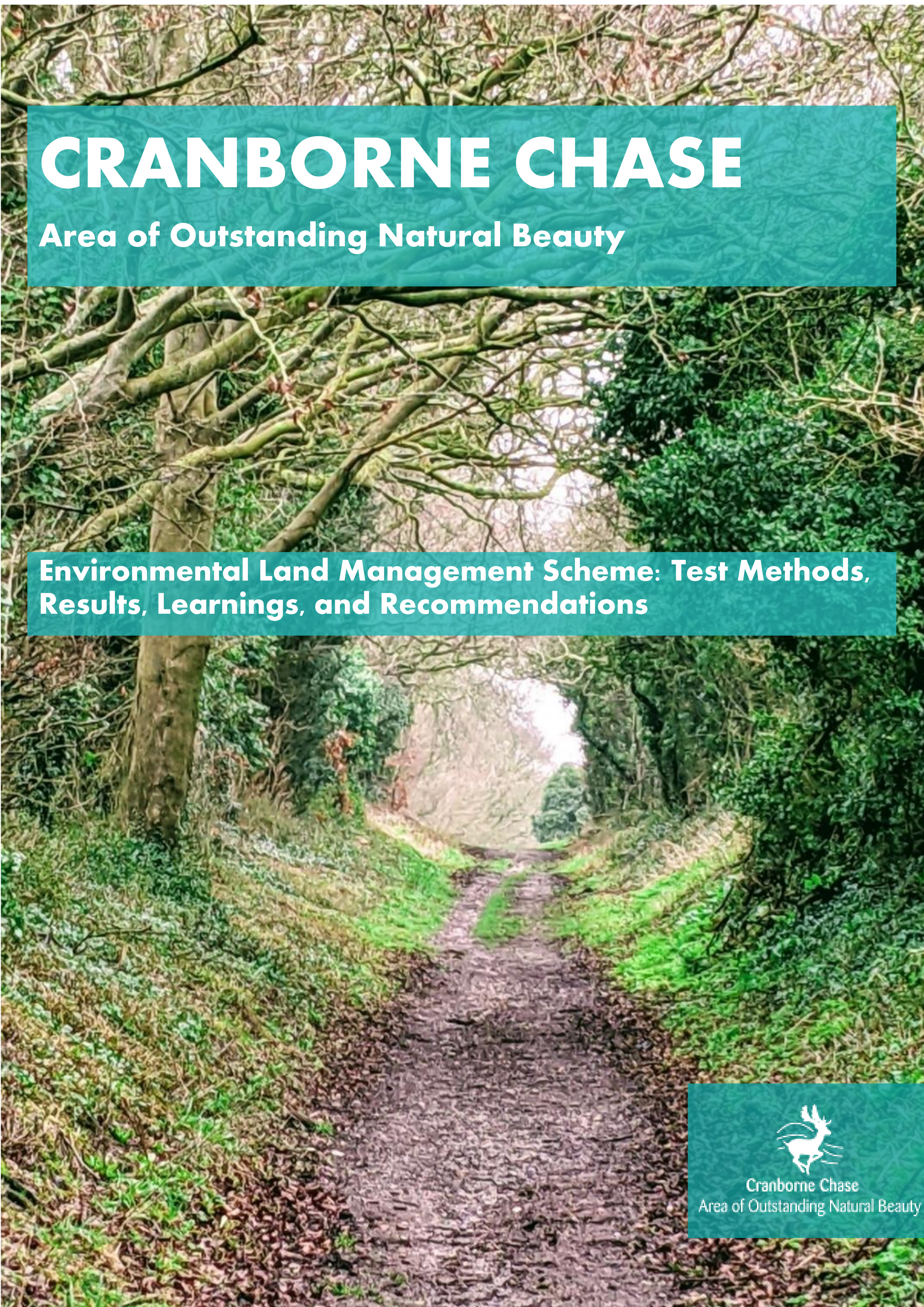

CRANBORNE CHASE

Area of Outstanding Natural Beauty

Environmental Land Management Scheme: Test Methods, Results, Learnings, and Recommendations

Cranborne Chase
Area of Outstanding Natural Beauty

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EXECUTIVE SUMMARY

A summary of the study, methods and key learning points are provided below.

Introduction

The Cranborne Chase Area of Outstanding Natural Beauty (CCAONB) Environmental Land Management (ELM) Test builds on the successful farmer cluster work throughout the region and the good relationships with local farmers. The strategic objective for the Test was to co-design the Land Management Plans derived from guidance and objectives in the CCAONB Management Plan. To do this, we reviewed the plan, particularly Chapter 7–Landscape Character; Chapter 9–Natural Environment and Chapter 12–Rural Land Management, to ensure components of the chapters were integrated into the plan. However, the CCAONB Management Plan is a strategic level, broad-brush document so there is not any specific or detailed guidance for farmers in each character area. The CCAONB Test asked farmers to consider what they want to do in terms of delivering public goods, how to establish baselines, how, what and when to monitor outcomes. The CCAONB Test also included gathering feedback from farmers on current and past agri-environment schemes.

Methodology

The CCAONB Test adopted the following methodologies:

- Farmer survey. A survey instrument focused on the ELMs Test was delivered to all farmers known to the CCAONB in the region.
- Farmer test selection. Farmers participating in the Land Management Plans were chosen based on a diversity of farm size, farm type (e.g., arable, diary, and beef cattle production), landscape type, participation in environmental land and countryside stewardship schemes, and farmer willingness to participate in the Test.
- Land Management Plan development. We co-developed the Land Management Plans with each farmer tailoring them to meet their needs, farm operations, and stewardship practices (both current and aspirational).
- Natural capital assessment. We performed a natural capital assessment for each farm using a spatial modelling tool that analysed carbon storage, flood mitigation, air purification, and pollination.
- Field surveys and farmer knowledge. The spatial analysis was complemented by field surveys from avian, invertebrate, and plant experts as well as local knowledge assessments, e.g., hedgerow or riparian habitat quality, by the farmers participating in the Land Management Plans.

Key Learning Points

- Data. Data availability, cost, and standardisation is uneven and challenges accurate measures of values for public goods at the farm scale.
- Natural capital. Modelling and mapping outputs are valuable for analysing natural capital but need to be conveyed in a user-friendly format. Interpretation of output maps must recognise the importance of spatial and temporal scale, while farmer knowledge is a key resource to complement the spatial data.
- Payments. There are serious concerns from farmers over income loss. Further income loss could drive farmers towards increased production and less to stewardship, creating a perverse subsidy. Payments must be fair and equitable and considered across farmer clusters and nature recovery areas.
- Land Management Plans. We found the data collection, testing of rapid survey methodologies, the natural capital assessment, and incorporating farmer knowledge of the landscape to be the most engaging and effective parts of co-developing the Land Management Plans. Although ensuring that the business perspective was part of the Land Management Plans, we found that integrating stewardship practices and changes in a manner compatible with the farm's agronomic and business operations was a more feasible approach.

- **Guidance and focus.** The lack of information and transparency about ELMs has created much uncertainty in the farming community. More guidance from Defra could have helped focus the CCAONB Test and answered more questions for the future of ELMs and, consequently, produced more directed results.
- **Farm succession.** Two of the farms participating in the study are facing succession plans and concerns. Farm succession will also affect how farmers approach ELMs, particularly those farmers nearing retirement.
- **Recreation**. There was little interest by farmers to be paid for recreational or cultural values. However, all of them were interested in maintaining paths and bridleways and all were interested in the opportunity to better connect public access to their farming and stewardship practices through signs and other practices.
- **Trust.** All aspects of the new scheme need to be based on trust between Defra and the farmers participating in true partnership. If an option is not working, then the farmer must be trusted to be able to change it to achieve results. Flexibility in trying new practices and measuring their success will be required.

ACKNOWLEDGEMENTS

We wish to thank Defra, National Association of Areas of Outstanding Natural Beauty, the CCAONB, all the participating farmers, particularly the 6 that completed Land Management Plans, Sandra Angers-Blondin at Liverpool John Moores University, Caspar Donnison at Southampton University, and Neville Kingdon, Lizzie Grayshon, Jessica Brooks, and Jodie Case at the Game and Wildlife Conservation Trust. We received valuable input and advice from Harriet Bell, Jon Burgess, Margaret Feneley, Helen Pengelly, Simon Smart, Peter Thompson, Bryan Pinchen, Harriet Bell, Jon Burgess, Cathy Hopley, Alison Holt, and Colette Beckham. We also recognise the Land App and EcoServeR tools as instrumental in carrying out the CCAONB ELMs Test.

