RESEARCH ARTICLE

People, nature and large herbivores in a shared landscape: A mixed-method study of the ecological and social outcomes from agriculture and conservation

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Abstract

1. In this exploratory study, we employ an interdisciplinary approach to explore potential synergies and trade-offs between the needs of people and nature in the context of agroecological farming and nature conservation.

2. Ecological field studies and management surveys from six sites were combined with a participatory-deliberative appraisal exercise using the Multi-Criteria Mapping (MCM) method. All six study sites and all four land use options in the appraisal were characterised by the use of large herbivores for agricultural and/or conservation purposes, to varying degrees, and were located in South-East England.

3. MCM participants identified habitat and species diversity, soil health, food production, provision of education and recreational access, as the principal benefits associated with successful management of such sites. Taken overall, their appraisals indicated that a combination of land uses may be best suited to delivering these diverse benefits, but with agroecological (While organic and biodynamic agriculture are subject to legal definition, agroecology offers a more flexible approach and can be viewed as 'a development pathway from input-intensive industrial systems through to highly sustainable, ecological systems'—see Laughton, R. (2017) 'A Matter of Scale', Land Workers Alliance and Centre for Agroecology, Coventry University) farming being perceived as a particularly effective multi-purpose option.

4. Five of the six sites were used for recreational purposes, and in total we recorded five times more humans than wild mammals. Ecological data from the sites indicated that the most conservation-oriented sites performed best in terms of species richness and activity (birds, mammals, bats and invertebrates) and number of species of conservation concern. However, beta diversity metrics indicated important variation in the species assemblages recorded within and between sites. Whereas both agroecological farms in our study produced the greatest weight

5. of saleable meat per unit area, the site that produced the most meat also demonstrated consistently strong performance across many biodiversity metrics.

5. Overall, expert perspectives and the performance of our study sites suggests that combinations of diverse approaches to the management of large herbivores, within a 'wildlife-friendly' envelope, are consistent with providing for the diverse needs of people and nature within shared landscapes.

1 | INTRODUCTION

Food production and biodiversity conservation are two important land uses for supporting people and nature, but often come into conflict. The conversion of wild land to anthropogenic uses is a major cause of biodiversity loss (Pereira et al., 2017), while wildlife can negatively impact agriculture (e.g. Baker et al., 2008). Conversely, farming is also dependent on nature (IPBES, 2019) and biodiversity conservation is often applied to farmland (Kleijn et al., 2011). The creation of agricultural land has increased the provisioning ecosystem services (e.g. food) nature provides to people. Thus, sufficient food is produced to feed the global population, although the failure to distribute this food effectively and equitably means ~800 million people are still undernourished (FAO, 2015; Ramankutty et al., 2018). However, gains in production have come at the cost of declining nature and associated regulating (e.g. carbon sequestration) and cultural (e.g. the opportunities nature provides for education) ecosystem services (Díaz et al., 2019). The loss of nature also threatens the sustainability of current food production (Díaz et al., 2019). The UN has declared 2021–2030 the decade of ecosystem restoration to help tackle the connected challenges of biodiversity conservation, food security, climate change and other global and national sustainability priorities (UN, 2020). This raises the questions: (a) what should our ecosystems be restored to by 2030 and beyond? and, (b) will individual land owners and associated stakeholders contribute to achieving this restoration?

1.1 | Agriculture and biodiversity conservation in the United Kingdom

The Government's 2018 publication of a 25 Year Environnement Plan (DEFRA, 2018), commitment to designating and protecting 30% of UK land for biodiversity by 2030 (UK Parliament, 2020a), Brexit preparations and debates around the Agriculture Bill 2019–2021 (UK Parliament, 2020b) and Environment Bill 2019–2021 (UK Parliament, 2020c) have provided a focus for recent policy debates on the needs of people and nature across the United Kingdom, although regional differences are of fundamental importance. The

South-East of England is an example of a challenging environment in which to achieve sustainability, because biodiversity losses and the societal demands for primary production (i.e. food, feed, fuel and fibre; Schulte et al., 2019) are related geographically to population density (Thompson & Jones, 1999). Therefore, an understanding of the synergies and trade-offs of meeting sustainability challenges in densely populated areas is pressing for both policymakers and practitioners. Here, we focus our analysis in the South-East of England for four reasons: (a) the region is highly ecologically degraded and has high human population density; (b) a variety of agroecological farming and conservation/restoration land uses are already being employed and so can be examined; (c) land management support policies and schemes are being redeveloped in the United Kingdom as a result of Brexit, so the country is in a moment of change and potential opportunity; and, (d) it is the authors' local landscape which allowed us to engage more deeply with local issues.

1.2 | What do sustainable landscapes look like?

How land is used will have a key bearing on whether and how sustainability challenges are met in the United Kingdom. Different visions of the future are favoured by different communities. For example, the 'Nature Needs Half' campaign seeks to protect 50% of the land and sea for nature by 2030 (NNH, 2020). In contrast, in the United Kingdom, the National Farmers Union has an ambition to maintain the area of farmed land but transition to carbon neutral farming by 2040 (NFU, 2019). These respective visions of the future are consistent with the ideas of 'land sparing', where land is separated for production and conservation, or 'land sharing', where there is integration of production and conservation (Fischer et al., 2014). This framing has been prominent in discussions about creating future landscapes. However, there is an increasing awareness that any national or regional-scale scheme needs to be implemented at the local scale, and that practical implementation considerations are more complex than just evaluating food production against conservation alone (Fischer et al., 2014). Exploring the attitudes towards and the performance of different land management practices can offer insights into how local sites and stakeholders might individually and

collectively support nature conservation and restoration and produce the goods and services required to meet the needs of people.

1.3 | Large herbivores in agriculture and conservation

Large mammalian herbivores (both wild and domestic; ≥10 kg) are important components of wild nature, agriculture and conservation sites, and as such may present a focal point for synergies between food production and conservation. Wild large herbivores are still prevalent over the global terrestrial ecosystem, excluding Antarctica (see Svenning et al., 2016). Over 25% of the terrestrial world is intentionally grazed by domesticated large herbivores, or 'livestock' (e.g. cattle, sheep, goats, pigs; Asner et al., 2004). Conservation grazing, in various forms, is a widely used tool to conserve biodiversity (WallisDeVries et al., 1998). In these instances, the abundance and functional traits (e.g. body mass and foraging strategy) of the large herbivore community, and the way people interact with them plays an important role in determining the quantity and type of food available to humans and carnivores (Gilbert et al., 2018; Sandom et al., 2017), the composition and structure of vegetation and soil (Bakker et al., 2016; Sandom et al., 2014) and direct greenhouse gas emissions (Smith et al., 2010; Springmann et al., 2018). Thus, large herbivores have important implications for the biodiversity the landscape can support and the suite of ecosystem services provisioned.

1.4 | Study purpose

In this exploratory study we employ a novel and interdisciplinary methodology to explore (a) expert opinion of what people and nature need and want from agroecological farming and conservation land in South-East England, and (b) how specific land management approaches within agriculture and conservation perform, and are perceived to perform, in delivering those needs. Ultimately, our purpose is to identify management strategies, and in particular how they relate to large herbivores, that reconcile the potential synergies and trade-offs between the needs of people and nature to help inform how ecosystems should be restored in areas of high ecological degradation and human density.

2 | METHODOLOGY

This project was explicitly designed to deliver an innovative approach for addressing a complex sustainability question. Stemming from our belief that science to address sustainability requires a combination of (a) seeking a broader perspective, (b) being innovative and (c) taking the time required to explore complexity, the aim of our study design was to better understand the problem, rather than to arrive explicitly at a solution. Therefore, our approach was both *interdisciplinary* (combining concepts from applied social science and

ecology, with both disciplines aiming to inform each other) and used *mixed-methods* (combining qualitative and quantitative techniques), as a way to 'spread the net wide'. As a corollary to this, sample size and statistical analysis have been limited in favour of breadth of understanding and openness to complexity in our analysis and interpretation (Stirling, 2007, 2010). We hope this approach will inform targeted future research.

2.1 | Study design

The study design comprises two interlinked methodological strands: (a) a Multi-Criteria Mapping (MCM) exercise, and (b) ecological field studies and an accompanying site management survey focused on large herbivores. A summary of the techniques used is provided below, with full details available in Supporting Information SI1. Both the MCM exercise and ecological field studies were designed with input from both disciplines and two stakeholder workshops.

