWP_{100}				
A. Current grazing regime: (cattle, sheep)	33 animal yrs 10.9 LU yrs (0.42 LU yrs/ ha)	104.23	37.79	NA	13.51		**Biodiversity Rating**: Medium **Carbon Reduction Rating:** NA **Feasibility Rating**: High **Overall Rating:** Unfavourable
B1. Reduce cattle stocking rate: Reduce cattle stocking to 60% of current	28 animal yrs 6.11 LU yrs	45.22	16.03	↓ 57%	-74.99		**Biodiversity:** High **Carbon Reduction:** High **Feasibility: High** **Overall:** Good
B2. Reduce sheep stocking rate: Remove sheep	11 animal yrs 6.54 LU yrs	53.81	19.00	↓ 48%	-61.95		**Biodiversity:** Medium **Carbon Reduction**: Low **Feasibility**: High **Overall**: Acceptable
B3. Reduce cattle and sheep stocking: Reduce cattle stocking to 60% and remove sheep	7 animal yrs 3.93 LU yrs	3.93	32.28	↓ 69%	-94.49		**Biodiversity:** High **Carbon Reduction:** High **Feasibility:** High **Overall:** Good
C1. Replace cattle and sheep with ponies/ horses: 100% of cattle & sheep replaced by ponies at eq. LUs.	14 animal yrs 10.90 LU yrs	14.21	5.44	↓ 86%	-122.15	Barriers: C, D	**Biodiversity:** Medium **Carbon Reduction**: Very High **Feasibility**: High **Overall:** Acceptable
C2. Mixed grazing with more ponies and less cattle and sheep: 50% of cattle & sheep replaced by ponies at eq. LUs.	23 animal yrs 9.81 LU yrs	40.47	14.53	↓ 61%	-82.30		**Biodiversity:** High **Carbon Reduction:** High **Feasibility:** High **Overall:** Good
C3. Mixed grazing with more ponies and less cattle & sheep: 20% of cattle & sheep replaced by ponies at eq. LUs.	29 animal yrs 9.16 LU yrs	56.23	19.99	↓ 46%	-58.39		**Biodiversity:** High **Carbon Reduction:** Medium **Feasibility:** High **Overall:** Acceptable
C4. Mixed grazing with more ponies and less cattle & sheep: 10% of cattle & sheep replaced by ponies at eq. LUs.	31 animal yrs 8.94 LU yrs	61.49	21.81	↓ 41%	-50.42		**Biodiversity:** High **Carbon Reduction:** Low **Feasibility:** High **Overall:** Acceptable
C5: Mixed grazing with more ponies & less sheep: 100% of sheep replaced by ponies at eq. LUs.	14 animal yrs 8.72 LU yrs	56.65	20.08	↓ 46%	-57.72		**Biodiversity:** High **Carbon Reduction:** Low **Feasibility:** High **Overall:** Acceptable
D.1 Methane-reducing masks: current regime, but with cattle wearing Zelp masks.	32 animal yrs 8.07 LU yrs	61.36	21.73	↓ 41%	-50.58		**Biodiversity**: High **Carbon Reduction**: Low **Feasibility**: Medium **Overall**: Acceptable
E1: Combination of Scenarios B1, C5 and D1: Reduce cattle stocking density to 50% (through reduced stocking rate B1 and targeted grazing D1) and replace sheep with horse at eq. LUs.	8 animal yrs 5.45 LU yrs	29.74	10.59	↓ 71%	-98.40		**Biodiversity**: High **Carbon Reduction**: Very High **Feasibility**: High **Overall:** Good
F1. Naturalistic grazing, very high density	15 animal yrs 4.5 LU yrs	24.94	9.02	↓78%	-121.45	NA	NA
F2. Naturalistic grazing, average density	0.49 animal yrs 0.15 LU yrs	0.82	0.30	↓ 99%	-157.74		
F3 Naturalistic grazing, low density	0.02 animal yrs 0.01 LU yrs	0.03	0.01	↓ 100%	-158.94		

8.5. Scenario Descriptions

The Derbyshire Wildlife Trust intend to take the grazing back into in house management. They intend to implement more naturalistic grazing using Highland cattle and Exmoor ponies. All the alternative scenarios (B-E) assume the 2-3 year-old Holstein Friesian dairy cattle currently being grazed will be replaced with Highland beef cattle with implications for the calculated GHG emissions.

8.5.1. Scenario A (current grazing regime)

The site is currently grazed a grazier with between 10 to 20 Holstein Friesian 2-3 year-old dairy cattle and up to 40 Texel x Swaledale sheep between the 15th of June and the 31st of December. The grazier typically grazes at or the near the maximum level (20 cattle and 40 sheep). The cattle are pre-lactation but are assumed to be pregnant and so classified as small dairy cattle for the GHG emission calculations. While the site is made up of compartments with fields separated by drystone walls, the gates are typically left open giving the livestock free access to the whole 26 ha grazing area. Because of the use of dairy cattle, the current grazing regime has very high GHG emissions. Assuming that switching to beef cattle or ponies doesn't increase the total number of large herbivores in the region, selecting an alternative grazing regime is recommended.

8.5.2. Scenario B1 – B3 (reducing the stocking rate)

Scenarios B1 to B3 explore reducing the stocking rate. It is currently felt that applying the maximum stocking rate (20 cattle and 40 sheep) every year is more grazing than is needed to achieve the conservation goals, and that a varied stocking would be better suited to achieve the conservation goals. The Trust is seeking to implement more naturalised grazing regimes by implementing pulsed grazing by rotating stocking densities on a 5-year cycle and removing sheep. In addition to switching from dairy to beef cattle (applied to all alternative grazing Scenarios), Scenario B1 involves reducing the cattle stocking density to 60% of current levels by stocking at 10 cattle for four in five years and returning the stocking density to higher levels for the remaining year. Scenario B2 considers keeping cattle grazing at current stocking levels but removing all sheep grazing. While Scenario B3 is a combination of B1 and B2. The main concern with these scenarios is that removing sheep will reduce the amount of very short (grazing lawn) sward, with negative impacts on some species.

8.5.3. Scenario C1 and C5 (replacing cattle and/or sheep with ponies)

Scenarios C1 to C5 explore switching cattle and/or sheep grazing to grazing with Exmoor ponies at equivalent LUs. C1 is a complete switch removing all cattle and sheep and implementing grazing with ponies only. However, there is a concern that this will lose some of the beneficial effects of the grazing that cattle provide in creating diverse vegetation sward structure and supporting food webs from their dung. Scenarios C2-C4 explore reducing cattle and sheep grazing by 50, 20, and 10% respectively and replacing the grazing with equivalent pony grazing. This has potential for increases in biodiversity by diversifying the grazing regime, however, the Trust's preference is to remove sheep grazing entirely. Scenario C5 explores keeping the cattle density the same and replacing all sheep grazing with pony grazing, with the anticipation that pony grazing will offer similar conservation outcomes.

8.5.4. Scenario D1 (targeted grazing)

Scenario D1 takes advantage of the Trust's Highland cattle being trained with NoFence collars that can allow targeted grazing on site allowing the conservation goals to be achieved with fewer cattle. The Trust estimate this could reduce the stocking density required by 10%.

8.5.5. Scenario E1 (combination scenario)

Scenario E1 combines scenarios B1, C5, and D1. On top of switching from young Holstein Friesian dairy cattle to Highland cattle the cattle stocking density is reduced by 50% (combining the 5-year rotational grazing regime and the targeted grazing using No Fence collars). The sheep grazing is switched to pony grazing at equivalent LUs. Because the Trust is already investing in purchasing its own livestock, has bought NoFence collars and trained their herd in their use, and has developed the infrastructure and experience needed to employ these grazing practices no major barriers are foreseen.