INTRODUCTION

The National Association for Areas of Outstanding Natural Beauty submitted a collaborative proposal comprising some fourteen separate trials to develop an Environmental Land Management Scheme (ELMs) test called Farming for the Nation. The proposed project was collaborative, covered several geographies and sectors, and brought together a series of objectives that each participating AONB wanted to deliver.

The CCAONB ELMs Test builds on the successful farmer cluster work throughout the region and the good relationships with local farmers. The Cranborne Test asked farmers to consider what they wanted to do in terms of delivering public goods, how to establish baselines, how, what and when to monitor outcomes.

Several farms representing different farm types within the AONB took part in the Test. Farm types included large arable, dairy, livestock, organic, and sporting. We assessed the Natural Capital on these representative farms using modelling techniques, taxonomic surveys, as well as input from the farmers. We also considered Information and data to assess potential landscape scale opportunities such as the existence of corridors.

Agreed Land Management Plans were created for the selected landholdings, building on existing farm plans and incorporating a variety of information, with technical advice and support provided by the CCAONB and the consultants involved in the project.

METHODOLOGY

The CCAONB Test consisted of several different steps aimed at garnering farmer input, compiling spatial data on natural capital, and developing Land Management Plans. These included farmer workshop and surveys, Land Management Plans, natural capital tools review, natural capital assessment, baseline data compilation, taxonomic field surveys, and farm-scale rapid assessment tool development.

Initial Farmer Workshop

The CCAONB ELMs test started with an initial project meeting and a tour of the CCAONB farms with the project facilitator and consultants. We then planned to facilitate two farmer workshops to introduce the project to local landowners followed by farmer selection for the Land Management Plans. The farmer workshops were also a key part of the test to gather feedback from farmers on past and current agri-environment schemes as well as the new approach of paying public money for public goods and the concept of natural capital. However, the Covid 19 pandemic prevented us from carrying out the original plan. Instead, we recorded workshop presentations on key subject areas and asked farmers to participate in a virtual workshop by watching the following videos:

- Farming for the Nation - CCAONB Test Environmental Land Management Scheme Test: https://youtu.be/yJWUhT8mIZQ
- Background on Natural Capital: https://www.youtube.com/watch?v=yFo31YNgOqo
- Land Management Plans: https://www.youtube.com/watch?v=6G-1mbCW814&feature=youtu.be

Invitations for the video were sent via email to all known farmers in the CCAONB.

Farmer Survey and Selection

Following video viewing all identified farmers were then asked to respond to a survey. Questions asked can be found here. Selected results from the survey are summarised in the Results section.

Following the survey, we developed a farmer shortlist for participation in the more detailed Land Management Plans. Farmer selection was based on the following criteria

- Size of holding
- Type of farm
- Located within the CCAONB
- The features/habitats present
- Part of a farm cluster
- Landscape character

After reviewing the shortlist, we sent invitations to six farmers with two farmers in reserve in case any of the top 6 candidates could not participate.

Land Management Plans

Once the initial list of farmers accepted Land Management Plan invitations and upon easing of Covid-19 restrictions during summer 2020, we made an initial visit to each of the farms. The farm visits consisted of 1) farmer interview; 2) overview of farm operations and land stewardship approach; and 3) farm tour. We shared a proposed outline template for the Land Management Plans with the farmers for review then revised it based on their feedback (see Results for outline of the plan). Each landowner received a copy of their specific Land Management Plan that included general results and discussion from the process.

Natural Capital Tools Review

We reviewed natural capital evaluation, quantification and accounting tools for various natural resources worldwide, although we focused on United Kingdom specific tools as much as possible. There is a wealth of knowledge about natural capital ranging from global to local scale. We included key natural capital themes most appropriate to the farm setting in the CCAONB, organised generally by biodiversity, soil, air, water and carbon. We then included general tools that encompass valuation of these multiple natural capital assets and reviewed the online sources for spatial data and associated tools. Recommendations from the review are included in the Results.

Natural Capital Assessment

For the natural capital assessment, we used EcoservR. This tool is an updated version of Ecoserv-GIS, a tool originally developed by Durham Wildlife Trust for mapping habitats and ecosystem services in the UK using widely available national datasets. EcoservR has been rewritten using R software, a free, open-source coding language. The tool generates an environmental baseline classifying over 200 habitat types and uses spatial models to map their capacity to provide a range of ecosystem services, as well as the demand for them. A suite of ecosystem services was modelled for the CCAONB ELMs Test, however, we selected four which were most relevant given the rural nature of the study area: carbon storage, air purification, pollination, and flood mitigation. We tested a beta version of EcoservR in collaboration with Dr. Sandra Angers-Blondin at Liverpool John Moores University and Caspar Donnison, a graduate student at Southampton University.

We developed a study footprint for the natural capital assessment using approximately 30 water catchments that encompassed the six farms and the adjoining area. Models were run across the whole study footprint and reported at the scale of the individual farms. The approach followed an iterative process involving both the researchers and farmers:

1. Generated environmental baseline maps using a variety of inputs including the Ordnance Survey Mastermap, Greenspace data, CORINE land cover dataset, the Crop Map of England, and elevation.
2. Ground-truthed the baseline maps for individual farms with their respective famers, in the field but also remotely (when logistically not possible).
3. Digitized hedgerow maps for each farm using Google Earth satellite imagery, followed by ground-truthing their accuracy with farmers in the field. Hedgerows were then incorporated into the baseline map.
4. Ran EcoservR using the revised baseline map for a suite of ecosystem services (at 10 m resolution), generating maps across the study footprint.
5. Generated summary data (average) of the ecosystem services available for each farm compared to the surrounding study footprint.
6. Created a composite map combining the four focal ecosystem services to indicate highlights and lowlights (for potential areas of greatest change or needed improvements).

Compilation of Baseline Data

In addition to the modelling of natural capital at a regional scale of the 30 water catchments, we also compiled data at the farm scale. Data included field, countryside stewardship and hedgerow boundaries using the Land App. We also downloaded baseline data on priority habitats and ancient woodlands from the MAGIC website, and baseline data from the Ordnance Survey, including Terrain50 and Mastermap. The project also purchased species records (section 41 species) for the last 10 years from the Wiltshire and Swindon Biological Records Centre and Dorset Environmental Records Centre for the six farms plus a 1 km buffer around them. Finally, we acquired data on butterflies in Dorset from Butterfly Conservation by 1 km grid cell.

Taxonomic Field Surveys

Field surveys for 5 of the 6 farms (access proved challenging for one farm) were completed for invertebrates, birds and plants (including woody species). In advance of surveys, input was gathered from the farmers on a walking tour of each farm, as to pertinent locations to survey, e.g., ancient hedgerows, unimproved grassland, downlands where species richness and abundance was likely to be high. This information was conveyed on maps provided to each surveyor.

Invertebrates

The invertebrate survey was undertaken by means of sweep-netting the vegetation with the aim of dislodging species resting on foliage or feeding at flowers. Occasionally direct searching (where species with known plant hosts may be present) was employed as the main survey technique. The lepidoptera (butterflies) were primarily recorded flying through/around the survey area. The following invertebrates were surveyed: Mecoptera; Neuroptera, Odonata, Orthoptera, Heteroptera, Trichoptera, Lepidoptera, Diptera, Hymenoptera, and Coleoptera. Only species were recorded, not abundance.

Avian

The bird surveys consisted of 2.5 hours spent on each farm. As many habitats were surveyed as possible in this time, in addition to the areas identified in the walking tour. Additional habitats included open fields, improved and unimproved grasslands, arable, woodland, scrub, hedges, water (streams, ponds), and farmstead and associated buildings. All birds seen, heard and flying over were recorded during the survey.

Botanic

The botanical surveys consisted of the following methodologies depending on habitat type and guided by recommendations from the Farm Environmental Plans. Species frequency was recorded during 10 stops across habitat to assess species present within a square metre, measured with a quadrat: a species was recorded as ‘rare’ if it occurred in one or two stops out of ten; ‘occasional’ if it occurred in three or four stops out of ten; and ‘frequent’ if it occurred in five or more stops out of ten. For example, for ‘lowland calcareous grassland’ habitats, at least two indicator species must be frequent and three occasional, in addition to wildflower and sedges cover being more than 30%; invasive trees and shrubs being less than 5%; less than 5% of undesirable species (e.g., common ragwort and nettle); and less than 10% bare ground (see botanical survey guidelines in the Appendices for details of other habitats).