We made our site selection for the ecological field studies based on desk research (web searches, informal scoping interviews by telephone and email correspondence with potential candidates) and stakeholder engagement (hosting a half-day workshop and participating in relevant local sector events), after which we compiled a database of 46 potential sites. Six readily accessible and engaged sites were selected from East and West Sussex all of which have multiple land management objectives, but include agroecological farming and/or biodiversity conservation: (a) Tablehurst Farm (Tablehurst—Agroecological Farm 1; community-owned biodynamic farm), (b) Saddlescombe Farm and Newtimber Hill (Saddlescombe—Agroecological Farm 2; South Downs farm managed by the National Trust and a tenant farmer), (c) Ashdown Forest (Ashdown—Conservation Site 1; owned by charitable trust, with elected members of East Sussex County Council), (d) Butcherlands (Butcherlands—Conservation Site 2; part of the rural Ebernoe Common Nature Reserve and managed by the Sussex Wildlife Trust), (e) Knepp Wildland Southern Block (Knepp—Rewilding Estate; a rewilding project on a formerly farmed estate) and (f) Sheepcote Valley and Wild Park (Council—Peri-urban Nature Reserve; city parks managed by the Brighton and Hove Council).

The sites were paired for landscape character, with each pair having a similar soil type and geographical location. Unfortunately, it was not possible to pair symmetrically for both management focus and landscape character, so pairings for landscape character are as follows: Tablehurst and Ashdown (High Weald location, close to several towns and large villages on weald clay); Knepp and Butcherlands (fairly isolated Low Weald location, on weald clay); and Saddlescombe and Council (located on the South Downs fringing the city of Brighton, on chalk).

Four land management 'options' were used in the MCM exercise, and were titled: (a) Agroecological Farm, (b) Peri-urban Nature Reserve, (c) Rewilded Estate and (d) Conventional Family Farm. The description of each option are given in Figure 1.

OPTION 1: AGROECOLOGICAL FARM
- Community-owned organic farm.
- Pasture, arable fields, orchards, hedgerows, woodland and wetland habitats.
- On the edge of a large village.
- Raising of various traditional livestock breeds is a core activity—home to suckler cows, pigs and sheep.
- Certified to the highest organic standard.
- Agrochemicals are banned and efforts are made to restrict off-farm inputs.
- Meat is sold to the public through the farm shop and café, via a small number of local outlets, by mail order and through Borough Market in London.
- Provides permanent residential care for ten adults.
- Hosts apprentices and agriculture students.
- Produces arable crops, fodder, fruits and vegetables.
- Runs a farm shop, butchers' shop, dairy, café and micro-brewery.
- The public are regularly invited onto the farm for guided walks, picnics, seasonal celebrations, craft workshops, experience days and volunteer work days.

OPTION 2: PERI-URBAN NATURE RESERVE
- Council-owned open space. Managed by the city council in partnership with the local Wildlife Trust.
- A patchwork of grass (dominant), scrub and woodland.
- On the boundary of a small city and surrounding national park.
- A roaming flock of traditional ewes are grazed to maintain the Downland habitat—creating an attractive and accessible environment, benefiting biodiversity and protecting specific species.
- The grassland is unimproved (no chemical inputs used).
- The Wildlife Trust mobilises volunteers for periodic scrub management.
- Sheep are managed by a professional shepherd with help from a team of amateur volunteers.
- The meat is sold to a local community buying group. This group—which is administered by local volunteers from the city—sells ¼ shares of hogget to its members, by pre-order and collection from the city centre.
- Doubles as a recreational space, popular for exercising and dog walking.

OPTION 3: REWILDED ESTATE
- Private farmland estate.
- Shifting landscape of open-grown trees, emerging scrub, grazing lawns, groves and thorny thickets.
- Relatively remote location—almost 10 miles from the nearest market town.
- Home to a range of large herbivore species— bison, various breeds of deer, ponies, cows and pigs— which play a central role in the rewilding project's conservation mission. All animals are allowed to roam freely across the estate.
- No fertilisers or other chemicals, imported feed, farm machinery or routine medication are used.
- Small quantities of meat are produced and sold on site as part of the culling regime to mimic natural predation.
- Despite attracting popular interest and media attention, the public are only engaged in small numbers through bespoke safari experiences.
- Public rights of way that cross the site are well maintained and accessible to walkers.

OPTION 4: CONVENTIONAL FAMILY FARM
- Family-owned lowland beef and lamb farm.
- Predominantly comprised of improved pasture and arable fields.
- Located in a relatively remote part of the Low Weald.
- Raising of fast-growing commercial livestock breeds is the main activity.
- Home to suckler cows and sheep.
- Also produces a small amount of fodder.
- Agrochemicals and other external inputs are used to fertilise the pasture, eliminate pests and weeds, and feed the animals.
- Compliant with environmental and animal welfare regulation—certified by Red Tractor.
- Sells most of its meat into the deadweight market—it is most likely bought by large abattoirs and sold on to UK supermarkets and for export overseas.
- No active attempts are made to engage the public in the farm's activities.
- The public rights of way that cross the site are well maintained and accessible to walkers.

FIGURE 1 The four Multi-Criteria Mapping options used within the appraisal interviews, as rendered within the participant briefing pack

Although there is no 1:1 relationship between the MCM options and the field sites, there is a correspondence between three of the options and three of the sites. MCM options (a) to (c) were informed by but not directly equivalent to Tablehurst, Council and Knepp respectively. At no point during the MCM interviews was the connection between MCM option and the study sites mentioned or discussed.

The two methodological strands were aligned to a common analytical framework that draws upon the categories of ecosystem services (ES) used within the Millennium Ecosystem Assessment (MEA, 2005) and the UK-relevant service themes used by Haines-Young and Potschin (2008) in their report for DEFRA, as outlined by Linstead et al. (2008). This framework was used as a source of conceptual categories for thematic analysis of both the ecological and social scientific data. Specifically, we used the top-level service categories, merging Supporting services and Regulating services into a 'Supporting and Regulating ES' (SRES) category (in line with the MEA), and also using 'Cultural ES' (CES) and 'Provisioning ES' (PES) as separate categories in their own right (Table 1). While recognising that biodiversity underpins ecosystem service delivery—and that Biodiversity and Ecosystem Services are complex and layered concepts (Mace et al., 2012)—we also recognise the *intrinsic value* of biodiversity and therefore included it as a stand-alone category within the analysis. Not all participant responses will necessarily fit these categories and we discuss these separately, specifically as those cut across the Ecosystem Service categories (referred to hereafter as 'Cross-cutting ES'), or those that are beyond the biodiversity and Ecosystem Service framework (referred to hereafter as 'Residual'; Table 1).

TABLE 1 Description of the Biodiversity, Ecosystem Services and Other categories used in the study. The Biodiversity and ecosystem service definitions are based on Haines-Young and Potschin (2008) and MEA (2005)

Thematic category	Description
Biodiversity	The variety and abundance of plant and animal life
Supporting and Regulating (SRES)	Benefits obtained from ecosystem processes regulation, such as climate regulation, water purification, natural hazard regulation, waste management, pollination, pest control, soil formation, nutrient cycling and atmospheric oxygen production
Provisioning (PES)	Products obtained from ecosystems such as food, wood, fresh water, fibre, genetic resources and medicines
Cultural (CES)	Includes non-material human benefits obtained from ecosystems such as recreation, spiritual enrichment and aesthetic values
Cross-cutting	Criteria that cut across multiple Ecosystem Service categories and so do not fit into any single Ecosystem Service category
Residual	Criteria that go beyond the Biodiversity and Ecosystem Service framework

2.2 | Data gathering

2.2.1 | Multi-Criteria Mapping exercise

The aim of the MCM exercise (Coburn & Stirling, 2016)—which combines structured interviewing and a workshop—was to explore different

understandings of the performance of contrasting management approaches and how they vary depending on the view that is taken. This was achieved by engaging 13 expert interviewees representing different perspectives on the issues—both in policy and practice—surrounding the management of large herbivores in biodiversity conservation and agroecological food production. A perspective is considered 'a grouping of viewpoints that may be seen on the basis of MCM analysis to display certain features in common' (Stirling & Coburn, 2014). For example, participants categorised within the 'farmer' perspective generally prioritised criteria around SRES and viability, while the 'conservation' perspective identified more criteria related to biodiversity. Interviewees were provided with the four contrasting strategies (or 'options') to appraise (this information was provided within a briefing pack; Figure 1) and asked to volunteer any additional options that they thought warranted appraisal in parallel. They were then asked to volunteer their own criteria for conducting the appraisal and led through a scoring process that enabled them to attribute pessimistic (worst-case scenario) and optimistic (best-case scenario) scores for each of the land management options against each of their self-selected appraisal criteria. Participants gave informed consent to participate in this study and approval was given by the University of Sussex Research Ethics Committee to carry out this research.