Note: NoFence collars are available for cattle, sheep and goats, but the manufacturer currently has no plans to develop them for horses and ponies.

8.5.6. Scenarios F1 – F3 (comparison to an estimated range of 'natural' grazing levels)

Wild large herbivorous mammals are a natural part of most ecosystems. Until relatively recently, these have had a largely ubiquitous presence on most continents over the last 40 million years. As a result of the Pleistocene megafauna extinction and subsequent dramatic decline in the remaining wild large herbivores, Britain has a considerably impoverished wild large herbivore assemblage. Deer species, including some introduced species, are essentially the only wild large herbivores that remain.

With no part of Britain unimpacted by people, it is difficult to assess what could be considered a natural assemblage and density of wild large herbivores. Making such an assessment would allow comparisons of GHG emissions from conservation grazing as a management approach with emissions associated with naturally occurring large herbivores. As a way of offering a broad comparison, we have compared the current conservation grazing scenario with the emissions estimates from the range of large herbivore biomass densities that have been calculated for the Net Primary Productivity of the site based on data recorded from

protected areas around the world. These are presented as very low, average and very high biomass density estimates. We then calculate the GHG emissions if this biomass density was entirely made up of deer. These estimates are aiming to provide a very broad comparison to consider and reflect upon in the knowledge of the considerable uncertainty and limitations in the data available to assess wild herbivorous mammal densities.

These estimates have been sourced from this published research: https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.14047

The current stocking level of 10.9 LUY is nearly 2.5 times greater than the estimated very high natural densities of large herbivores. The very high natural density estimate is predicted to have 78% lower GHG emissions than the current grazing regime.

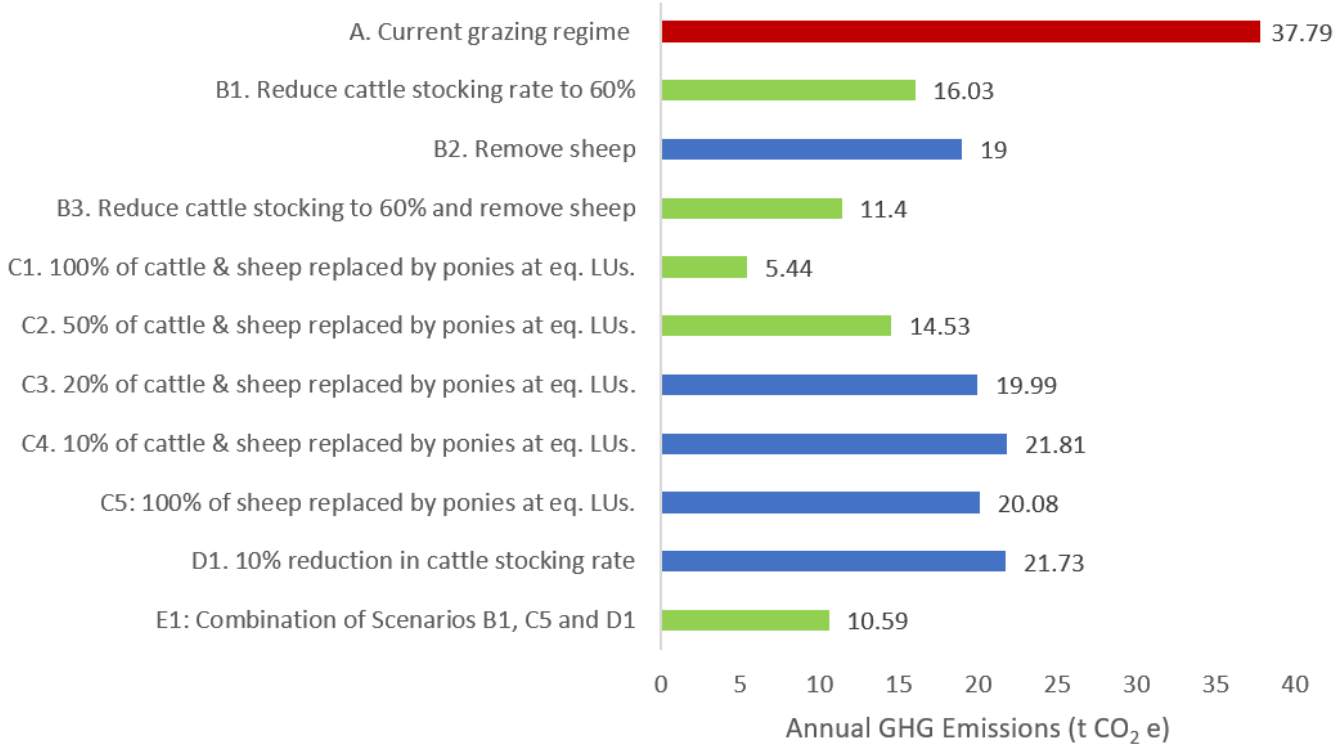

Figure 8: Annual GHG Emissions (GWP100 t CO_2e) from current grazing regime and alternative grazing scenarios at Hartington Meadows (using GWP100). Green bars indicate Overall Scenario Rating of 'Good'; blue bars indicate 'Acceptable'; red bars indicate 'Unfavourable'.

8.6. Recommendations

Based on the estimated reductions in GHG emissions, positive ecological impacts, and practical feasibility, **Scenario E1** is considered the most desirable grazing plan. This scenario combines switching from dairy to beef cattle, reducing cattle stocking by 50% by implementing targeted and rotational grazing, and switching sheep to pony grazing. This could reduce emissions by 71%, while also maintaining grazing to achieve the conservation goals.

Any changes made to the grazing should be monitored to allow adaptive management to ensure conservation goals are being considered. There is also interest in considering additional strategies such as applying emission reducing supplements. However, there is a need to have considerable confidence of the benefits and feasibility of application in a conservation setting is proven before they are trialled.

Appendix 1d

Alternative scenarios not included

Goats, Pigs and European bison: Goats and European bison were not included in the scenarios as their emissions are not much lower than cattle. The option of using pigs was discussed with site staff, but pigs were not considered to be appropriate for the conservation goals of the Old Sulehay grassland habitats. They were, however, being considered for a different nature reserve where pigs were likely to be more suited to the habitats and conservation goals.

Machinery: The use of machinery as an alternative to grazing was discussed in the staff interviews. It was felt that machinery would be unlikely to provide the diverse ecological benefits of grazing animals. Machinery was also not explored in the case study scenarios as details of GHG emissions from machinery and staff travel are not readily available.

Stop grazing: The option of ceasing grazing and allowing natural succession to occur was not considered as an alternative scenario. The option to stop grazing entirely would be incompatible with conservation goals to maintain the grasslands in favourable condition.

Methane-reducing Supplements: There was discussion of how supplements (such as Bovaer) could potentially be administered to cattle. It was considered that this would currently be difficult to administer in the context of free-roaming animals and it would be difficult to ascertain how much each cow was consuming.

9. Case Study 5: Wheldrake Ings

9.1. Background

Hartington Wheldrake Ings is a Yorkshire Wildlife Trust Nature Reserve that lies within the Derwent Valley. It is 157ha in size and made up of lowland meadow and pasture, wetlands and scrubland. The site is protected as a Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar Site, and National Nature Reserve (NNR). Six areas within the reserve (98ha in total) are grazed by either sheep or cattle in the autumn. The site is grazed to reduce nutrient levels, create structural diversity in the sward, and prevent succession in some places. Wheldrake Ings and the wider protected area in the Lower Derwent Valley is of considerable conservation importance for its breeding birds, vascular plants, and invertebrates, including an outstanding dragonfly assemblage.