Farm-scale Rapid Assessment Tools

To develop rapid assessment tools and capture locally relevant farm knowledge on natural capital, we adapted a farm scorecard kindly shared by Dartmoor National Park Test colleagues. Our objective was to distil and shorten the comprehensive list of indicators that describe various ELMs focused aspects of farm operations and natural capital. This effort helped inform the development of the farm rapid assessment tool (see Results section and Appendices). We also included scorecard results in each of the Land Management Plans.

Hedgerow Assessments

Farmers assessed the hedgerows present on farms using the ranking scheme developed by the Dartmoor National Park Test according to several criteria: the number of hedgerow and tree species present, the height, width and percent gap within the hedgerow (Table 1). The ranking is based on national hedgerow ranking criteria and the contributions each hedgerow makes to natural capital. The most valuable hedgerows are allocated a score of 3 and the least valuable a score of 1.

Table 1. Hedgerow ranking criteria. The ranking is based on national hedgerow ranking criteria and contributions to natural capital, with 3 being the highest or most valuable hedgerows and 1 being the lowest or least valuable.

Species	Gap (%)	Height (m)	Width(m)	Tall trees	Rank
0 to 2	≥25	≤1.5	≤1.5	0-1	1
3 to 4	5 to 25	2	2	2 to 4	2
≥5	0 to 5	≥3	≥2	≥5	3

River/Riparian Assessments

River and riparian habitat assessments on two of the six farms were based on a variety of criteria, including the diversity of species on the river bank; sinuosity of the river course; bank angle of the river profile; flood mitigation; width of buffer strips; and the percent of the river in shade (Table 2). The highest ranking of 5 is the most valuable riparian habitat for its contribution to natural capital, and 1 being the least valuable.

Table 2. River and riparian habitat assessment criteria. The highest ranking of 5 is the most valuable riparian habitat for its contribution to ecosystem services with 1 being the least valuable. For the sample area row m^2 = m^2.

Indicator	**Bank diversity**	**River course**	**River profile**	**Flood mitig.**	**Buffer strips**	**Shade/Light**	
Sample area	50m^2	Full length	50m^2	50m^2	50m^2	Full length	**Ranking**
Metric	*Species*	*Sinuosity*	*Bank angle*	*Area increase*	*Width*	*% in shade*	
	0-2 species	Straight channel	0-10 deg	0	>0-3 m	>10% or >95%	1
	2-4 species	0-20 deg turns	10-20 deg	0.5x	3-5 m	10-30% or 85-	2
	4-6 species	20-50 deg turns	20-40 deg	1x	5-7.5 m	30-40% or 75-	3
	6-8 species	50-70 deg turns	40-60 deg	3x	7.5-10 m	40-50% or 65%	4
	8-10 species	70-90 deg turns	>60 deg	5x	>10 m	55-65%	5

Both the river and hedgerow assessments were included in corresponding Land Management Plans.

Additional Rapid Assessments

We identified and evaluated four additional rapid assessment tests for future use, although we were unable to conduct for this Test due to an unusually cold and wet spring. These included

1. Soil health: shovel tests using a 20 cm spade, select the worst, best and average site in a field. Dig a soil sample of 20x20x20 cm with the spade and count the number of earthworms present.
2. Soil health: tea bag test. Bury tea bags 5-10 cm with biodegradable bags (not brands with plastic in the bag). Revisit bags monthly and record time to degrade.
3. Avian point counts: record GPS location. Count birds at same time in morning for 10 minutes. Record all birds seen and heard. Select 2-5 representative locations on farm by arable, grassland and woodland.
4. Pollinator counts. The full methodology for pollinator counts can be found at the UK Pollinator Monitoring Scheme website. The flower-insect time count method is here. In general, the method consists of recording insects to morpho species level (e.g., bumblebees, hoverflies, wasps) in temperatures above 13 C, on relatively calm days between April-September. At a flowering site, drop a 50x50 cm quadrat and count all insects to morpho species visiting flowers for 10 minutes. The method is quick and easy to do because it does not require identification to species level but still gives an indicator of invertebrate and pollinator diversity.

RESULTS AND DISCUSSION

Results and Discussion sections are combined in the next section and are divided by the main project tasks.

Farmer Survey

The farmer survey received a total of 28 responses. Of these farmers, 86% are currently in an agri-environment scheme (Figure 2), with the highest percentage pertaining to the Countryside Stewardship Mid-Tier scheme.

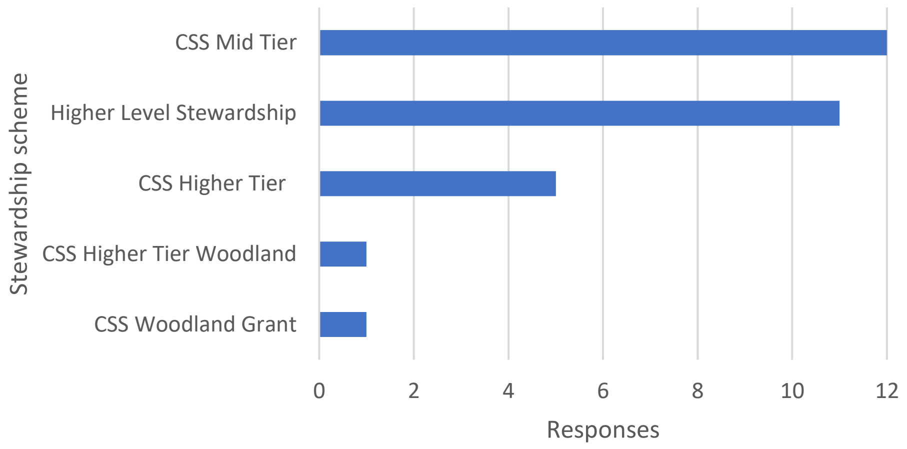

Figure 2. Type of stewardship schemes in which landowners are participating.

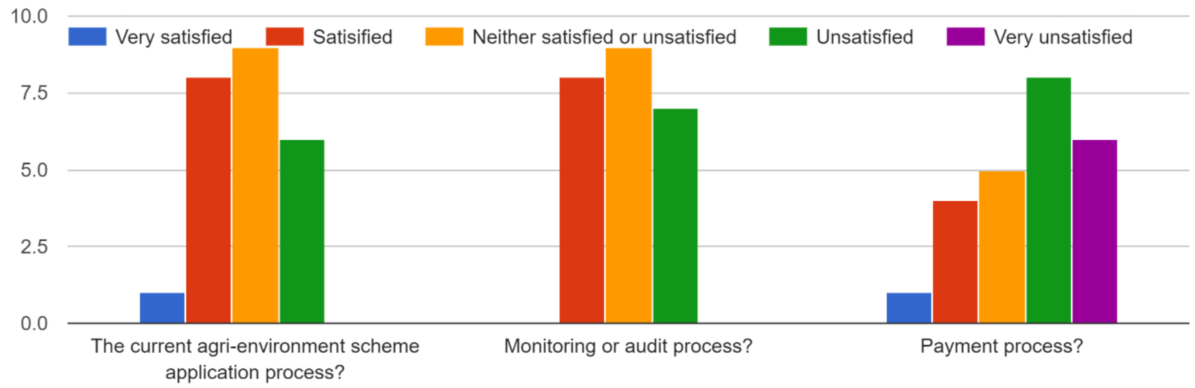

Figure 3. Level of satisfaction with scheme administration.

Although participation in schemes is high, landowners are typically not satisfied with the administration and payments for schemes (Figure 3). Individual responses included sentiments such as 'The paper application was really very clumsy'; 'Payment has been up to one year late'; and 'The current CS scheme is enormously and unnecessarily complex, inflexible and bureaucratic. It is an exercise in top-down micromanagement which blocks innovation and fails to allow for a locally tailored approach. Upgrading is strictly forbidden within the time-period of the scheme agreement so you can't keep improving outcomes.'

Nevertheless, farmers tend to be happy with the outcomes of the schemes, particularly from an environmental and revenue diversification standpoint: 'Results of my mid-tier scheme have been pleasing in terms of biodiversity which goes to show how much more could be achieved by a less rigid, prescriptive scheme.' or 'As long as you have a project officer who's accessible the land management works well.'

The public goods mentioned by landowners were mostly related to soil health, clean air and water, food production/security and wildlife conservation. When asked which management options provided public goods, the top three responses were: nitrogen reduction (100%), pesticide reduction (100%) and tree planting/carbon sequestration (82%).