2.2.2 | Ecological field studies overview

During July and August 2018, we measured six ecological metrics at four randomly situated plots at each site: (a) vegetation structure (drone-derived aerial photographs and hand-held LiDAR mapping), (b) medium/large mammal species diversity and activity (camera traps), (c) ecological and anthropogenic soundscapes (Wildlife Acoustics SMIIs), (d) bird species diversity and activity (Wildlife Acoustics SMIIs), (e) bat diversity and activity

(Wildlife Acoustics SMIIs) and (f) invertebrate abundance and diversity (pan-trapping). Over a fortnight, data were collected from four 30 × 30 plots within each pair of sites. These 24 sampling plots were selected by randomly generating co-ordinates >100 m apart within the grazed areas of each site (ArcGIS 10.5). At each location we placed (a) a SMII recorder with ultrasonic (for bats) and acoustic microphone (for bird and human activity) for a period of 96 hr; (b) three pan traps for a period of 24 hr; and (c) four camera traps for a period of 96 hr. Species identification was achieved using morphological traits (pan traps specimens), acoustic recognition (bird calls), visual recognition (camera trap footage) and spectrogram analysis (bat echolocation calls). Five soil samples were also collected from each plot and were analysed for endo- and ecto-mycorrhizae, pH, organic matter, bulk density, content of sand/silt/clay, phosphorous, potassium and magnesium.

2.2.3 | Management survey

Site managers of the six study sites were invited to participate in an online management survey, constructed using Qualtrics. The survey comprised of 10 substantive questions covering different aspects of management, plus four demographic questions for the purposes of identifying the respondents and linking them to the correct sites (Supporting Information SI6). The aspects of management covered by the survey included the presence of different domestic livestock and incidental wild species on the land; abundance/stocking densities, stock movements and motivations behind stocking decisions (cf. species and abundance); prices obtained for sales of any meat produced from the land; managerial responses to incidental wild species; and management regimes and actions relating to (inter alia) large herbivores (including medical interventions, feeding, housing etc.), the vegetation community (e.g. applications of herbicides) and the soil (e.g. applications of fertilisers). The survey data were used to contextualise ecological field studies, as well as providing an indication of the meat provision from each site. Additional information was sought from managers as required.

2.3 | Analysis

2.3.1 | MCM analysis

The 13 MCM interviewees' self-selected appraisal criteria were reviewed and structured into the Biodiversity, Ecosystem Service and Residual categories framework based on a conceptual proximity between the categories (summarised in Table 1) and the title, key features and description of the criteria given by the interviewees. The pessimistic and optimistic scores given by each interviewee for each criterion (or set of criteria) were summed for each land management option to give overall perceived worst- and best-case performance score of each option. This was presented diagrammatically to enable comparison across the options and criteria, as well as between perspectives and issues (Biodiversity, SRES, PES, CES). It is important not to misinterpret or overemphasise the ranking of the options in the MCM analysis—the picture of ranks does not represent statistically significant preferences about land use. Rather, it provides an indication of how the options for managing large herbivores defined within this exercise have been appraised by individuals selected for their capacity to view the issues from a range of relevant perspectives. These data were also considered according to the different perspectives and issues.

2.3.2 | Ecological analysis

We used the ecological and management survey data to make relative assessments of sites contribution to Biodiversity, and SRES, PES and CES delivery. For Biodiversity, we considered species-focused metrics (taxon-specific—birds, bats, invertebrates, mammals—species richness, abundance, diversity and protected status metrics). For SRES, we considered soil nutrient traits, soil organic matter (SOM) and endomycorrhizae. For CES, we considered recreational use (number of people and diversity of

activities). For PES, we considered the quantity of meat production and meat sale price.

All metrics for Biodiversity, SRES and CES were standardised across all sites so that the best performing plot for a particular metric scored a 1 and the other plots were scaled against this metric score (standardised metric plot score = plot metric score/maximum metric score). Quantity of meat production was standardised at the site level as there is no relevant plot scale data. Site's maximum and minimum plot score, highest and lowest plot mean score, and the overall site median were calculated for all metrics regardless of category association (Combined in Figure 3) and for the specified set of metrics in each category (Biodiversity, SRES and CES in Figure 3). This approach was designed to allow a degree of comparison between the MCM and ecological methodologies. Both methods use a standardised scale, a form of best-case and worst-case scenario, and use multiple metrics to assess Biodiversity, and SRES and CES delivery performance. However, they are not directly equivalent because of: (a) differences between the MCM options and ecological sites, (b) different assessment metrics used to assess Biodiversity, and SRES and CES delivery performance for the MCM and ecological methods. Moreover, (c) the ecological data are limited by the maximum score recorded at our study sites while the MCM approach is not.

3 | RESULTS

3.1 | Exploring the needs of people and nature in South-East England

Of the 67 appraisal criteria volunteered by MCM interviewees, just over 70% of these (49) are conceptually aligned to the various categories of Biodiversity and Ecosystem Services used in the analysis: Biodiversity (n = 14), SRES (n = 7), PES (n = 13), CES (n = 13) and Cross-cutting ES (n = 2), see Supporting Information (SI4-MCM Ranks and Subrank Charts). The remaining Residual criteria (n = 18) are related to different aspects of 'Viability' (including Financial, Political and Practical) and 'Desirability' (including Ethics and Efficiency/Effectiveness).

Of the 14 criteria relating to biodiversity, both diversity of habitats and diversity of species were frequently mentioned and generally distinguished from each other, with diversity being universally understood as a positive feature. In addition to two mentions of specific target habitats (chalk downland, woodland, marsh/bog) and key/rare species (insects and pollinators), interviewees were concerned with habitat and species diversity more generally, across a variety of habitats and species.

Of the seven criteria relating to SRES, soil health (construed in terms of fertility, sustainability, regeneration, carbon sequestration and capacity for climate regulation) featured much more prominently (i.e. within five criteria, each volunteered by different participants) than any other issues that were mentioned, which included air quality, water quality, flood water management and climate change

objectives. In contrast, two interviewees focused on ecological processes which relate more directly to supporting services, mentioning the importance of 'interactions between plants and animals' (landowner from Council) and the maintenance of 'healthy ecosystems' (director of Tablehurst).

Of the 13 criteria that relate to PES, food dominated. Indeed, with 11 separate criteria relating to it, the provision of food was considered in terms of both its utilitarian value (relating to quality, quantity and variety), as well as its contribution towards extrinsic values (such as affordability, security and sustainability). Otherwise, only energy provision (generation of renewable energy balanced against fossil fuel use) and water availability (sustainability of abstractions and quality/degree of pollution) were volunteered as criteria of this sort.

Education and health emerged as the most prominent concerns across the 13 criteria that were found to correspond to CES. Education was construed in terms of learning opportunities for both members of the public and farmers, whereas health was construed in terms of public access to the countryside for exercise and recreation, rather than a concern for the occupational health of farmers. Both engagement of the local community in the running of the site, as well as the development of rural (particularly agricultural) infrastructures, were also given a place within these criteria by multiple interviewees, while only one interviewee mentioned 'Beauty', volunteering it as a criterion in its own right (landowner from Knepp).

The 18 criteria that do not directly relate to the ecosystem service categories included criteria about the basic desirability of different approaches and the viability of these approaches. Desirability includes the issue of animal welfare, mentioned by four interviewees, and the issue of the relative efficiency and effectiveness of the options—or 'land use intensity' (University of Sussex lecturer). Criteria relating to the viability of the different approaches relate predominantly to finances, but also include factors such as consumer behaviour (grazing manager for Surrey Wildlife Trust), reputational benefits (conservation manager for South East Water), the availability of expertise (agricultural adviser for a National Government department), political support (conservation manager for a local authority) and the suitability of the options' locations in relation to their surroundings (ibid.).

3.2 | Which land uses deliver for people and nature?