9.2. Summary of outcomes

- The case study found that the **highest reductions in GHG emissions (an estimated 80%+ reduction) could be achieved by replacing all cattle and sheep with ponies.** However, this was not considered to be the most ecologically desirable scenario due to the loss of some specific ecological benefits because of the differences with the way ponies and cattle graze.

- Of the alternative options explored, **the most ecologically acceptable was a mixed grazing scenario involving smaller numbers of cattle and sheep, with proportionately more ponies (achieving between an estimated reduction in GHG emissions of between 8 and 40%).**

We conclude that substantial reductions in GHG emissions are possible, but the implications for biodiversity and the key conservation goals of the site would need to be monitored with changes implemented gradually.

9.3. Site details

Site Name	Wheldrake Ings
Site Management Organisation	Yorkshire Wildlife Trust
Address	Ings Lane, York, North Yorkshire, YO19 6AX
OS Map Reference	SE 69404 44411
Site Size	Total size: 157 ha Grazed area: 98.16 ha
Site Description	"A peaceful reserve with one linear route along the edge of the meadow. In winter the reserve is often flooded but hosts flocks of thousands of overwintering waders and wildfowl. In summer, lowland waders and farmland birds nest here and make the most of rich supply of insects"
Website	https://www.ywt.org.uk/nature-reserves/wheldrake-ings-nature-reserve
Key habitats	• Lowland meadow and pasture (78%) • Scrubland (16%) • Wetlands (6%) Neutral grassland (mostly MG4, MG7, MG8, and with some S5 and S28) covers 121.6 ha of the site. The scrubland occurs predominantly around the ungrazed boundary, as well as in the coppiced willow adjoining the main pool and on the banks of the former river channel. The wetland is made up of a pool, scrapes, large ditches, reedbeds and the river Derwent.
Designations	• Site of Special Scientific Interest (SSSI) • Special Area of Conservation (SAC) • Special Protection Area (SPA) • Ramsar Site • National Nature Reserve (NNR)
Agri-environment funding	The site has agri-environment funding and is currently in a Higher Tier scheme (2010-present, £47,000 a year). An application for Countryside stewardship Higher tier is planned for 2024.
Site access	Access: "Only accessible on foot along newly surfaced loose stone track. Kissing gate is not special access. This site is a natural floodplain and in winter floods from the river." Walking trails: Permissive footpaths. The paths are level, but muddy after wet weather. Keep to footpaths as there are areas of deep water. The ground is often soft and slippery. Dogs: "No dogs permitted" Grazing: No public access on grazed land

9.3.1. Conservation goals for grazing

The grassland is the target of the conservation grazing, with the wetland area only occasionally grazed and the scrubland left ungrazed. The wetter National Vegetation Classification (NVC) communities are cut for hay and then aftermath grazed with cattle, while the mesotrophic grasslands (MG) communities are largely grazed by sheep.

Goal 1	**Maintaining nutrient levels for MG4 floodplain,** grazing is used to help reduce the nutrient levels while also creating habitat structure and supporting invertebrate populations that help feed autumn migrant birds and spring breeding waders.
Goal 2	**Achieving a sward height of 5-15cm by November,** while the hay cut reduces the nutrients there is usually not enough regrowth for the farmers to find a second cut cost effective. To achieve the HLS sward height target aftermath grazing of the regrowth is used to take the sward down prior to flooding. Sheep are primarily used because local stock availability and their lower water requirements. However, where possible there is a desire and requirement to use cattle. Some fields do not get aftermath grazing either due to lack of stock or impracticality of grazing the fields due to lack of water supply.
Goal 3	**Holding some of the rougher swamp vegetation back:** there is an ongoing effort to stop areas of the species-rich meadows reverting to swamp. This requires the farmers to cut and remove those areas to stop a yearly expansion. In particularly wet years, including 23/24, this becomes particularly difficult as the low value of the crop plus poor ground conditions for vehicles leads to larger areas being left that only grazing can help to redress part of the problem.
Goal 4	**Creating a tussocky vegetation structure,** the purpose of using the cattle grazing in the wetter areas on the east of the site is to open up the Glyceria and Phalaris dominated areas that have been cut to create a more suitable tussocky habitat for the snipe and redshank to breed in those areas the following spring.

9.3.2. Current grazing animals

Species	Breeds	Number (max. herd size)	Ownership
Sheep	Meatlinc	150	Grazier
Sheep	Hebridean	300	Wildlife Trust
Cattle	Stabiliser	28	Grazier
Cattle	Highland	5	Wildlife Trust

9.3.3. Grazing areas

Wheldrake Ings is divided into 6 grazing areas, which cover a total area of 98.16ha of the 156 ha. Additional water supply and stock availability would increase the grazed area.

Grazed area	Area (ha)	Main habitat	Conservation goals
Main Meadow	35	Species rich neutral floodplain	1, 2, 3
Tower Hide	4.9	Species rich neutral floodplain but with wetter swamp communities at the downstream end	1, 2, 3
The Refuge	8.26	Less spp rich floodplain wetter with more swamp spp	1, 2, 3
North Hills	45	Mix of spp rich & less spp rich floodplain meadow	1, 2, 3
Windpump Ings	5	Mix of spp rich & less spp rich floodplain meadow	1,2,3,4
Total	98.16		