One focus of the survey was on how future schemes should be designed to which simplification, engagement and ease of payments predominated in the responses. One landowner said: 'It should be simple, generous and based on the public goods delivered and the goods that are the scheme is also striving to deliver. The payments should not be based necessarily on the delivery of specific outcomes as this would mean a lot of bureaucratic inspections.'

With regards to future schemes another farmer mentioned '…well-managed public goods outcomes should be the basis of a potential new profit centre for the business…' Other comments tended towards recommending more frequent, regular and results-driven payments.

An impressive 71% of farmers currently have data about public goods on their farms. These include numerous surveys, mapping and cropping/tillage regimes (Figure 4). The top four types of surveys conducted were soil analysis (89%), farmland mapping surveys (82%), butterfly (39%), which was surprisingly higher than water quality (32%). Over half (61%) of respondents indicated they had detailed mapping conducted on their lands.

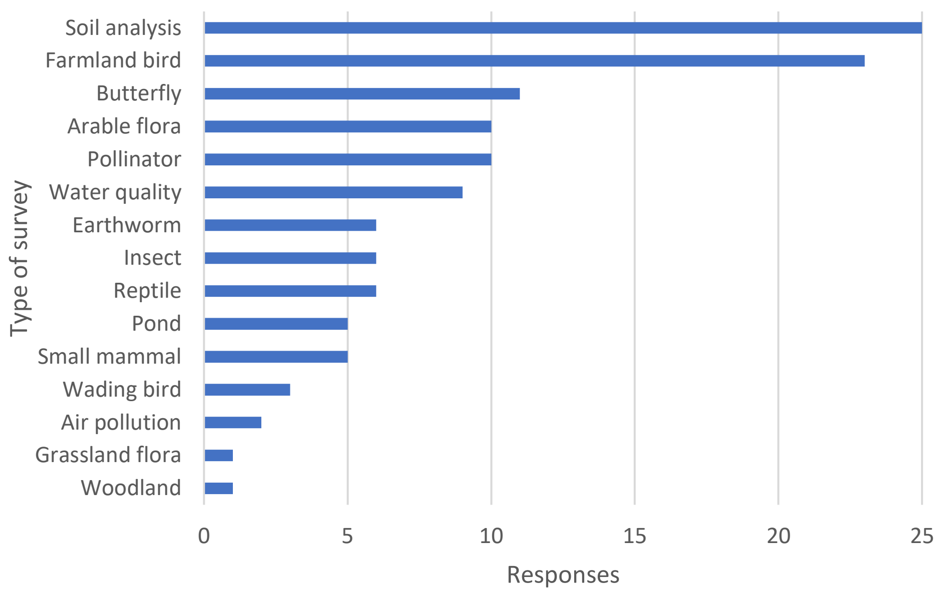

Figure 4. Types of surveys already conducted on farms.

For future baseline or data collection surveys, 61% of respondents indicated that self-monitoring is a feasible option on their farm. Types of surveys for self-monitoring mirrored those already carried out, e.g., farmland surveys, soil analysis and various wildlife species. Surprisingly, more than half of respondents (52%) said they would spend 5-8 hours on self-monitoring surveys, suggesting much potential for these if it could be partnered with appropriate training opportunities. In terms of farm plans, many farmers had a variety of plans already developed for their farms: 85% having developed a soil management, 74% a nutrient management, 59% a business and 52% have some type of land management plan.

One topic to note is the mixed feelings farmers have about working across farm boundaries. Despite 61% having Countryside Stewardship Facilitation funding, only 43% responded in favour of working across farm boundaries and 47% indicating they were 'somewhat in favour'. There may be a survey bias in this response, however as most qualitative answers explaining the responses indicated the opposite sentiments. For example, 'Nature doesn't agree with the artificial boundary the farm creates' or '[there is an] Advantage of scale in making the link of the landscape for the benefit on the environment, that it makes sense to work with neighbours for common goals and that it stimulates ideas, keeps up momentum, and aids adoption of new or beneficial practices.'

Incentives to encourage farmers to work across boundaries typically included the financial payments, but also made mention of the importance of funding for cluster facilitators and training in new practices.

Land Management Plans

We found the data collection, testing of rapid survey methodologies, the natural capital assessment, and incorporating farmer knowledge of the landscape to be the most engaging and effective parts of co-developing the Land Management Plans. Although ensuring that the business perspective was part of the plan, for ELMs we found that integrating stewardship practices and changes in a manner compatible with the farm's agronomic and business operations was a more feasible approach, especially since most of the participating farmers already had sound farm business plans. In this way, the Land Management Plan complimented those existing plans.

Besides using QGIS and ArcGIS, we also used Land App extensively for the Land Management Plan process and found the mapping tools easy to use and intuitive. It was especially powerful when combined with survey and spatial data.

The Land Management Plans consisted of:

1. Executive Summary
2. Farm Overview
    a. Farm map
    b. Agronomic and farm business
    c. Biophysical setting
    d. Farm cluster
3. Risks & Opportunities
    a. Cost/benefit analysis
    b. Good husbandry/land stewardship
    c. ELMs questions
4. Natural Capital Assessment
    a. Rapid surveys
    b. Spatial modelling
    c. Missing data
5. Baseline Survey
6. Vision & Goals

Plans were shared with each farmer upon completion.

Natural Capital Tools Review

Many tools exist for natural capital evaluation and quantification. Unfortunately, most of these are not applicable from a data availability or cost feasibility standpoint at the farm scale. Although costs are rapidly decreasing, data is becoming more available and finer scale technology, such as LiDAR imagery, could be future game changers for valuating natural capital. Ideally, the Environmental Land Management Scheme will offer real, place-based values for the public goods that farms will provide in the future. Based on the tools review, we offer the following recommendations:

- General–Tools such as the Natural Environment Valuation Online Tool can be used to evaluate farm measures such as carbon storage and water quality/quantity as a start followed by filling farm scale data gaps through surveys and spatial data analysis.
- Baseline–Where information on ecosystem services is lacking, e.g., biodiversity, it might be worth investing collectively in establishing baseline values of biodiversity. To reduce costs, surveys could be completed by farmer cluster members along transects and data interpolated to areas similar in land characteristics and use. Economies of scale can be gained by surveying broad areas at the same time and more cost effective by pooling grant and individual funds to cover key costs. The cluster should decide which 4-5 biodiversity indicators might be most cost effective from a cost/benefit perspective.
- Carbon storage–Calculating above and below ground carbon of various vegetation types and estimating the carbon in soil is not currently technically or financially feasible for most farmers at the farm scale (i.e., accounting for management actions that might increase soil carbon). Determining how to make carbon valuation easier for landowners and creating an open source, site-specific carbon

calculator is critical to the future quantification and accurate valuation of carbon stocks for the Environmental Land Management Scheme.

- Farmer led surveys–We found that many of the farmers responding to our Environmental Land Management Scheme survey were willing to spend significant amounts of time conducting surveys to create baseline data and, from which, changes in natural capital can be assessed over time. For instance, nearly 30% of farmers responded they would spend 5-8 hours/month; just under 25% would spend an entire day a month; and 6% more than one day per month. In all likelihood, more would be interested with increased training and financial incentives.
- Surrogates–Using surrogate indicators,[1] e.g., recording bryophyte diversity and abundance to measure overall species biodiversity, carbon storage and air quality, could prove a cost-effective means to cover multiple natural assets using a single measure. While not perfect, determining the ratio of proxy value to actual value could help keep costs low whilst maintaining accurate values.
- Qualitative data–Use of rapid assessment ranking for certain hard-to-obtain or cost prohibitive data might be one approach to circumvent the lack of data. The Bowland Hills AONB has effectively done this by ranking certain natural assets then mapping them at the farm scale. Not perfect by any means but if done in standardized manner, qualitative evaluations could be complementary to quantitative data until further information is available.
- Tools– Tools should be easy to use and transparent, with the ability to incorporated local knowledge of the farm with national scale datasets (e.g., incorporating hedgerow condition into EcoservR).
- Woodland–Since many of the farms in the CCAONB have generally maximized woodland to agriculture production land ratios, one suggestion is to maximize farm edges and margins for woodlands. This could be achieved by increasing the number of trees in field edges and margins, and the subsequent use of imagery to measure canopy cover. Expanding trees in margins could be a small gain by each farm that contributes greatly to the total 1% increase in woodland cover national goal and would take little to no land out of production while increasing woodland, biodiversity and carbon storage values.