3.2.1 | Stakeholder perspectives on the performance of land management options

Across all biodiversity and ecosystem service categories and perspectives, the Agroecological Farm option outperformed other land use and management options (Figure 2), scoring higher rank means versus the other options. Looking between perspectives shows that this pattern of performance is driven by several different factors. For conservationists, the principal driver is very low scores (indicating aversion) for the Conventional Farm option (Figure S5, Supporting Information SI4). For farmers, the principal
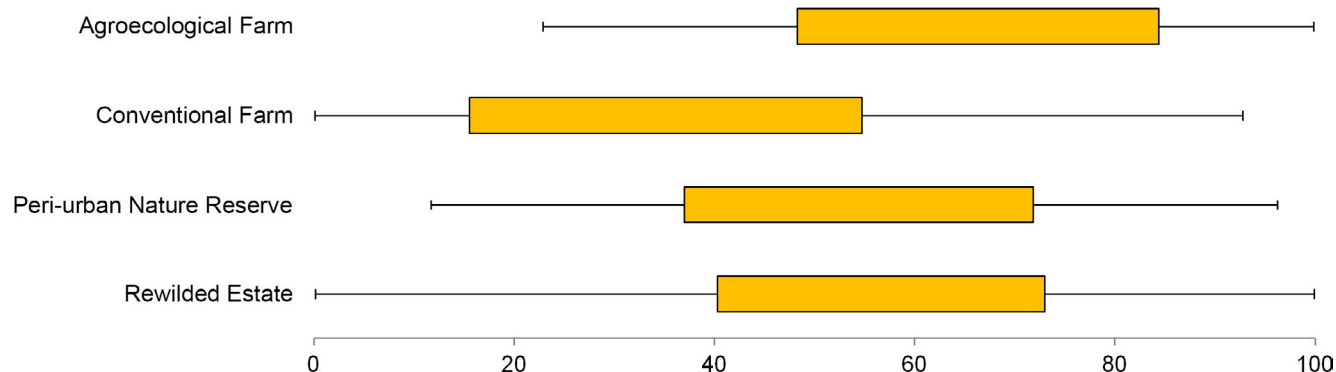
FIGURE 2 Multi-Criteria Mapping rank chart showing the aggregate ranks for the core options, calculated using pessimistic (hypothetical worst-case scenario) and optimistic (hypothetical best-case scenario) scores assigned by all perspectives using all criteria. The 'rank extrema' (black bars) represent the full variability in the ranks assigned by different participants, and the 'rank means' (orange boxes) the distribution of participants' ranks within the full ranges
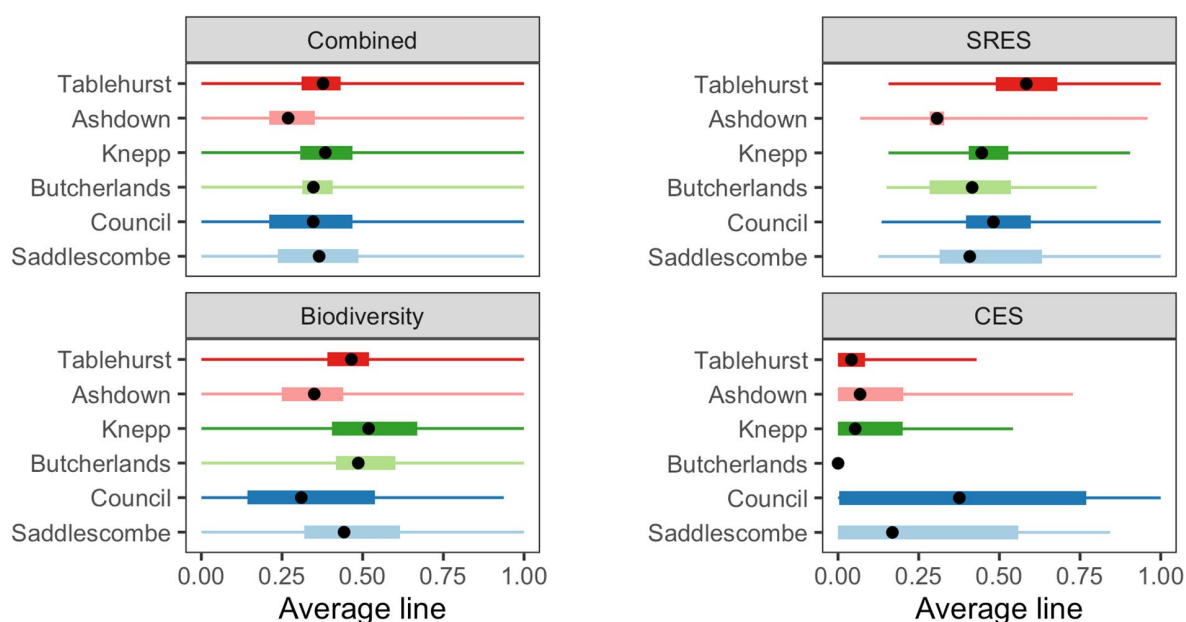

FIGURE 3 Standardised summary of site performance for all metrics ('Combined'), and sets of metrics for 'Biodiversity', Supporting and Regulating Ecosystem Services ('SRES') and Cultural Ecosystem Services ('CES') categories. Line ends represent each site's maximum and minimum plot score, box ends represent the highest and lowest plot mean scores for the relevant metrics, and black points represent the overall site median for the relevant metrics in each category across all plots. A score of 1 represents the highest scoring plot for each metric, and score of 0 is an absolute zero for that metric. Colour indicates site: Tablehurst—Agroecological Farm 1, Ashdown—Conservation Site 1, Knepp—Rewilding Estate, Butcherlands—Conservation Site 2, Council—Peri-urban Nature Reserve, Saddlescombe—Agroecological Farm 2

driver is high scores (preference) for the Agroecological Farm option (Figure S6, Supporting Information SI4). Looking across perspectives but between categories, other drivers emerge. Under biodiversity-related criteria only, the Conventional Farm performs poorly, while the Rewilded Estate and Peri-urban Nature Reserve both outperform the Agroecological Farm. Under SRES-related criteria only, the Conventional Farm also performs poorly, but the Agroecological Farm performs best. Under PES-related criteria only, the Agroecological Farm performs well but is outperformed by the Conventional Farm. Finally, despite high scores for the Peri-urban Nature Reserve, the Agroecological Farm scores are

the highest under CES-related criteria only (Figure S7, Supporting Information SI5).

3.2.2 | Site performance for people and nature

A numerical summary of the described below is available in Table B (Supporting Information SI3). When analysing site performance across all metrics, all sites are making important contributions to the needs of people and nature (i.e. all sites have plots that score a maximum score of 1 for at least one metric; Figure 3). There was a

wide variability in performance for all metrics across the four plots at each site, with all sites having plots that perform the best and worst for at least one Biodiversity or SRES metric (Figure 3). Our CES and PES metrics, limited to recreation and meat production, respectively, mean Peri-urban and agricultural sites dominate these ecosystem services respectively.

3.2.3 | Site performance for nature

Species richness, abundance, diversity and protection metrics
All sites except for Council have at least one plot that scored the highest for at least one taxon-specific species-focused metric (Figure 3). Council and Butcherlands on average perform similarly and marginally better across the biodiversity metrics compared to other sites. Tablehurst and Saddlescombe are also strong performers, on average performing marginally better than their paired sites.

In total, 146 species or morphospecies were recorded across all taxa, across all sites. Tablehurst (83), Knepp (79) and Butcherlands (76) recorded the highest species richness, while Saddlescombe (65), Ashdown (63) and Council (60) were not quite as rich. The highest recorded animal activity was at Knepp (15,265 recordings) and Butcherlands (11,722 recordings). This was primarily driven by the high number of bird vocalisations recorded (14,918 and 11,336

respectively). Butcherlands had the highest level of bat activity (234 passes), and Tablehurst recorded the highest total abundance of invertebrates (240 individuals). Mean Shannon's Diversity Index scores varied from 0.14 for wild mammals at Ashdown to 2.54 for birds at Tablehurst (Figure 4). Tablehurst performed consistently well, ranking first for bat, bird, and invertebrate diversity and second for mammals. We recorded the greatest number of species of conservation focus (i.e. with national or European conservation status) at Ashdown: the grey long-eared bat *Plecotus austriacus*, the serotine bat *Eptesicus serotinus*, the meadow pipit *Anthus pratensis*, the Dartford warbler *Sylvia undata* and a hoverfly *Xylota abiens*. Nathusius's pipistrelle *Pipistrellus nathusii* was also recorded at Butcherlands and Knepp, the herring gull *Larus argentatus* at Council and Saddlescombe, and the turtle dove *Streptopelia turtur* at Knepp and Butcherlands.