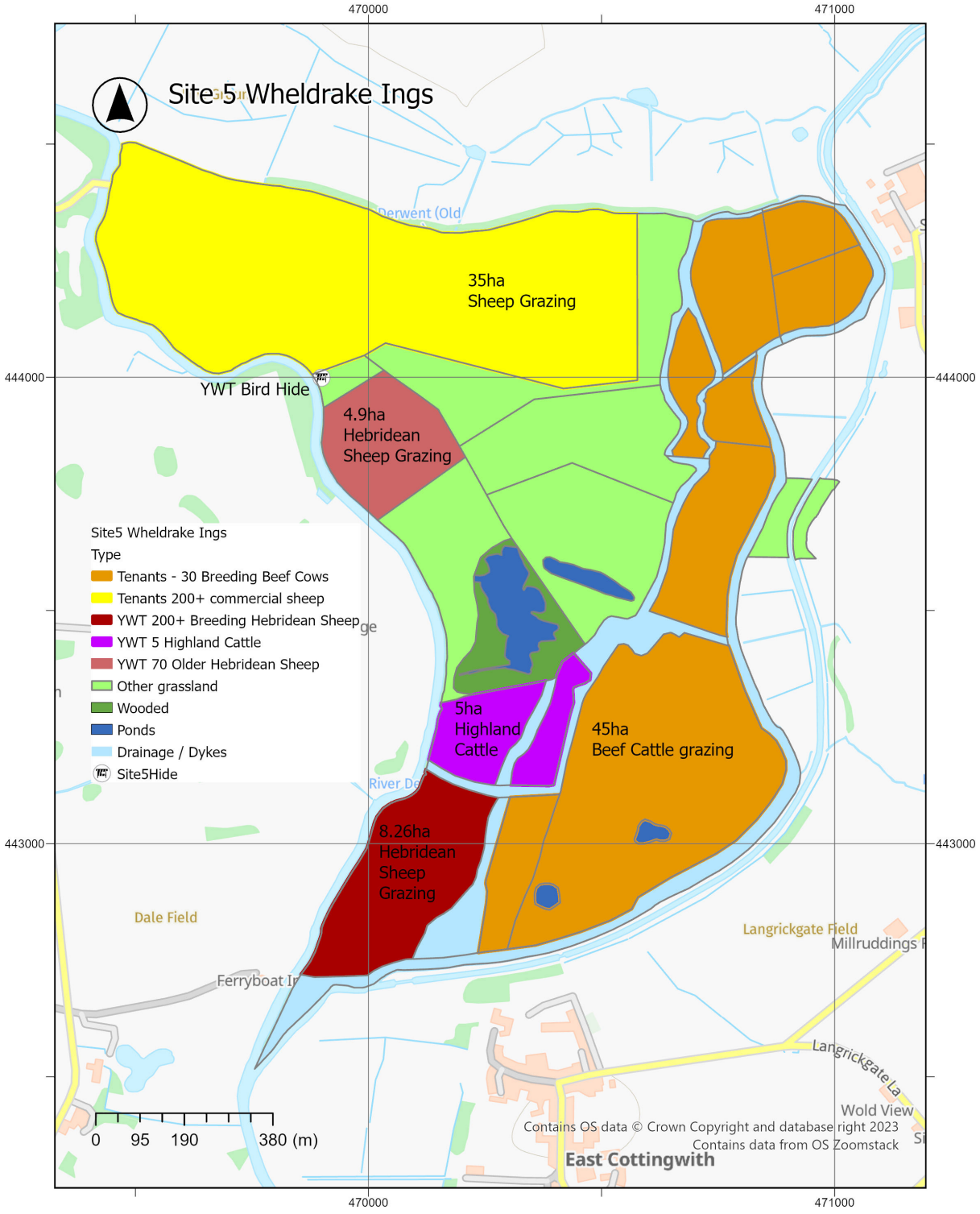

Figure 9: Map of Grazing Compartments at Wheldrake Ings. Map provided by Yorkshire Wildlife Trust and presented here with permission.

9.4. Comparison of Grazing Scenarios

Scenario	Annual Grazing Activity (Animal Yrs / Livestock Unit Yrs)	Emissions (t CO_2e / year)		Reduction (vs. current scenario)	Modelled change in warming potential using GWP* (t CO_2we)	Barriers	Scenario Rating
		GWP_{20}	GWP_{100}				
A. Current grazing regime: (cattle, sheep)	Total: 94.88 animal years (14.21 LU yrs) Cattle: 10.2 Sheep: 84.7	103.89	36.9	NA	12.42	NA	**Biodiversity Rating**: High **Carbon Reduction Rating:** NA **Feasibility Rating**: High **Overall Rating:** Acceptable
B1. Replace cattle and sheep with ponies/horses: 100% of cattle & sheep replaced by ponies at eq. LUs.	Total: 16.54 (14.21 LU yrs) Ponies: 16.5	19.79	7.58	↓ 81%	-115.03	Barriers: A, C, K, N, O	**Biodiversity:** High **Carbon Reduction:** High **Feasibility: High** **Overall:** Good
B2. Mixed grazing with more ponies and less cattle and sheep: 50% of cattle & sheep replaced by ponies at eq. LUs.	Total: 55.71 (14.21 LU yrs) Cattle: 5.1 Sheep: 42.3 Ponies: 8.3	61.84	22.24	↓ 40%	-51.31		**Biodiversity:** Medium **Carbon Reduction**: Low **Feasibility**: High **Overall**: Acceptable
B3. Mixed grazing with more ponies and less cattle & sheep: 20% of cattle & sheep replaced by ponies at eq. LUs.	Total: 79.21 (14.21 LU yrs) Cattle: 8.2 Sheep: 67.7 Ponies: 3.3	87.07	31.03	↓ 16%	-13.07		**Biodiversity:** High **Carbon Reduction:** High **Feasibility:** High **Overall:** Good
B4. Mixed grazing with more ponies and less cattle & sheep: 10% of cattle & sheep replaced by ponies at eq. LUs.	Total: 87.05 (14.21 LU yrs) Cattle: 9.2 Sheep: 76.2 Ponies: 1.7	95.48	33.97	↓ 8%	-0.32		**Biodiversity:** Medium **Carbon Reduction**: Very High **Feasibility**: High **Overall:** Acceptable
C1. 10% reduction in stocking rate: achieved through more targeted grazing strategies	Total: 85.39 (12.79 LU yrs) Cattle: 9.2 Sheep: 76.2	93.50	33.21	↓ 10%	-3.27	Barriers: F - Inexperience with methods for targeting grazing	**Biodiversity:** High **Carbon Reduction:** High **Feasibility:** High **Overall:** Good
D1. Mixed grazing with more pigs and less cattle & sheep: 50% of cattle & sheep re-placed by pigs at eq. LUs.	Total: 61.65 (14.21 LU yrs) Cattle: 5.1 Sheep: 42.3 Pigs: 14.2	54.23	19.56	↓ 48%	-62.82	Barriers: M,J, P, Q	**Biodiversity:** High **Carbon Reduction:** Medium **Feasibility:** High **Overall:** Acceptable
D2. Mixed grazing with more pigs and less cattle & sheep: 20% of cattle & sheep re-placed by pigs at eq. LUs.	Total: 81.59 (14.21 LU yrs) Cattle: 8.2 Sheep: 67.7 Pigs: 5.7	84.03	29.96	↓ 19%	-17.67		**Biodiversity:** High **Carbon Reduction:** Low **Feasibility:** High **Overall:** Acceptable
D3. Mixed grazing with more pigs and less cattle & sheep: 10% of cattle & sheep re-placed by pigs at eq. LUs.	Total: 88.23 (14.21 LU yrs) Cattle: 9.2 Sheep: 76.2 Pigs: 2.8	93.96	33.43	↓ 10%	-2.63		**Biodiversity:** High **Carbon Reduction:** Low **Feasibility:** High **Overall:** Acceptable

Scenario	Annual Grazing Activity (Animal Yrs / Livestock Unit Yrs)	Emissions (t CO_2e / year)		Reduction (vs. current scenario)	Modelled change in warming potential using GWP* (t CO_2we)	Barriers	Scenario Rating
		GWP_{20}	GWP_{100}				
E1. Naturalistic grazing, very high density:	Total: 96.99 (29.39 LU yrs) Deer: 97	162.95	58.96	↑ 57 %	100.76		**Biodiversity**: High **Carbon Reduction**: Low **Feasibility**: Medium **Overall**: Acceptable
E2. Naturalistic grazing, aver-age density:	Total: 3.22 (0.98 LU yrs) Deer: 3.2	5.41	1.96	↓ 95%	-136.34		**Biodiversity**: High **Carbon Reduction**: Very High **Feasibility**: High **Overall:** Good
E3. Naturalistic grazing, low density:	Total: 0.4 (0.12 LU yrs) Deer: 0.4	0.68	0.25	↓ 99%	-143.46		NA

9.5. Scenario Descriptions

9.5.1. Scenario A (current grazing regime)

Conservation grazing on the site is currently achieved using non-dairy Highland and Stabilizer cattle as well as Hebridean and Meatlinc sheep. They are stocked between August and October, with up to 370 sheep and 33 cattle. All the grazed areas are SSSIs and have recently (2023) been assessed to be in Favourable condition, indicating the current grazing strategy is meeting biodiversity conservation objectives.

9.5.2. Scenario B1 – B4 (replacing cattle and sheep with ponies)

Scenarios B1 to B4 all involve replacing cattle and sheep with horses/ponies to varying degrees. The greatest reduction in GHG emissions (81% lower than the current regime) is achieved by Scenario B1 - replacing all of the cattle and sheep with ponies at an equivalent number of Livestock Units (LUs). This would be equivalent to ~67 horses, split over the 5 grazed areas, over the 3 months the sites are currently grazed. Creating mixed grazing scenarios by replacing 50%, 20% or 10% of the cattle with ponies reduces GHG emissions by an estimated 40%, 16% or 8% respectively. These scenarios would require between 7 to 34 horses during the grazing period.