Natural Capital Assessment

The foundation layer created by EcoservR is a baseline map compiling a variety of input data (Ordnance Survey Mastermap, Crop Map of England, CORINE land cover data) and categorising parcels of land into different habitat definitions based on the Joint Nature Conservation Committee's Handbook for Phase 1 Habitat Surveys (Figure 5).

[1] Sometimes known as proxy variables or indicators.

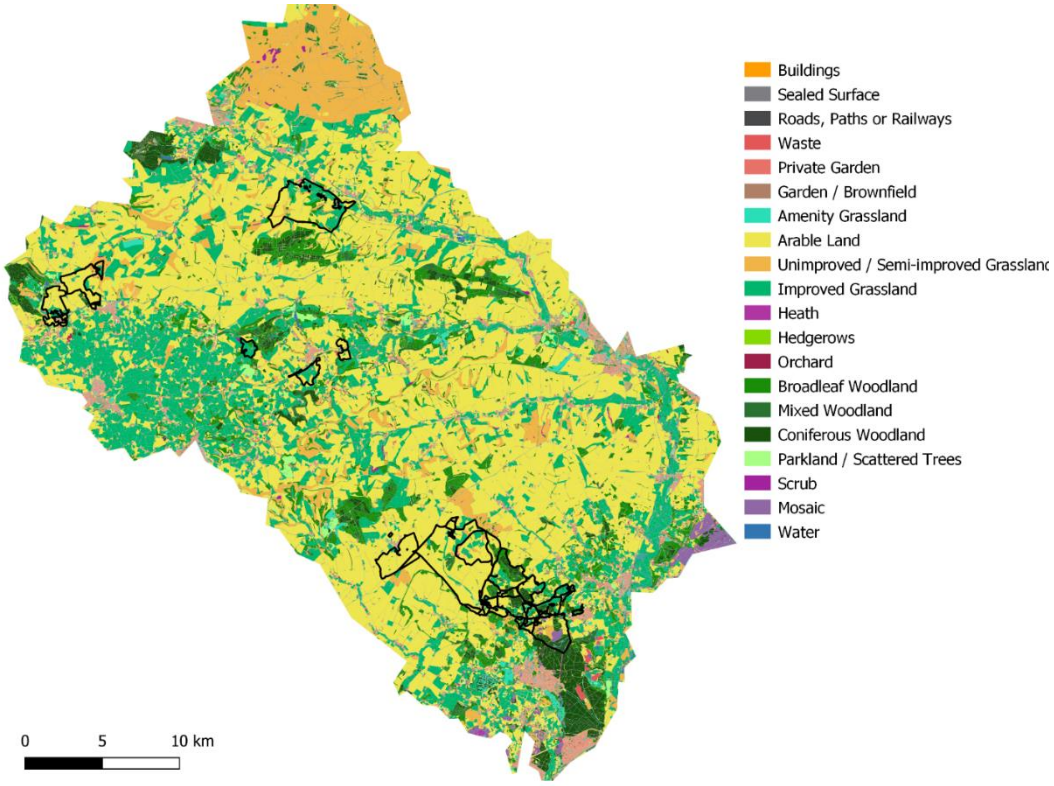

Figure 5. Basemap generated by EcoservR for the 30 water catchments that encompass the six farms (black outline)

We reviewed the basemap with each farmer and modified the habitat definition assignments, if necessary, e.g., changing arable land to improved grassland. Using the modified basemap, we ran EcoservR (at 10 m resolution) to create six different layers of natural capital (hereafter ecosystem services). Each service is modelled in different way using different decision rules and thresholds which are grounded in the scientific literature.[2] For example, carbon storage applies estimates of the amount of carbon stored in aboveground and belowground vegetation as well as the top 30cm of soil; pollination reflects the likelihood of pollination based on the available habitat for bees (used as an indicator of all pollinators) and the distance of areas away from the source habitats of pollinators; the air purification service reflects the ability of vegetation to intercept and absorb pollution depending on vegetation type and height, and the proximity of areas to vegetation; and finally flood mitigation services considers the elevation and the distribution of vegetation types.

For ease of interpretation the output services values are rescaled from 0 (low value of service) to 100 (high value). We ran a summary statistics tool to determine the average value of each ecosystem service layer for each of the farms (Table 3) and compared the values for each farm to the average of the whole study footprint that encompassed 30 water catchments from Figure 5.

As might be expected, the highest levels of carbon storage in above- and below-ground vegetation were found in areas of woodlands and more natural vegetation types, e.g., scrub versus arable land (Figure 6). A notable consideration at this regional mapping scale is that efforts by farmers for increasing soil carbon through local activities are not captured, although EcoservR does include the hedgerow data we generated using Google Earth and farmer input, so increased carbon storage through hedgerow planting would be recognised in future runs. Air purification was similarly higher near woodlands and natural areas, with land in closer proximity to these features, having higher values for removing pollution from the air.

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[2] Winn, J.P., Bellamy, C.C. and Fisher, T. 2018. EcoServ-GIS: a toolkit for mapping ecosystem services. *Scottish Natural Heritage Research Report No. 954.*

The likelihood of pollination map was dominated by linear features with a high service index which are modelled based on the distance of each pixel to pollinator source habitats. Little of the study footprint had low likelihood of pollination, largely because this is a predominantly rural rather than urban landscape. Finally, flood mitigation highlighted the importance of woodland habitat and stream courses which all received high ecosystem services values. One recommended next step to increase the accuracy of the ecosystem services models and leverage data collected from the farm scale would be to integrate information on the condition of these hedgerows based on farmer-knowledge.