Habitat diversity
At a landscape scale (100-m radius areas around each plot), the vegetation structure of the sites was broadly similar. They all contain a mixture of predominantly ground vegetation (vegetation height ≤50 cm), with a lesser coverage of shrubs (>50 and ≤200 cm) and trees (>200 cm). For most sites, except for Council and Ashdown, this structure is primarily driven by an active or remnant field and hedgerow structure. At the plot scale (30 × 30 m plot), there is a clear difference in vegetation structure between sites. Shrubs are
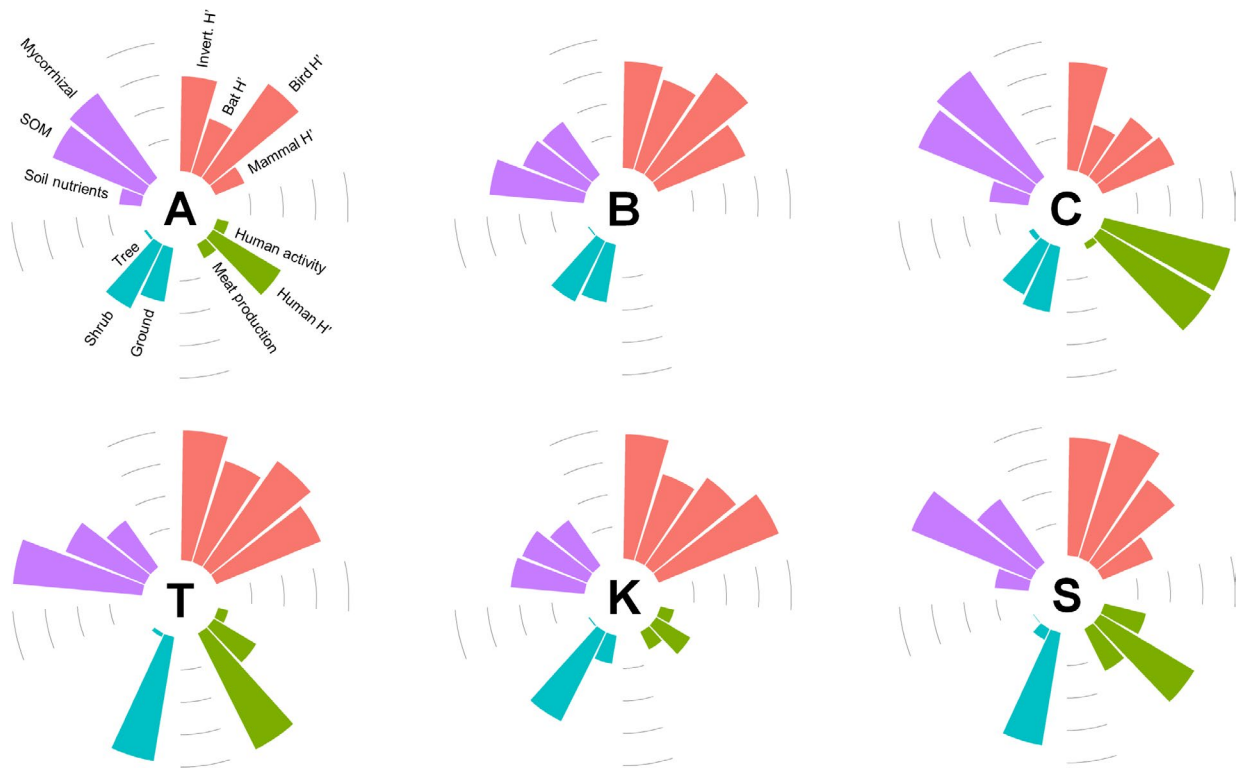

FIGURE 4 Biodiversity (red; invertebrate, bat, bird and mammal H' diversity index), human use (green; human activity, H' activity diversity index and meat production), vegetation structure (blue; plot scale proportion ground, shrub or tree layer) and soil health (purple; mycorrhizal colonisation, soil organic matter and phosphorus) measured at the six study sites: Ashdown—Conservation Site 1 (A), Butcherlands—Conservation Site 2 (B), Council—Peri-urban Nature Reserve (C), Tablehurst—Agroecological Farm 1 (T), Knepp—Rewilding Estate (K) and Saddlescombe—Agroecological Farm 2 (S). Each score is the mean across the four plots for each site, except for meat production which is a site estimate. Each category has been scaled against the maximum value recorded across the six sites

more prevalent in plots at Knepp (mean 77%), Ashdown (55%) and Butcherlands (52%), while ground vegetation dominates at the agro-ecological farms: Tablehurst (97%) and Saddlescombe (88%). Plots on Council have the most inter-plot diversity of vegetation structure with ground vegetation and shrubs well-represented (Figure 4).

Beta diversity

Within site (i.e. between plots situated on the same site) species dissimilarity varied from 0.32 on Butcherlands to 0.67 on Council. Between site (i.e. between plots situated on different sites) beta diversity varied from 0.53 for Tablehurst to 0.64 for Council. Despite having low overall species richness, both within sites and between sites, Council had the greatest dissimilarity of species recorded. All sites had average between-site dissimilarity >0.5 (mean 0.56), indicating important variation in species records between sites. Within-site dissimilarity was lower (mean 0.45) but still variable, highlighting the variability between plots within site.

Supporting and Regulating Ecosystem Services

Our SRES metrics, all relating to soil, record Tablehurst as the highest performing site, and noticeably higher compared to its paired site Ashdown (Figure 3). Soil fertility (nutrient availability in the soil) was found to be low via the DEFRA Index Scale at five of the six sites (Figure 4), averaging very low (Ashdown) to low across the major nutrients: phosphorus, potassium and magnesium (DEFRA, 2010). The highest levels were recorded at Tablehurst (moderate to high), and these relatively higher nutrient levels are the reason for the overall higher performance of Tablehurst across the SRES measures. For SOM and Mycorrhizal levels, Ashdown, Council and Saddlescombe performed particularly well. Butcherlands and Knepp performed very similarly across the metrics, and Tablehurst had similar levels of SOM and Mycorrhizal levels to these sites.