However, replacing cattle and sheep with ponies/horses presents some challenges. There are health and safety concerns, with horses/ponies expected to attract more interaction with people visiting the site and concern that the public will feed them. Some of the fenced areas do not have public access which makes these areas more feasible. Much of the sheep grazing is managed using electric fencing, but it is felt replacing sheep with ponies would require permanent fencing to be installed. Water supply is also a potential issue, the sheep do not drink as much while horses have larger requirements. The cattle grazing is particularly valued for creating structural diversity in the sward leading to concern that ponies would be less effective. It is felt that there is less difference between sheep and pony grazing, and so potentially less risk in changing between the two. Finally, there is a concern that the latrines created by horses will take longer to decompose and as a result the dung will get collected in the hay cut.

9.5.3. Scenario C1 (targeted grazing – reduced cattle and sheep numbers)

Scenarios Scenario C1 involve the use of NoFence collars or other measures to achieve targeted grazing with lower livestock numbers. This could involve spatial targeting of areas most requiring grazing and/or temporal targeting to reduce livestock numbers at times when they are less required for grazing.

Scenario C1 is based on the current grazing regime, but with cattle numbers reduced by 10%.

The main barriers to these scenarios were identified as:

- **Practical and logistical challenges in targeting specific grazing areas and moving animals between grazing blocks**
- **Lack of experience working with them**
- **The cost of NoFence collars**

Note: NoFence collars are available for cattle, sheep and goats, but the manufacturer currently has no plans to develop them for horses and ponies.

9.5.4. Scenario D1 – D3 (replacing cattle and sheep with pigs)

Scenarios B1 to B4 all involve replacing cattle and sheep with pigs to varying degrees. The greatest reduction in GHG emissions calculated (48% lower than the current regime) is achieved by Scenario D1 - replacing 50% of the cattle and sheep with pigs at an equivalent number of Livestock Units (LUs). Creating mixed grazing scenarios by replacing 20% or 10% of the cattle and sheep with pigs reduces GHG emissions by an estimated 19% or 10% respectively. These scenarios would require between 12 and 58 pigs to be stocked across the site in the 3 grazing months.

However, introducing pigs on to the site is not considered feasible because of the risk they pose to the habitats and species protected at the site. Introducing pigs would also come with considerable practical difficulties of finding sufficient animals, securely fencing them in, and managing them.

9.5.5. Scenario E1 – E3 (comparison to possible 'natural' grazing levels)

Wild large herbivorous mammals are a natural part of most ecosystems and, until relatively recently, have had a largely ubiquitous presence over the last 40 million years. However, as a result of the Pleistocene megafauna extinction and subsequent dramatic decline in the remaining wild large herbivores, Britain has a considerably impoverished large herbivore assemblage. Deer species, including some introduced species, are essentially all that remain.

With no part of Britain unimpacted by people, it is difficult to assess what could be considered a natural assemblage and density of large herbivores. Making such an assessment would allow comparisons of GHG emissions from conservation grazing as a management approach with emissions associated with naturally occurring large herbivores. As a way of offering a broad comparison, we've compared the current conservation grazing scenario with the emissions estimates from the range of large herbivore biomass densities that have been calculated

for the Net Primary Productivity of the site based on data recorded from protected areas around the world. These are presented as very low, average and very high biomass density estimates. We then calculate the emissions if this biomass density was entirely made up of deer. These estimates are aiming to provide a very broad comparison to consider and reflect upon in the knowledge of the considerable uncertainty and limitations in these data.

These estimates have been sourced from this published research: https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.14047

The current conservation grazing regime is within the broad estimates of what might be expected for natural densities of large herbivores. However, the current stocking level of 14.21 LU is 14.5 times greater than the global average large herbivore density, with the average natural estimate having a 95% lower emissions estimate.

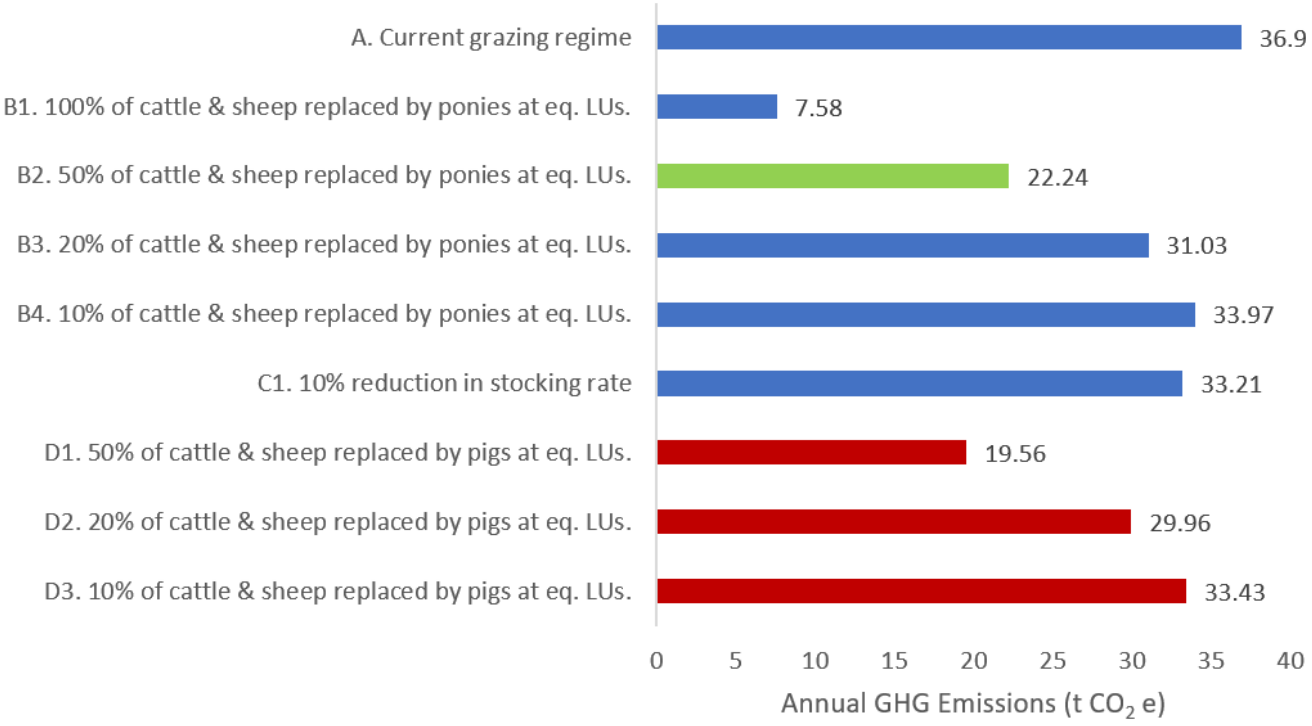

Figure 10: Annual GHG Emissions (GWP100 t CO_2e) from current grazing regime and alternative grazing scenarios at Wheldrake Ings (using GWP100). Green bars indicate Overall Scenario Rating of 'Good'; blue bars indicate 'Acceptable'; red bars indicate 'Unfavourable'.

9.6. Recommendations

Based on the estimated reductions in GHG emissions, nature conservation benefits, and practical feasibility, **Scenarios B2 and B3** are considered the most feasible and desirable of the alternative options. Both scenarios involve increasing the number of ponies and reducing the number of cattle and sheep. The scenarios are likely to cut GHG emissions by between 40 and 16% respectively, whilst retaining the ecological benefits of mixed grazing with ponies, cattle and sheep. Because of the higher GHG emission reductions associated with scenario B2 it considered the most favourable. However, a gradual and experimental approach would help to overcome the barriers identified, allowing staff to build up their experience working with ponies whilst assessing ecological impacts and adjusting proportions as required. However, this scenario would require permanent fencing to be constructed.

Appendix 1e

Alternative scenarios not included

Reduced grazing intensity: The possibility of reducing the grazing intensity was discussed, but it was felt that this would have a negative impact on the conservation goals in all the fenced areas.