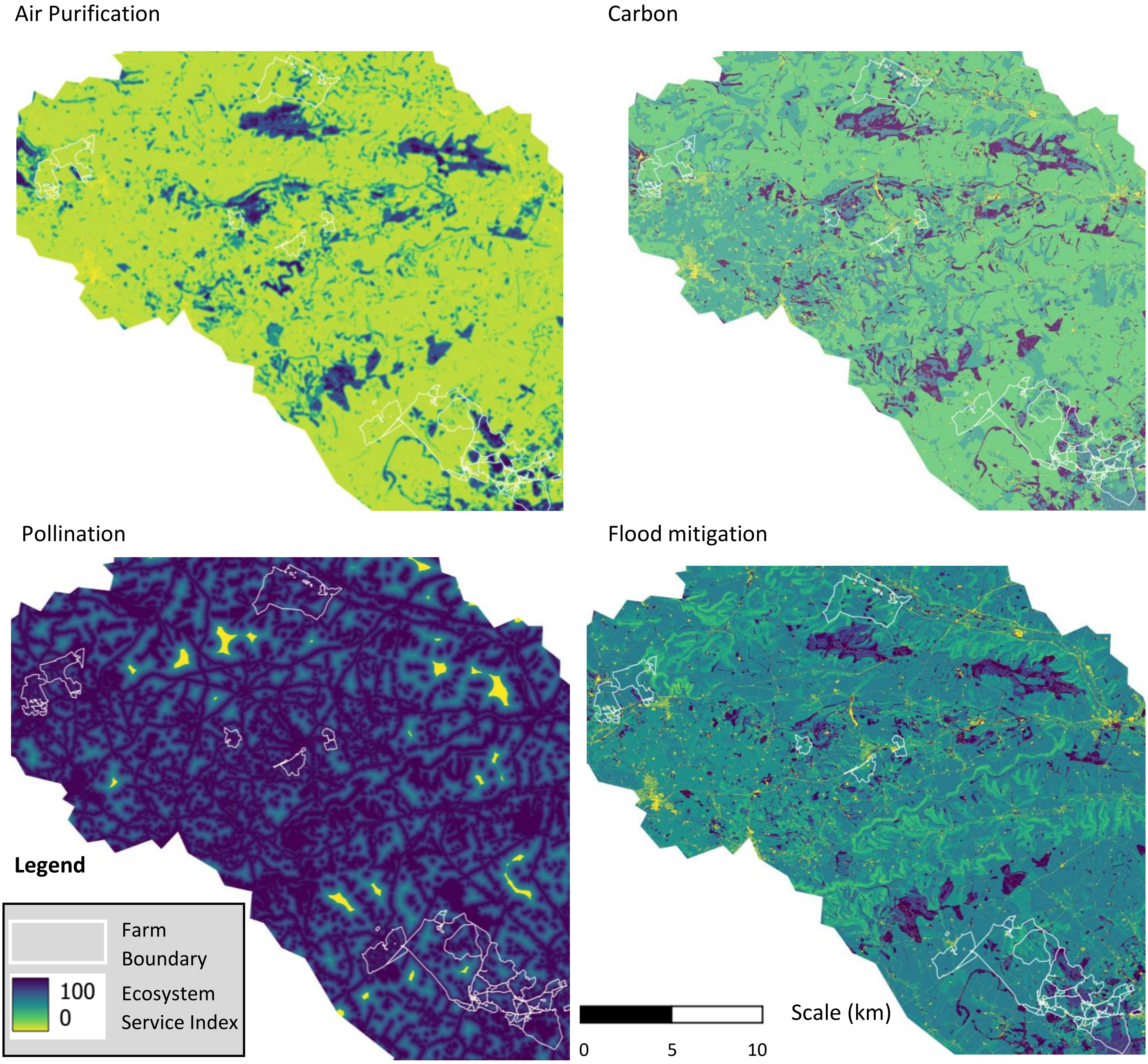
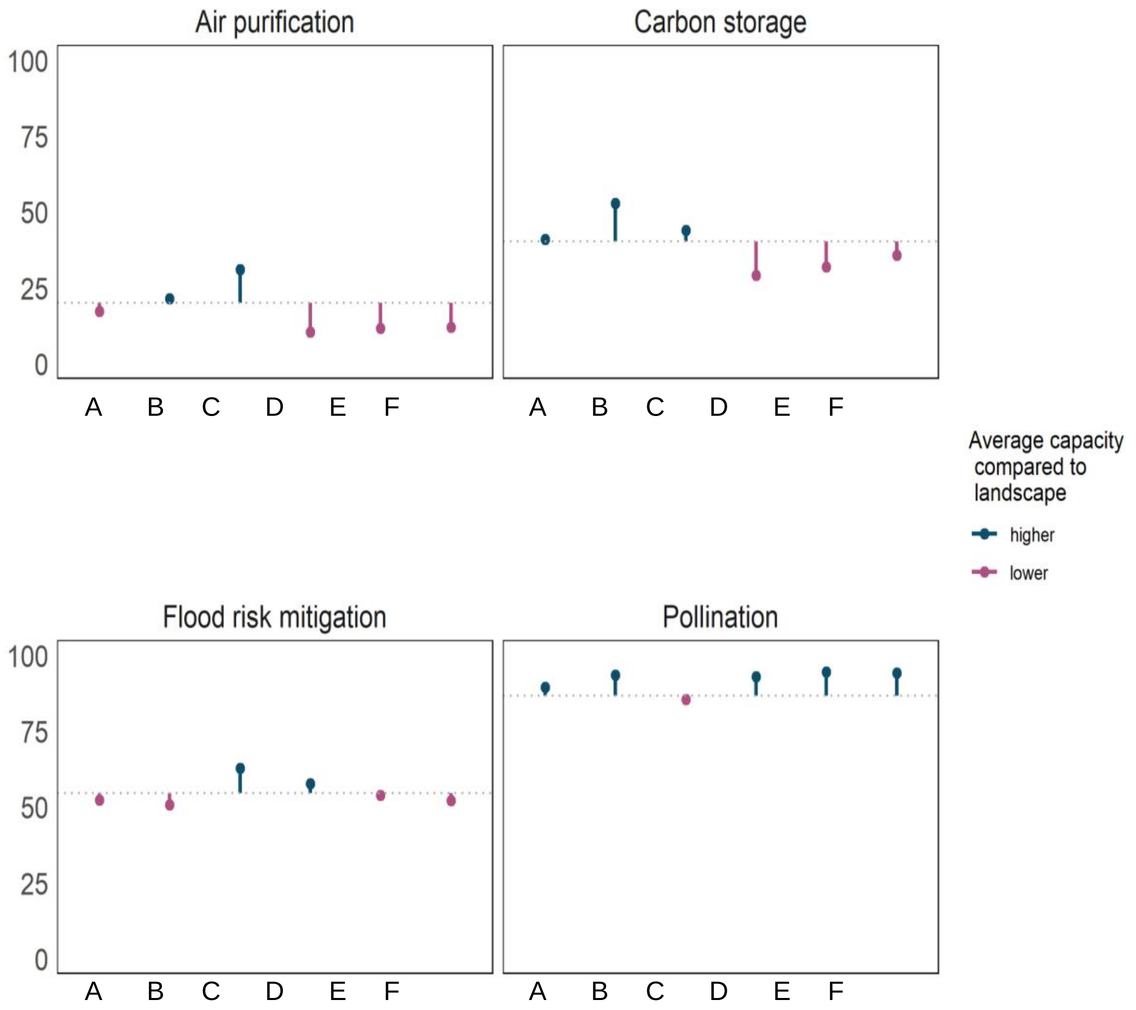


Figure 6. Maps of ecosystem services generated by Ecoserv.

A summary of values by farm indicates that average values for the likelihood of pollination is highest across the six CCAONB farms compared to the carbon storage, flood mitigation and air purification; with 4 of the 6 farms scoring above 90 (Table 3). Scores for flood mitigation were relatively high, with Farms C and D scoring higher than the others, likely due to the number of catchments and woodlands within or surrounding the two farms. The average carbon storage values for each farm had the greatest range of any of the services: with Farm B having a top score of 53 and Farm D the lowest of 29. Air purification services also had a relatively large range of values across the farms, from Farm B with 31 to Farm D with 10. The range of values for carbon storage and air purification might reflect the different amounts of woodland on each farm and the relative important of woodland in the EcoServR models. When viewed across the entire landscape a heterogeneous picture appears and shows the contribution of individual farms to ecosystem services across the region and the value of working across clusters throughout Cranborne Chase to maximise the provision of these services.

Table 3. Summary of ecosystem service values modelled by participating farms.

	Farms					
	A	B	C	D	E	F
Pollination	89.4	93.4	85.4	92.9	94.4	94.1
Flood risk mitigation	52.3	50.7	62.7	57.6	53.8	52.2
Carbon storage	40.9	52.8	43.8	29	31.9	35.7
Air purification	17.2	21.3	31	10.4	11.6	11.9



Understanding the individual farm's contribution to the regional landscape can be seen by viewing the

Figure 7. Average farm scores (blue and red lollipop lines) compared to the surrounding landscape (horizontal dotted line).

average farm value for each ecosystem services with the average of the surrounding landscape (Figure 7). For the likelihood of pollination services, 5 out of 6 farms scored higher than the surrounding landscape, indicating the important relationship between this service and farms. Farms B and C scored higher than the surrounding region for air purification and carbon storage compared to the surrounding landscape.

By combining the data, we can see areas that provide a high level of service provision (hotspots) compared to areas of relatively low service provision, which present opportunities for land management activities (Figure 8). Comparing across the farms shows that Farms A and C have relatively more spatial area in the hotspot category, again, given the substantial amount of woodland and natural habitat within and surrounding the farms. Farm B also has a relatively high proportion of high service areas for its size, given the woodland and natural grassland cover. Farms D and F have a relatively low amounts of high service provision areas, as they are dominated by more arable crops, but do offer much opportunity for activities to increase them, e.g., increasing vegetation types such as woodland that would help contribute to services such as air purification and carbon storage. These areas could either benefit from improved management or may have a high change from current baseline if practices are put in place to improve those services. Farm F is mostly improved and unimproved grassland with some woodland in the middle of the farms and offers a range of service provision values.