Cultural Ecosystem Services

The CES metrics used to create Figure 3 are limited to record human use and activity at the plots. As such the sites close to Brighton and Hove, a city with a population of ~300,000 people performed particularly well. The camera traps recorded five times more people (960) than wild mammals (171) across the six sites. Human activity recordings were dominated by two plots on Council (328 and 245) and one plot on Saddlescombe (179). A diverse range of activities were recorded across the sites including walking, dog walking, jogging, cycling and horse riding. The highest diversity of activities also took place at the high use plots on
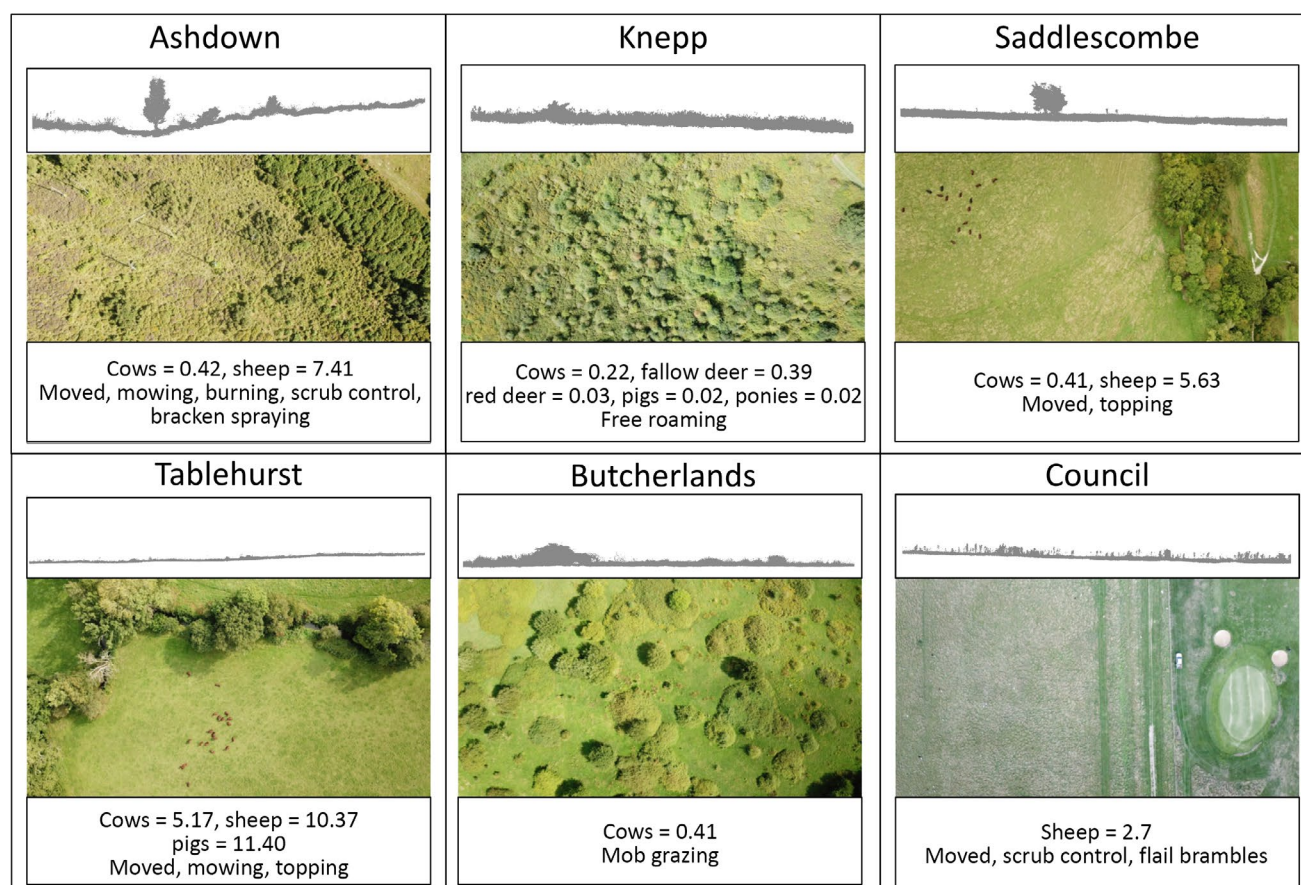

FIGURE 5 Examples of the vegetation structure and habitat types recorded at the six study sites. Cross sections generated via LiDAR mapping and aerial photographs via drone surveying. Also shown is the stocking densities (individuals per hectare) and management practices of the six sites derived from management surveys. Ashdown—Conservation Site 1, Knepp—Rewilding Estate, Saddlescombe—Agroecological Farm 2, Tablehurst—Agroecological Farm 1, Butcherlands—Conservation Site 2 and Council—Peri-urban Nature Reserve

Council and Saddlescombe (Figure 4). Human activity was highly variable with 10 plots recording no human activity, and no people were recorded at Butcherlands. It is notable that two Council plots recorded over 200 people and two plots recorded only two people. At Saddlescombe, three plots recorded fewer than 10 people and one 179.

Provisioning ecosystem services

Across the sites, harvesting of cattle, sheep, pigs and/or fallow deer was reported. Only from Butcherlands were no livestock harvested. Tablehurst reported harvesting 50 cattle per year (0.23 cattle ha^{-1} year^{-1}), considerably greater than other sites (Figure 5). Total production for all livestock species was estimated for each site using a standardised estimated body weight for each species (Supporting Information SI1) and based on self-reported data. This was greatest at Tablehurst (121 kg ha^{-1} year^{-1}; Figure 4). At the other sites where livestock were harvested, production ranged from 6 kg ha^{-1} year^{-1} on Council land to 44 kg ha^{-1} year^{-1} at Saddlescombe.

All five sites producing meat sold their meat at above market prices. In particular, Tablehurst (beef and pork), Ashdown (beef and lamb) and Knepp (beef and venison) receive a large premium, with their prices being approximately threefold that of the national average (beef and lamb: AHDB, 2016, pork: AHDB, 2018, venison: SRUC, 2019).

4 | DISCUSSION

4.1 | Summary

The criteria our stakeholders identified to appraise the performance of agroecological farming and biodiversity conservation/restoration sites focused on biodiversity, soil health, food production, and human health and education. Of the four land management options explored in the MCM exercise, the stakeholders ranked the Agroecological Farm the best across the stakeholder-selected appraisal criteria. However, it is also clear there is perceived variation in option performance across the different criteria and from different perspectives. This means agroecological farming is not perceived to be the best or most favoured land use to meet *all* the separate needs of people and nature, but is perceived to be the most multi-functional and best compromise. To some extent, our ecological studies support this perception when focusing only on food production and biodiversity conservation. For example, Tablehurst was notable in having the highest meat production and recording the highest total species richness as well as performing well across the species diversity metrics. However, when taking into account all the stakeholder criteria measured, the overall site performances were very similar to each other because of the variation in site performance across the full diversity of metrics. In the context of the UN's Decade of Ecosystem Restoration, our results suggest consideration should be given to how a diversity of land management and restoration approaches, along the spectrum of agroecological farming to nature conservation, can be supported to create ecosystems that can provide diverse benefits for people and nature.

4.2 | What do people and nature need and want from agroecological and conservation land in South-East England?

The 67 appraisal criteria recorded in the MCM exercise suggest that in South-East England agroecological and conservation land management can at least be assessed against: (a) the amount and variety of affordable, high-quality food produced, (b) the richness, abundance, diversity,and rarity of species and habitats supported, (c) the quality of soil and water sustained, (d) the contribution to flood mitigation and carbon sequestration, (e) the health and educational benefits provided to visitors and staff and, (f) the financial viability and ethical standards of the operation. This breadth of potential appraisal criteria represents the considerable diversity of people and nature's needs and desires. This diversity presents a considerable challenge to policymakers seeking to transform land management subsidy payments to the principle of 'public money for public goods and services', as has been proposed in the United Kingdom's new Agricultural Bill and the associated Environmental Land Management scheme (DEFRA, 2020). Can all needs and desires be supported and which should be prioritised may be difficult questions to address. This challenge is compounded by the difficulty of designing and selecting appropriate metrics and targets when a diversity of outcomes is needed. These issues have long been challenges in bio*diversity* conservation (Jones et al., 2011; Pereira et al., 2013). Despite the challenges created by the need for diverse outcomes, it is important to keep complexity within decision-making (Stirling, 2010) and avoiding over-simplifying the discussion, as has arguably happened in the 'land sharing versus sparing' debate (Fischer et al., 2014). Our study not only makes this explicit, but also offers a means for these to be considered in a systematic way.

4.3 | Which agroecological farming and conservation land management approaches are delivering those needs?

All sites are making contributions to providing a home for nature and have good soil quality and all sites except Butcherlands are provisioning meat produce and recorded people using the site. Despite the good individual site performances, it is perhaps more important to consider the collective performance of our sites and how they complement each other, in order to highlight the synergies and trade-offs between different land management options:

Ashdown and Tablehurst are geographically close but differ in their soil, vegetation structure, species composition and landscape appearance (Figure 5). Tablehurst has the fertile soil, vegetation structure and large herbivore stocking densities to produce more meat compared to our other sites, while supporting relatively high species richness and diversity. In contrast, Ashdown has comparatively infertile soil that supports some regionally rare habitat and species not supported by other sites, but also with lower large

herbivore stocking densities and levels of food production. Data from these sites suggest that the higher large herbivore stocking densities we investigated are not incompatible with supporting a biodiverse and multi-functional environment, but that these conditions are not suitable for all species and habitats.

Knepp and Butcherlands are similar in many metrics, despite differences in their large herbivore management strategies. Butcherlands is a relatively small site (39 ha) and livestock are moved in and out of site to create temporally diverse grazing and browsing dynamics. Knepp's southern block is relatively large in comparison (421 ha) and supports a higher variety of permanent large herbivores but with spatially diverse grazing and browsing dynamics (Dando, 2018). It is worth noting that after conventional agricultural practices ceased at Knepp, there followed a period of large herbivore absence (3–8 years, as fields were taken out of production in different years) which allowed a period of vegetation community reestablishment. The comparison between these sites highlights the potential for reducing the frequency and intensity of human management with increasing size of site when working with natural processes (Sandom et al., 2013).