Supplementary feeding & new technologies: Feed additives to reduce GHG emissions and new technologies to capture GHG emissions directly from livestock are being developed. Mineral supplements are occasionally used, and water is provided meaning exploring the use of supplements may be worth considering. There was also scepticism that the new technologies would be effective in a conservation grazing setting where it is likely the technology would be easily knocked off.

Goats, European bison and water buffalo: The use of alternative species, including goats, bison and water buffalo were not included in the case study scenarios as their methane emissions are not significantly lower than those of cattle.

Machinery: The alternative of an additional hay cuts is not practical due to the ground nesting lowland waders and farmland birds including skylark and quail.

10. Case Study 6: Gait Barrows

10.1. Background

Gait Barrows is a National Nature Reserve (NNR) that lies within the Arnside and Silverdale Area of Outstanding Natural Beauty (AONB), Lancashire. It is approximately 122ha in size and made up of a diverse mosaic of habitats including open water, wetland, woodland, limestone pavement and grassland. The site is protected as both a Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC). A third of the reserve (42ha) is grazed for parts of the year by cattle to help maintain specific habitats (including reed beds, flower rich calcareous grassland, and Yew woodland) and species (including Duke of Burgundy and High Brown Fritillary), as well maintaining the overall mosaic of habitats where 'wood pasture, scrub, grassland and wetland blend seamlessly into one another' (Natural England n.d.).

10.2. Summary of outcomes

- The case study found that the **highest reductions in GHG emissions (an estimated 80%+ reduction) could be achieved by replacing all cattle with ponies.** However, this was not considered to be the most ecologically desirable scenario due to the loss of some specific ecological benefits particularly associated with cattle.

- Of the alternative options explored, **the most ecologically acceptable was a mixed grazing scenario involving smaller numbers of cattle, with proportionately more ponies (achieving an estimated reduction in GHG emissions of between 8 and 40%).**

We conclude that substantial reductions in GHG emissions are possible, but the implications for biodiversity and the key conservation goals of the site would need to be monitored with changes implemented gradually.

10.3. Site details

Site Name	Gait Barrows
Site Management Organisation	Natural England
Address	Gait Barrows, Silverdale, Lancashire, near LA5 0JF
OS Map Reference	SD 483777
Site Size	Total size: 122 ha Grazed area: 42 ha
Site Owner	Natural England
Website	https://publications.naturalengland.org.uk/publication/5368002631434240
Key habitats	• Fen, marsh and swamp (M13,M24,M27,S2,S4,S24,S25) • Calcareous grassland (CG9) • Broad-leaved, mixed and yew woodland (W2,W8,W9,W13) • Neutral grassland (MG5,MG6) • Scrub community (W21)
Designations	• National Nature Reserve (NNR) • Site of Special Scientific Interest (SSSI) • Special Area of Conservation (SAC) • Special Protection Area (SPA) • Within Area of Outstanding Natural Beauty (AONB; Arnside and Silverdale)
Agri-environment funding	Previously, only Basic Payment Scheme (BPS) payments have been claimed by the grazier. In 2022, Gait Barrows Pastures were entered SFI pilot in 2022 under the Low Input Grassland (LIG) action. In 2023, Boathouse fen and Challan Hall pastures were also entered into SFI LIG. The ambition is to enter all grazed land into CSS Mid Tier organic management and native breeds supplements later in 2024.
Site access	There is public access to the site. There are approximately 1600m of Public Rights of Way (PRoW) through the grazed areas of the site and the whole reserve is designated as open access. For the most part, the PRoW are kept separate from the livestock, but some footpaths cross the grazed meadows.

10.3.1. Conservation goals for grazing

Goal 1	Maintain low nutrient inputs into the alkaline fen.
Goal 2	Maintain a species rich grassland (see below for grassland types).
Goal 3	Maintain the species diversity of the Marl Grassland through grazing to reduce rank vegetation, scrub and bracken encroachment.
Goal 4	Help to ensure a full range of ecotones is achieved between habitats.
Goal 5	Management of bracken is a minor consideration.

10.3.2. Current grazing animals

Species	Breeds	Number (max. herd size)	Ownership
Cattle (non-dairy)	Red Poll (Cows 450-600kg, Bulls 550-750kg) & Short horn (Cows 500-600 kg)	33	Grazier
Ponies	Fell Ponies	2	Grazier

10.3.3. Grazing areas

Gait Barrows is divided into 7 grazing areas, which cover a total area of 42 ha.

Grazed area	Area (ha)	Main habitat	Conservation goals
A: Gait Barrows pastures Red dotted line wet	Total: 22.79 Grazed: 14.62	Lowland fen Open water/carr woodland (willow-alder) Mixed ash-sycamore + small leaved lime woodland / neutral grassland (MG5)/ areas of yew woodland on limestone pavement	1, 2, 4, 5
B: Lake-side fen pastures/ Bill: Hawes Water Edge	2.54	Lowland fen/ marl grass-land/ thinned beech wood plantation/bracken bed	1, 3, 5
C: Summer-house fen	1.41	Lowland fen/willow-alder carr along tarn edge/ash-sycamore woodland on higher ground (recently heavily thinned)	1, 4
D: Boathouse fen	3.06	Lowland fen/fen-grassland /Wet (willow-alder carr) wood-land/Mixed ashwood/ neutral grassland on upper slopes	1, 2, 4
E&F: Challan Hall pastures	6.25	Semi-improved long-term neutral grassland (MG6) being restored to unimproved MG5 by reduction in management intensity. Some calcareous grassland areas on thinner soils/steeper slopes.	1, 2, 4
Gait Barrows pavement	39.92	Mainly limestone pavement; some areas intact, others damaged, much of it subject to scrub encroachment. Mature yew/ash woodland around edges	
G: Moss Lane pastures	0.77	Not SSSI	1