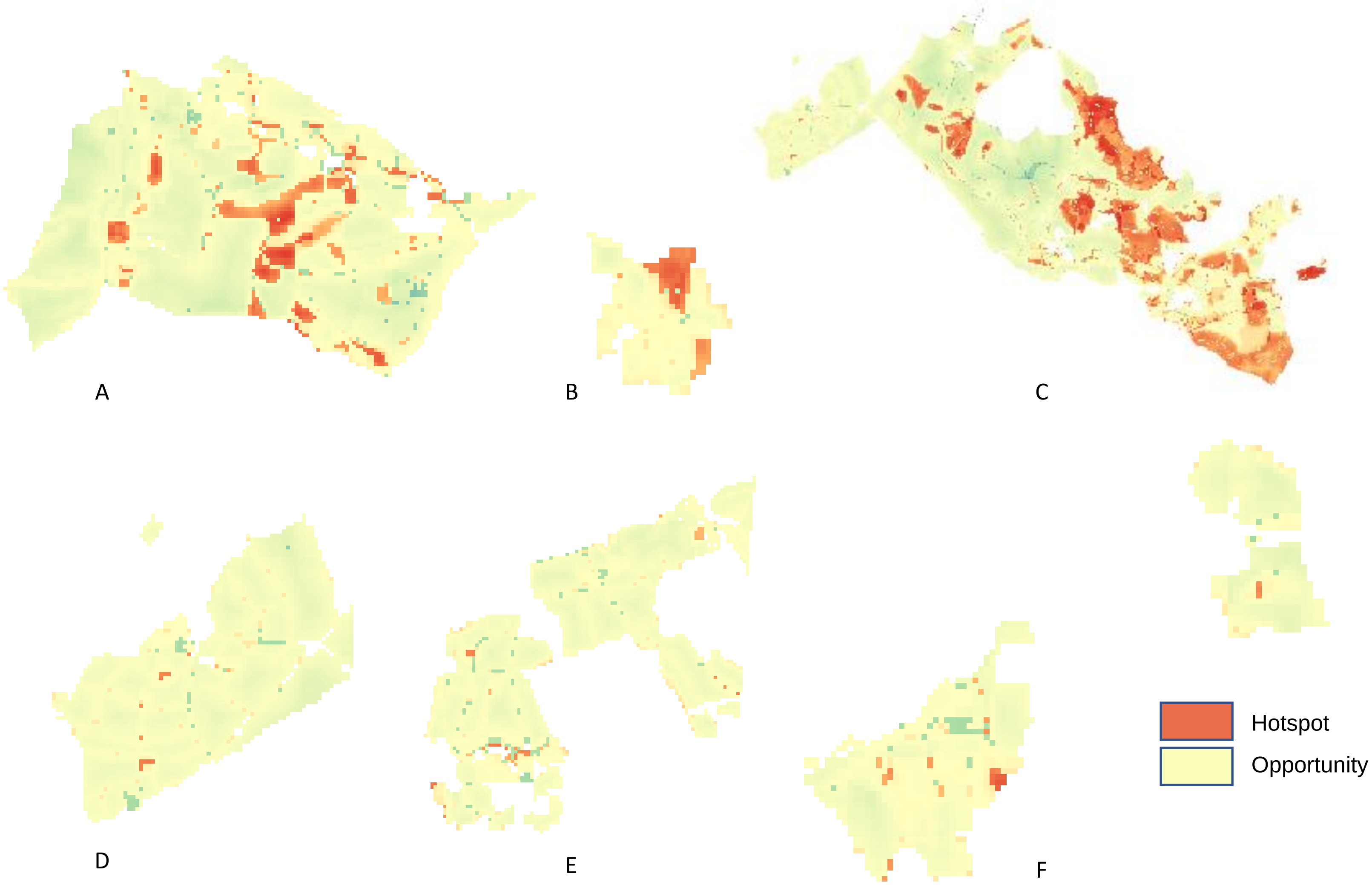


Figure 8. Composite ecosystem service maps of each farm showing hotspots and opportunity areas. Not to scale.

Baseline Data and Taxonomic Surveys

To complement the creation of data at the regional scale generated through EcoservR we also compiled data at the farm scale from several sources. The farm scale data are intended to provide a baseline dataset for each farm, from which future data can be compared and reviewed in conjunction with any changes in activities on the farm.

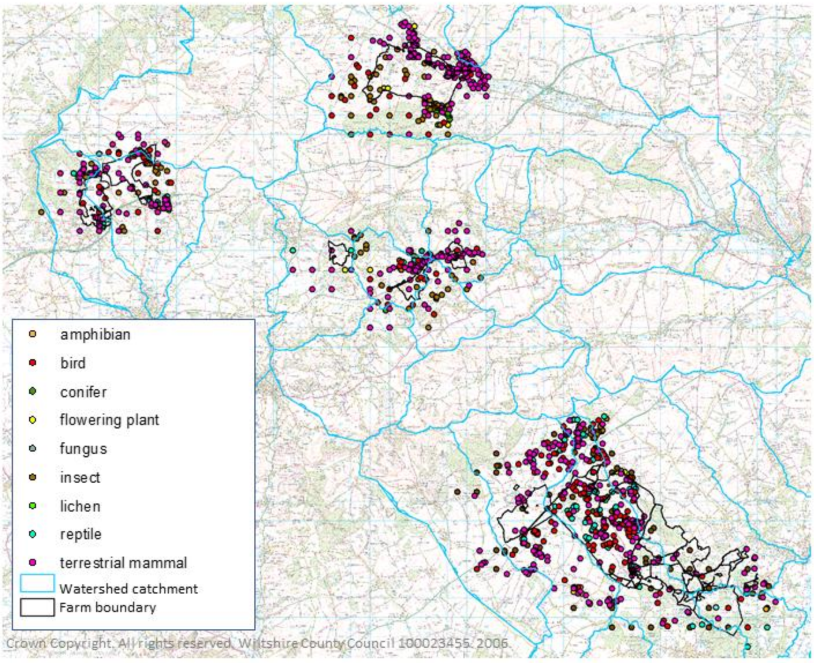


Figure 9. Section 41 species records from the last 10 years for Dorset and Wiltshire. Different colours indicate different taxonomic groups.

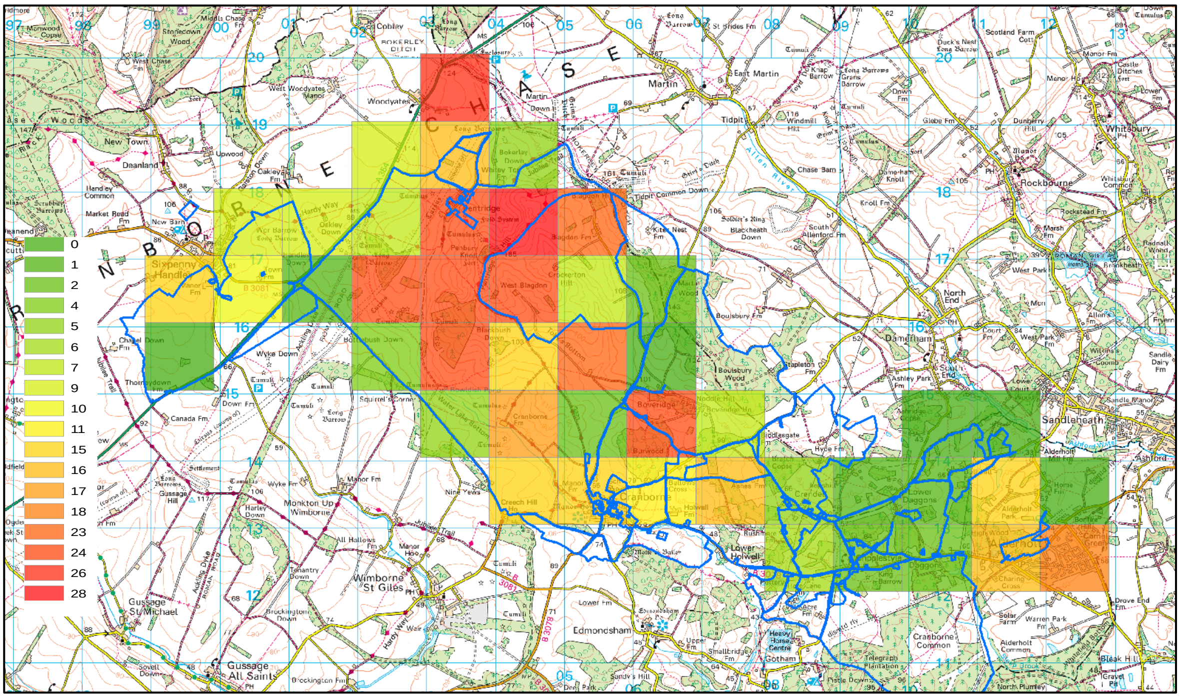


Figure 10. Butterfly Conservation records showing total number of butterflies from lowest (green) to highest (red).

Environmental Record Centre data for Dorset and Wiltshire were purchased for section 41 species for the last 10 years (Figure 9). However, coordinates for many of these records (if sensitive species) are the centre of a 1 km gridcell, so it would be challenging to relate changes in species presence with changes at the farm, such as an increase in grassy margins.

We were able to acquire data from Butterfly Conservation for the farms occurring in Dorset (Figure 10). The data represent the number of butterfly species per 1 km gridcell for the last 5 years. Again, the scale is relatively coarse for comparing with any specific activities on the farm but understanding whether there is a general increase or decrease in butterfly species richness in future years at a regional scale is still valuable information.