Council and Saddlescombe perform similarly across the metrics, although Saddlescombe performed slightly better in the biodiversity and food production metrics and Council scoring better on the recreation metrics. As the only sites close to a city, both sites recorded very high human activity. However, this was concentrated on certain plots indicating highly variable intensity of human recreational use across the sites. Council is notable as the only site not to stock cattle. Both sites performed particularly well for soil quality, with high soil organic matter. These finding suggest that multi-functional land management is possible in areas with high human activity.

Collectively our sites are delivering a variety of complementary benefits to people and nature, indicating considerable synergies between agroecological farming and biodiversity conservation. In this sense, all of our sites are arguably both agroecological and conservation sites to differing degrees, with Butcherlands being the most conservation-orientated site and Tablehurst being the most agroecological site. Ashdown and Tablehurst offer the starkest example of trade-offs between desired outcomes and highlight the importance of diverse land management practices. Butcherlands and Knepp indicate that similar outcomes are possible by adapting management to the context of the site, in this case altering livestock management to account for the different size of each site.

It is also important to note that our selection of sites and metrics limits our overall understanding of synergies and trade-offs between land management options. For example, our sites are not maximising food production and the price premiums on meat produced indicate collectively that they are not producing high quantities of affordable meat products. Nor did we assess the full variety of criteria and metrics such as the financial viability or ethical standards of the operation. Adding more conventional forms of agriculture and increasing the criteria studied to the research design would help expand the scope of the study to further

understand the synergies and trade-offs between these land management strategies at a regional scale.

4.4 | Did our mixed and interdisciplinary methodology work?

We designed the project with ambitions of conducting a broad sustainability assessment, albeit with a bias towards meat production and biodiversity conservation. While we were not able to cover all criteria highlighted by the MCM interviewees in our site surveying, our coverage was broad (Table A, Supporting Information SI2). The range of biodiversity criteria described by our interviewees relates well to both a set of 'essential biodiversity variables' reported by Pereira et al. (2013), and the biodiversity metrics we analysed through ecological field measures. However, our biodiversity metrics were a snapshot in time and limited to four taxonomic groups. Financial and logistical constraints prevented this exploratory study from monitoring additional taxonomic groups for a longer period, for example, the entire breeding season (and hence, peak activity) of all the study groups (e.g. Balfour et al., 2018). Unfortunately, the true costs of long-term monitoring are commonly underestimated (Caughlan & Oakley, 2001). Our experiences indicate that despite recent advances in ecological monitoring techniques (e.g. bat and bird acoustics, camera trapping), field-based, simultaneous, long-term measurement of multiple biodiversity metrics across multiple sites will be limited by financial constraints.

Our measures of food provision were even more limited as compared to the criteria described by participants. Interviewees highlighted the quantity of provision, which we were able to estimate, but also meat quality (taste, nutrition, carcass quality and safety), variety (including non-meat products), sustainability of supply (financial and environmental), affordability, availability, food security (locally, nationally, globally) and prioritisation, which we did not measure at our study sites. Within SRES, soil was a notable consideration for many interviewees that was highlighted as a priority in the first stakeholder engagement workshop and was added to our ecological field study as a result. A variety of CES were also highlighted as important success criteria, including recreational access, which we were able to measure by proxy, but also education, community involvement, opportunities for social care, support for rural communities, employment opportunities and retaining traditional knowledge, which were not quantified.

We are aware that many other categories of ES are delivered from these sites beyond those recorded. Our intention is that the selection of services reported herein provides an indication of the different types of benefits that can be delivered from each site—focusing on those services that were found to be most relevant to a range of stakeholders from the South-East of England. Unfortunately, ecosystem management is a wickedly complex, multifaceted problem (DeFries & Nagendra, 2017) and the cost, resources and time required to monitor biodiversity, ES and other key variables are likely to be prohibitively expensive and present a challenge to

policies seeking to ensure that public money is spent on delivering public goods and services (DEFRA, 2020).

4.5 | Implications for policy

Our results suggest that challenges for delivering a land management subsidy scheme that uses public money to deliver public goods and services include: (a) identifying what people and nature need in any particular location, (b) prioritising support appropriately in space and time and (c) identifying monitoring metrics and targets to assess whether land management is meeting society's needs while also maintaining healthy and sustainable ecosystems. If these challenges can be overcome, this policy frame could help restore diverse ecosystems, supported by diverse land management practices, that provide for the diverse needs of people and nature.

Further work could incorporate MCM, ecological assessment and Geographic Information Systems (GIS) to enable a more context-sensitive and spatially explicit understanding of these issues and support decision-making within the South-East of England and further afield. Current debates in the United Kingdom provide an opportunity for enhanced interdisciplinary studies such as this to pioneer broader and more flexible methods that can cater for locally specific needs. These could in turn inform decision processes across the EU and at the level of individual EU Member States, and also contribute to more diverse international efforts during the UN Decade of Ecosystem Restoration.

CONFLICT OF INTEREST
The authors have no conflict of interest to declare.

AUTHORS' CONTRIBUTIONS
C.J.S. and R.D. conceived the idea; N.J.B., R.D. and C.J.S. collected and analysed the data, and led the writing of the manuscript. All the authors developed the study, designed the methodology, contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT
Data associated with this manuscript are accessible at Figshare https://doi.org/10.25377/sussex.13536497 (Balfour et al., 2021).

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REFERENCES
AHDB. (2016). *Beef & Lamb Stocktake Report 2016*. The Agriculture and Horticulture Development Board.

AHDB. (2018). *UK Pork Yearbook 2018*. The Agriculture and Horticulture Development Board.

Asner, G. P., Elmore, A. J., Olander, L. P., Martin, R. E., & Harris, A. T. (2004). Grazing systems, ecosystem responses, and global change. *Annual Review of Environment and Resources*, *29*, 261–299. https://doi.org/10.1146/annurev.energy.29.062403.102142

Baker, P. J., Boitani, L., Harris, S., Saunders, G., & White, P. C. L. (2008). Terrestrial carnivores and human food production: Impact and management. *Mammal Review*, *38*, 123–166. https://doi.org/10.1111/j.1365-2907.2008.00122.x

Bakker, E. S., Gill, J. L., Johnson, C. N., Vera, F. W. M., Sandom, C. J., Asner, G. P., & Svenning, J. C. (2016). Combining paleo-data and modern exclosure experiments to assess the impact of megafauna extinctions on woody vegetation. *Proceedings of the National Academy of Sciences of the United States of America*, *113*, 847–855. https://doi.org/10.1073/pnas.1502545112

Balfour, N. J., Durrant, R., Ely, A., & Sandom, C. J. (2021). Data from: People, Nature and Large Herbivores in a shared landscape: A mixed-method study of the ecological and social outcomes from agriculture and conservation. *Figshare*, https://doi.org/10.25377/sussex.13536497

Balfour, N. J., Ollerton, J., Castellanos, M. C., & Ratnieks, F. L. (2018). British phenological records indicate high diversity and extinction rates among late-summer-flying pollinators. *Biological Conservation*, *222*, 278–283. https://doi.org/10.1016/j.biocon.2018.04.028

Caughlan, L., & Oakley, K. L. (2001). Cost considerations for long-term ecological monitoring. *Ecological Indicators*, *1*, 123–134. https://doi.org/10.1016/S1470-160X(01)00015-2

Coburn, J., & Stirling, A. (2016). *Multicriteria Mapping Manual - Version 2.0, SPRU Working Paper SWPS 2016–21*. Retrieved from https://www.sussex.ac.uk/webteam/gateway/file.php?name=2016-21-swps-coburn-et-al.pdf&site=25

Dando, T. (2018). *Drivers and impacts of large herbivore foraging behaviour in a rewilded landscape* (Masters thesis). University of Sussex.

DEFRA. (2010). *The fertiliser manual* (8th ed.) (RB209).

DEFRA. (2018). *A Green Future: Our 25 Year Plan to Improve the Environment*.