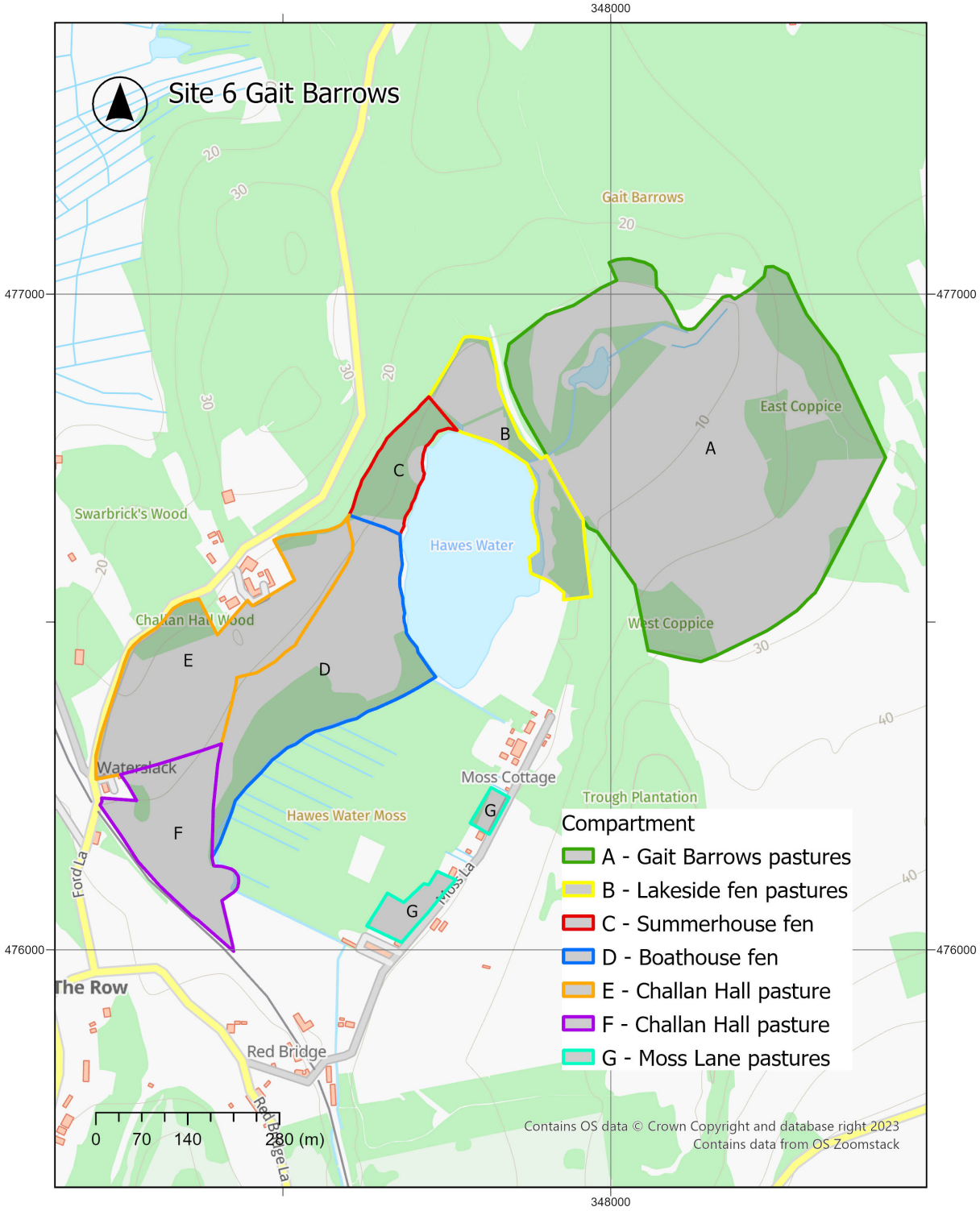

Figure 11: Map of Grazing Compartments at Gait Barrows. Map provided by Natural England and presented here with permission

10.4. Comparison of Grazing Scenarios

Scenario	Annual Grazing Activity (Animal Yrs / Livestock Unit Yrs)	Emissions (t CO_2e / year)		Reduction (vs. current scenario)	Modelled change in warming potential using GWP* (t CO_2we)	Barriers	Scenario Rating
		GWP_{20}	GWP_{100}				
A. Current grazing regime (cattle, ponies)	7.97 Animal Yrs 5.2 LU yrs	47.08	16.68	NA	5.57	NA	**Biodiversity Rating**: High **Carbon Reduction Rating:** NA **Feasibility Rating**: High **Overall Rating:** Acceptable
B1. All ponies: All cattle re-placed by ponies at equivalent LUs.	5.33 Animal Yrs 5.2 LU yrs	8.00	3.06	↓ 83%	-53.67	Barriers: C	**Biodiversity:** Low **Carbon Reduction:** Very High **Feasibility:** Medium **Overall:** Acceptable
B2. Mixed grazing with more ponies and less cattle: 50% of cattle replaced by ponies at eq. LUs.	6.65 Animal Yrs 5.2 LU yrs	27.54	9.87	↓ 42%	-24.05	Barriers: C	**Biodiversity:** Medium **Carbon Reduction**: High **Feasibility**: Medium **Overall**: Acceptable
B3. Mixed grazing with more ponies and less cattle: 20% of cattle replaced by ponies at eq. LUs.	7.44 Animal Yrs 5.2 LU yrs	39.27	13.95	↓ 17%	-6.28	Barriers: C	**Biodiversity:** High **Carbon Reduction:** Medium **Feasibility:** High **Overall:** Good
B4. Mixed grazing with more ponies and less cattle: 10% of cattle replaced by ponies at eq. LUs.	7.7 Animal Yrs 5.2 LU yrs	43.18	15.32	↓ 8%	-0.36		**Biodiversity:** High **Carbon Reduction**: Low **Feasibility**: High **Overall:** Acceptable
C1. Targeted grazing - current composition: Current regime with 10% reduction in cattle (targeted grazing with NF collars)	7.17 Animal Yrs 4.68 LU yrs	42.38	15.01	↓ 10%	-1.55	Barriers: F	**Biodiversity:** High **Carbon Reduction:** Low **Feasibility:** Medium **Overall:** Acceptable

10.5. Scenario Descriptions

10.5.1. Scenario A (current grazing regime)

Conservation grazing on the site is currently achieved using non-dairy Red Poll and Short horn cattle, with two ponies also grazing part of the site. They are primarily stocked over the winter and spring, in herds of up to 20 individuals. A small group of cattle are also stocked in late summer.

10.5.2. Scenarios B1 – B4 (replacing cattle with ponies)

Scenarios B1 to B3 all involve replacing cattle with ponies to varying degrees. The greatest reduction in GHG emissions (83% lower than the current regime) is achieved by Scenario B1 - replacing all the cattle with ponies at an equivalent number of Livestock Units (LUs). Creating mixed grazing scenarios by replacing 50%, 20% or 10% of the cattle with ponies reduces GHG emissions by an estimated 42%, 17% or 8% respectively.

The main ecological concern and practical barriers to increasing the proportion of ponies on site were:

- That ponies would not be as effective as cattle at removing the rank grass and bramble, and that they would put pressure on different plant species.
- That ponies would be less well suited to the high public access of the site, especially with the large numbers of dogs.

The site has been grazed by more ponies in the past. Most concerns came with uncertainty about potential outcomes. There was interest in exploring the GHG emission reduction potential of a range of scenarios, and the possibility of exploring them in the future.

10.5.3. Scenario C1 (targeted grazing – reduced cattle numbers)

Scenario C1 involve the use of NoFence collars or other measures to achieve targeted grazing with lower livestock numbers. This could involve spatial targeting of areas most requiring grazing and/or temporal targeting to reduce livestock numbers at times when they are less required for grazing.

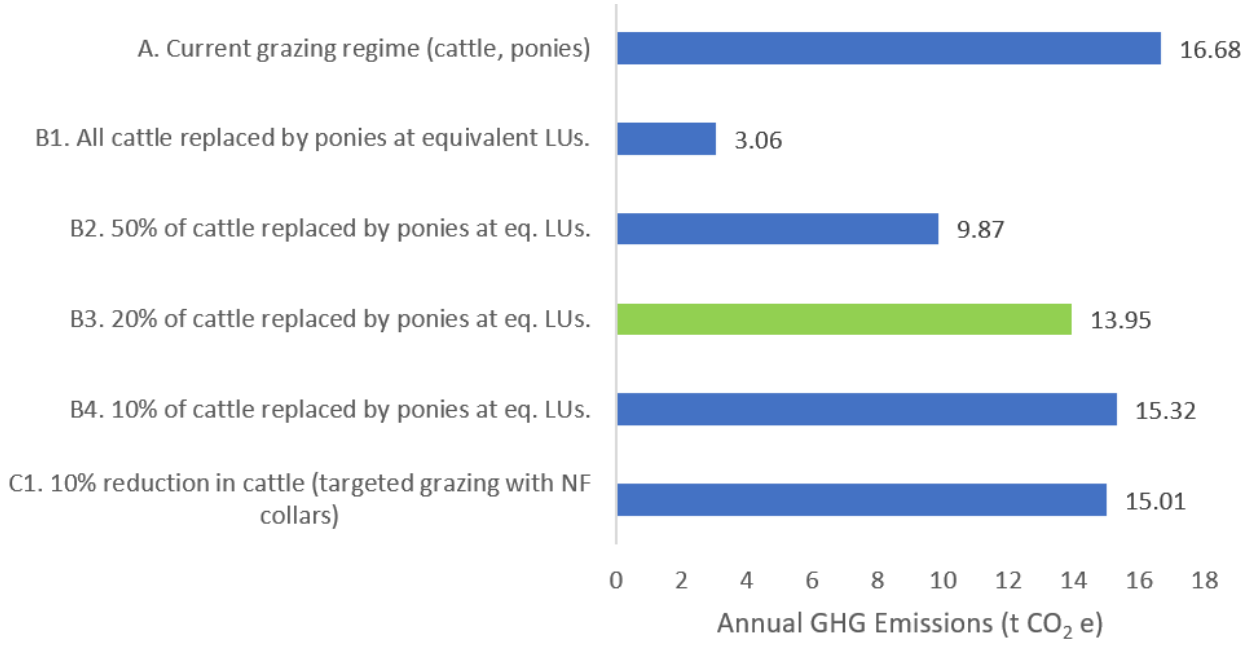

Figure 12: Annual GHG Emissions (GWP100 t CO_2e) from current grazing regime and alternative grazing scenarios at Gait Barrows (using GWP100). Green bars indicate Overall Scenario Rating of 'Good'; blue bars indicate 'Acceptable'; red bars indicate 'Unfavourable'

Scenario C1 is based on the current grazing regime, but with cattle numbers reduced by 10%. The main barriers to these scenarios were identified as:

- Practical and logistical challenges in targeting specific grazing areas and moving animals between grazing blocks
- The cost of NoFence collars
- No meat output from horses
- Concern that it will compromise Goal 4, creating ecotones

Note: NoFence collars are available for cattle, sheep and goats, but the manufacturer currently has no plans to develop them for horses and ponies.

10.6. Recommendations

Based on the estimated reductions in GHG emissions, low adverse ecological impacts, and practical feasibility, **Scenario B3** is considered the most feasible and desirable of the alternative options. The scenario involves reducing the number of cattle by 20% and increasing the pony grazing by the equivalent LUs. This scenario would cut GHG emissions by about 17%, whilst retaining the ecological benefits of mixed grazing with ponies, cattle and sheep.

Appendix 1f

Alternative scenarios not included

Reduced grazing intensity: The possibility of reducing the grazing intensity was discussed, but it was felt that this would have a negative impact on the conservation goals in all of the fenced areas – particularly conservation goals 2 to 5. In the Lakeside fen pastures, grazing has been lower in the recent past and rank grassland was beginning to dominate the Marl grassland. Since grazing intensity has been increased, plant species richness is thought to be increasing.

Pigs: The use of pigs for conservation management was discussed in the staff interviews. Pigs have low methane emissions and can provide a range of ecological benefits (Ramsay et al. 2023). The use of pigs was considered too big a risk for the Gait Barrows site and would be a more appropriate consideration in a nature recovery project. There was particular concern that there would be a negative effect on rare and vulnerable species, such as the Fly Orchid. However, there was some interest in pigs rooting bracken. But fencing the site to keep pigs in was not seen as practical.

Supplementary feeding & new technologies: Feed additives to reduce GHG emissions and new technologies to capture GHG emissions directly from livestock are being developed. However, no supplementary feed is provided to the cattle and so feed additives weren't considered viable. There was also scepticism that the new technologies would be effective in a conservation grazing setting where it is likely the technology would be easily damaged or removed as the animals move around the site.

Goats, European bison and water buffalo: The use of alternative species, including goats, bison and water buffalo were not included in the case study scenarios as their methane emissions are not significantly lower than those of cattle.

Machinery: The use of machinery as an alternative to grazing was discussed in the staff interviews. Machinery was not explored in the case study scenarios as details of GHG emissions from machinery and staff travel are not readily available.

11. Conclusions

Across all the case studies, 'Good' rated scenarios that have the greatest emission reduction potential are estimated to reduce GHG emissions by an average (mean) of 42% (range 17-71%).

At all six case study sites, switching at least some grazing livestock from cattle and/or sheep to ponies/horses is rated a 'Good' alternative grazing scenario with the potential to reduce emissions. However, maintaining some cattle grazing is desired to safeguard established nature conservation goals. The proportion of cattle and sheep that could be replaced by ponies/horses varies between sites, ranging from 20 to 75%. At Hartington Meadows, replacing all sheep with ponies is favoured. Switching from primarily cattle and sheep grazing to include horses or ponies is likely to be the best opportunity to reduce GHG emissions while achieving the stated conservation goals for most conservation grazing sites.

Reducing livestock stocking density, measured in Livestock Unit Years/ha, is only included in the best alternative grazing scenario at two sites: Birkdale Sandhills and Hartington Meadows. Birkdale Sandhills already has the lowest stocking density, which is unsurprising due to its habitat (sand dunes as opposed to grassland). A small reduction is thought possible (0.024 to 0.022 LUY/ha) using targeted grazing with NoFence collars. The current stocking density at Hartington Meadows is the second highest (0.42 LUY/ha), after Kingcombe Meadows (0.61 LUY/ha). It is considered possible to maintain conservation goals at Hartington Meadows with 50% of the stocking density (0.21 LUY/ha), bringing it down to a level that is more consistent with the other case study grassland dominated sites. In contrast, reducing stocking density at Kingcombe Meadows is considered less favourable for meeting conservation goals. Reducing stocking density is a potentially important opportunity to reduce GHG emissions from conservation grazing, although at most sites this may be done through targeted grazing. However, our assessment has not included the embedded carbon in the construction and running of these collars, which needs to be taken into account.

There was interest in using technology and feeding supplements to reduce GHG emissions, but they did not feature in the best alternative scenarios. This is primarily because of the uncertainty about the practicality of their use and the GHG emission reduction potential in a conservation grazing setting.

Implementing a switch to increased pony and horse grazing does face a variety of barriers, including the need to develop the skills, experience, infrastructure, public awareness, and processes for increased use of pony and horse grazing at conservation sites. To overcome these barriers there is a need for staff training programmes, knowledge exchange between Trust's with experience of working with ponies/horses and those looking to introduce their use, investment in infrastructure and processes, and visitor education programmes.

Rigorous applied research is also needed to test the application of these alternative scenarios to gain empirical data on the changes in GHG emissions, conservation outcomes, and the potential for overcoming barriers. Further research would also help resolve unanswered questions related to carbon sequestration in grazed habitats and how it interacts with changes in grazing. Additionally, there is a need to understand the broader system-level effects of the proposed changes. For example, it is important to consider the impact of reducing cattle and sheep stocking and increasing horse and pony grazing at conservation sites on the total population of each species in a region, as well as considering how animals are housed and fed to ensure reductions in GHG emissions on nature reserves do not result in increased GHG emissions from large herbivores in the broader region.

This report has explicitly considered the GHG emissions from conservation grazing used to deliver specified biodiversity conservation goals. These goals focus on maintaining habitats and features that support species of conservation importance. However, while these objectives are critical, the broader aspiration of rebuilding and sustaining landscape-scale functional and resilient ecosystems is another crucial consideration. Reviewing conservation grazing practices against broader nature recovery ambitions could result in changes in large herbivore assemblage and abundance, impacting GHG emissions.

To this end, estimations of natural wild herbivore biomass densities were considered for Hartington Meadows and Wheldrake Ings, along with the GHG emissions if this biomass density comprised entirely of wild deer. Although these natural large herbivore biomass density estimates are broad and derived from larger protected areas worldwide (controlled for net primary productivity), comparing these estimates of natural densities and GHG emissions to current conservation grazing sites indicates that conservation grazing densities and emissions are high.

This exploration of conservation grazing case studies suggests there are considerable opportunities to reduce GHG emissions while maintaining nature conservation goals. Implementation and testing of these alternatives are needed to confirm this potential.

12. References

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