DEFRA. (2020). *Environmental land management policy discussion document*, February 2020. Retrieved from https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf

DeFries, R., & Nagendra, H. (2017). Ecosystem management as a wicked problem. *Science*, *356*, 265–270. https://doi.org/10.1126/science.aal1950

Díaz, S., Settele, J., Brondízio, E. S., Ngo, H. T., Agard, J., Arneth, A., Balvanera, P., Brauman, K. A., Butchart, S. H. M., Chan, K. M. A., Garibaldi, L. A., Ichii, K., Liu, J., Subramanian, S. M., Midgley, G. F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., ... Zayas, C. N. (2019). Pervasive human-driven decline of life on Earth points to the need for transformative change. *Science*, *366*(6471). https://doi.org/10.1126/science.aax3100

FAO. (2015). *The State of Food Insecurity in the World (2015). Meeting the 2015 international hunger targets: Taking stock of uneven progress*. FAO. Retrieved from http://www.fao.org/3/a-i4646e.pdf

Fischer, J., Abson, D. J., Butsic, V., Chappell, M. J., Ekroos, J., Hanspach, J., Kuemmerle, T., Smith, H. G., & von Wehrden, H. (2014). Land

sparing versus land sharing: Moving forward. *Conservation Letters*, 7, 149–157. https://doi.org/10.1111/conl.12084

Gilbert, M., Nicolas, G., Cinardi, G., Van Boeckel, T. P., Vanwambeke, S. O., Wint, G. R. W., & Robinson, T. P. (2018). Global distribution data for cattle, buffaloes, horses, sheep, goats, pigs, chickens and ducks in 2010. *Scientific Data*, 5, 180227. https://doi.org/10.1038/sdata.2018.227

Haines-Young, R., & Potschin, M. (2008). *England's terrestrial ecosystem services and the rationale for an ecosystem approach.* Full Technical Report. DEFRA.

IPBES. (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (S. Díaz, J. Settele, E. S. Brondízio, H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y. J. Shin, I. J. Visseren-Hamakers, K. J. Willis, & C. N. Zayas, [Eds.]). IPBES Secretariat.

Jones, J. P. G., Collen, B., Atkinson, G., Baxter, P. W. J., Bubb, P., Illian, J. B., Katzner, T. E., Keane, A., Loh, J., Mcdonald-Madden, E., Nicholson, E., Pereira, H. M., Possingham, H. P., Pullin, A. S., Rodrigues, A. S. L., Ruiz-Gutierrez, V., Sommerville, M., & Milner-Gulland, E. J. (2011). The why, what, and how of global biodiversity indicators beyond the 2010 target. *Conservation Biology*, 25, 450–457. https://doi.org/10.1111/j.1523-1739.2010.01605.x

Kleijn, D., Rundlöf, M., Scheper, J., Smith, H. G., & Tscharntke, T. (2011). Does conservation on farmland contribute to halting the biodiversity decline? *Trends in Ecology & Evolution*, 26(9), 474–481. https://doi.org/10.1016/j.tree.2011.05.009

Linstead, C., Barker, T., Maltby, E., Kumar, P., Mortimer, M., Plater, A., & Wood, M. (2008). *Reviewing targets and indicators for the ecosystem approach.* Final Report. University of Liverpool, Institute for Sustainable Water, Integrated Management and Ecosystem Research.

Mace, G. M., Norris, K., & Fitter, A. H. (2012). Biodiversity and ecosystem services: A multilayered relationship. *Trends in Ecology & Evolution*, 27, 19–26. https://doi.org/10.1016/j.tree.2011.08.006

MEA. (2005). *Millenium Ecosystem Assessment Ecosystems And Human Well-Being: Synthesis*. Island Press.

NFU. (2019). *National Farmers Union, Achieving Net Zero, Farming's 2040 Goal Report*. Retrieved from https://www.nfuonline.com/nfu-online/news/nfu-reports/achieving-net-zero-farmings-2040-goal

NNH. (2020). *Nature needs half*. Retrieved from https://natureneedshalf.org

Pereira, H. M., Ferrier, S., Walters, M., Geller, G. N., Jongman, R. H. G., Scholes, R. J., Bruford, M. W., Brummitt, N., Butchart, S. H. M., Cardoso, A. C., Coops, N. C., Dulloo, E., Faith, D. P., Freyhof, J., Gregory, R. D., Heip, C., Hoft, R., Hurtt, G., Jetz, W., … Wegmann, M. (2013). Essential biodiversity variables. *Science*, 339, 277–278. https://doi.org/10.1126/science.1229931

Pereira, H. M., Navarro, L. M., & Martins, I. S. (2017). Global biodiversity change: The bad, the good, and the unknown. *Annual Review of Environment and Resources*, 2012(37), 25–50.

Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M., & Rieseberg, L. H. (2018). Trends in global agricultural land use: Implications for environmental health and food security. *Annual Review of Plant Biology*, 69, 789–815. https://doi.org/10.1146/annurev-arplant-042817-040256

Sandom, C., Donlan, C. J., Svenning, J. C., & Hansen, D. (2013). Rewilding. *Key Topics in Conservation Biology*, 2, 430–451.

Sandom, C. J., Ejrnaes, R., Hansen, M. D. D., & Svenning, J. C. (2014). High herbivore density associated with vegetation diversity in interglacial ecosystems. *Proceedings of the National Academy of Sciences of the United States of America*, 111, 4162–4167. https://doi.org/10.1073/pnas.1311014111

Sandom, C. J., Faurby, S., Svenning, J. C., Burnham, D., Dickman, A., Hinks, A., Macdonald, E. A., Ripple, W., Williams, J., & Macdonald, D. (2017). Learning from the past to prepare for the future: Felids face continued threat from declining prey. *Ecography*, 41, 140–152. https://doi.org/10.1111/ecog.03303

Schulte, R. P., O'Sullivan, L., Vrebos, D., Bampa, F., Jones, A., & Staes, J. (2019). Demands on land: Mapping competing societal expectations for the functionality of agricultural soils in Europe. *Environmental Science & Policy*, 100, 113–125. https://doi.org/10.1016/j.envsci.2019.06.011

Smith, F. A., Elliott, S. M., & Lyons, S. K. (2010). Methane emissions from extinct megafauna. *Nature Geoscience*, 3, 374–375. https://doi.org/10.1038/ngeo877

Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B. L., Lassaletta, L., de Vries, W., Vermeulen, S. J., Herrero, M., Carlson, K. M., Jonell, M., Troell, M., DeClerck, F., Gordon, L. J., Zurayk, R., Scarborough, P., Rayner, M., Loken, B., Fanzo, J., … Willett, W. (2018). Options for keeping the food system within environmental limits. *Nature*, 562, 519. https://doi.org/10.1038/s41586-018-0594-0

. SRUC. (2019). *Scotland's Rural College, Red Deer - Finishing Stags for Venison*. Retrieved from https://www.sruc.ac.uk/info/120183/alternative_livestock/289/red_deer_-_finishing_stags_for_venison/4

Stirling, A. (2007). A general framework for analysing diversity in science, technology and society. *Journal of the Royal Society Interface*, 4, 707–719. https://doi.org/10.1098/rsif.2007.0213

Stirling, A. (2010). Keep it complex. *Nature*, 468, 1029–1031. https://doi.org/10.1038/4681029a

Stirling, A., & Coburn, J. (2014). *Multicriteria Mapping Manual*. Version 1.0. Version, 1. Retrieved from www.sussex.ac.uk/spru/documents/2014-11-swps-mcm-manual-1-0.pdf

Svenning, J. C., Pedersen, P. B. M., Donlan, C. J., Ejrnaes, R., Faurby, S., Galetti, M., Hansen, D. M., Sandel, B., Sandom, C. J., Terborgh, J. W., & Vera, F. W. M. (2016). Science for a wilder Anthropocene: Synthesis and future directions for trophic rewilding research. *Proceedings of the National Academy of Sciences of the United States of America*, 113, 898–906. https://doi.org/10.1073/pnas.1502556112

Thompson, K., & Jones, A. (1999). Human population density and prediction of local plant extinction in Britain. *Conservation Biology*, 13, 185–189. https://doi.org/10.1046/j.1523-1739.1999.97353.x

UK Parliament. (2020a). *30 by 30 Announcement*. Retrieved from https://www.gov.uk/government/news/pm-commits-to-protect-30-of-uk-land-in-boost-for-biodiversity

UK Parliament. (2020b). *Agriculture Bill 2019–21*. Retrieved from https://services.parliament.uk/bills/2019-21/agriculture.html

UK Parliament. (2020c). *Environment Bill 2019–21*. Retrieved from https://services.parliament.uk/bills/2019-21/environment.html

UN. (2020). *Decade on ecosystem restoration*. Retrieved from https://www.decadeonrestoration.org

WallisDeVries, M. F., Bakker, J. P., & Van Wieren, S. E. (1998). *Grazing and conservation management*. Springer Science & Business Media.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.