Finally, we assembled data on hedgerows for five out of the six farms (where logistically possible). One of these farms already had a large proportion of hedgerows mapped and for the other four farms we used Google Earth to map hedgerows as linear features (through visual interpretation). Hedgerow maps were reviewed with the respective farmers and edits were made, e.g., extending or omitting portions of hedgerows where it was unclear in the imagery. The hedgerow data was used as an input into the basemap of EcoservR and ranked based on their condition for the Farm Scale Rapid Assessment. The hedgerow information (length and condition) on each farm can again be used as a baseline dataset for comparison in the future.

Final Workshop

Farmers involved in Land Management Plan creation and various farmers involved in previous test workshops participated in a final project workshop held on 22 June 2021 (Figure 12). The total number of workshop participants was 27. Tracy Adams introduced the workshop and provided an overview of the CCAONB Test. The presentations involved one on the development of the Land Management Plans, farmer survey summary, taxonomic surveys, and rapid survey techniques and another on of natural capital spatial data.

Figure 11. Final workshop with farmers, demonstrating rapid assessment of hedgerow scorecard.

Following the CCAONB Test results one farmer said that it seems clear that unless farmers themselves collect the data, the system is not going to work. Owning data is important–tools are critical to collect data in a consistent manner. He talked about an innovative company and suggested that farmers need something they can use on the move, i.e., drones, to effectively manage their land. He explained that we are in an in-between time and that new technology is still being developed. Another farmer made the comment that a change in mindset within the farming community is needed. Trust is also need by people paying the money, for farmers to collect data and to manage land sympathetically for the environment.

Following the presentation on the natural capital assessment, one farmer noted that 'We have to start somewhere, and collection of baseline data is imperative, but getting this is challenging and ecologists are a scarce resource'. Another mentioned that although at a coarse scale, none of this spatial data would have been possible to view 10 years ago. Discussion and points made during the workshop are incorporated into the key findings and recommendations for the study.

CONCLUSIONS

The top three key learning points were related to data availability, natural capital, and payments, but there were many other finer points that arose from the test. We summarise those in the key findings and recommendations sections below.

Key Findings

- Data. Data availability from the farm to regional scale is a major impediment for land management to ecosystem service quantification. Data is variable by taxa, not standardised by survey or analysis methodologies, can be prohibitively costly to obtain, and is often missing.
- Natural capital. There were several findings related to natural capital during the test:
    - There are multiple areas of high value natural capital throughout CCAONB. The CCAONB is high in likelihood of pollination, variably high in carbon capacity and flood mitigation. The opportunity to greatly increase these values in a coordinated landscape scale effort across the CCAONB is remarkably high with many opportunities to interlink natural with farmed landscapes. For example, increasing soil organic carbon through various practices such as low/no-till and using green manures or cover crops could increase carbon capacity over large areas of land.
    - Mapping/modelling is fantastic for analysing and capturing natural capital data and changes. However, the modelling is not yet contained in an easy user interface that any farmer can access, input and use to participate in a scheme. Determining a software that can be widely used and requires little training will be critical for future success.
    - Capacity building. Participant farmers were willing to conduct manageable baseline and ongoing surveys if they were simple and/or training was provided to proficiently carry them out. Developing baseline data for key indicators and species though rapid assessment surveys, e.g., earthworm spade counts, or pollinator counts could be rapidly deployed and require minimal training to accurately collect data in recognized methodologies.
    - Farmer knowledge and easy survey methods, e.g., the farm scorecard or hedgerow assessment, that can rapidly assess natural capital and complement quantitative data to provide a more rounded picture of local and changing conditions, will be critical for the future scheme. Building capacity by adding peer learning into ELMs implementation and farm cluster support could be a way to rapidly scale future ELMs use and uptake. We intended to incorporate farmer knowledge rankings, e.g., scorecard assessments and hedgerow rankings into the natural capital assessment maps, however EcoservR is not yet coded to include qualitative scorecard rankings. Ensuring that both spatial data and farmer knowledge can be incorporated into the future scheme will be critical to its success.
    - Understanding/definition of natural capital. Many farmers still need assistance in understanding how natural capital may work and be improved on their farms.
- Payments
    - There are serious concerns over income loss especially through BPS.
    - Further income loss could drive farmers towards increased production and away from sustainable agriculture and conservation contradicting the aims of the 25 Year Environment Plan.
    - Payments must be fair & equitable and considered across farmer clusters, nature recovery areas and regionally. Determining how each farm contributes, for instance to biodiversity and their role across a connected landscape will be challenging.
- Land Management Plans. We found the data collection, testing of rapid survey methodologies, the natural capital assessment, and incorporating farmer knowledge of the landscape to be the most engaging and effective parts of co-developing the Land Management Plans. Although ensuring that the business perspective was part of the Land Management Plans, we found that integrating

stewardship practices and changes in a manner compatible with the farm's agronomic and business operations was a more feasible approach. In this way, the Land Management Plan complimented those existing plans.

- Guidance and focus. The lack of information and transparency about what ELMs will really look like has created much uncertainty in the farming community. More guidance from Defra could have helped focus the Test and answered more questions for the future of ELMs and likely produced more directed results. Instead, we had to make assumptions on what management practices ELMS *may* contain and test these elements. Trialling actual practices, tools, and software could have provided much more feedback to Defra during the Test, even if embryonic or in beta form.
- Farm succession. Two of the farms participating in the study are facing succession plans and concerns. Farm succession will also affect how farmers approach ELMs, particularly those nearing retirement.
- Recreation. There was little interest by farmers to be paid for recreational or cultural values. However, all farmers were interested in maintaining paths and bridleways and many were interested in the opportunity for public education related to farming practices, stewardship, and responsible recreation (e.g., leave no trace, keep dog on lead).

Recommendations

- Payments. Payments need to be made on time, with trust and in a transparent and collaborative system that rewards good stewards but does not pay those who fail to comply.
    - Practiced-based payments. Pay farmers for maximising use of sustainable farming practices known to benefit the environment which do not require vast amounts of survey data to measure and quantify. For example, switching from ploughing to minimum/no-till; increasing soil organic carbon by switching from chemical to organic fertiliser; reducing insecticide use through pest threshold testing in arable crops and using faecal egg counts in livestock systems.
    - Transition. Integrating policy that covers transitions to production of ecosystem services, e.g., carbon sequestration through tree planting or restoring habitat, much in the same way that organic farmers can be subsidised while in transition to organic, should be factored into the future ELMs scheme.
    - Gaps. Covering gaps left by the loss of BPS should be factored into the future scheme.
    - Tier 3. Creating opportunities for clusters to participate in Tier 3 connectivity and nature recovery and be paid equitably for their contribution, should be an opportunity for any type of farmer.
    - Public-Private Partnerships. Recognize that farmers may be interested to participate in both public and private schemes related to natural capital. Establishing policies that allow for fair market participation, avoid double counting whilst allowing stacking benefits, create regulatory checks and balances without creating a bureaucratic system, and ensure outcomes are measured will be important to integrate across ELMs, environmental conservation, and climate change policy.
    - Farming and Stewardship. Creating an additional payment to reward farmers for environmentally friendly farming should be incorporated into ELMs.
    - Incentivising past practice versus change. Determining how to reward high levels of stewardship built up over decades must factor into payments. Change from baseline should be rewarded but cannot create a perverse incentive to remove habitat or highly valuable past practices.
- Data. The amount of data to make ELMs function accurately at a local level needs to be collected quickly and accurately.
    - High quality data. Begin gathering high quality data from the region or use algorithms to integrate multiple scale spatial data and create data where there are gaps.

    - Forestobservatory.com is a good example of algorithms that are covering missing LiDAR data throughout forested regions until more flights and analysis can be completed.
    - **Standardised data collection and analysis methods.** Standardising data collection methods will be crucial to a future system that provides baseline and change information dependent on adopted practices.
- Natural capital assessment
    - Incorporate qualitative farmer knowledge, e.g., scorecard rankings, into quantitative natural capital mapping to create a more robust picture of on-farm natural capital.
    - Whereas the basemaps did include hedgerows (which for four farms had been mapped by hand using Google Earth images) a recommended next step to increase the accuracy of the services models would be to add information on the condition of these hedgerows based on farmer-knowledge into the basemap.
- **Scale**. ELMs must work from the field to regional scale. As a result, connected actions, data and learning will have to be braided together in a seamless system for tangible results and overall policy success to occur.
- **Peer learning.** Farmer-to-farmer peer learning through clusters and regionally should be encouraged and built into the ELMs subsidy to engage farmers, increase uptake, and accelerate learning about what works in agronomic and ecological settings.
- Capacity building
    - **Technology**. Determine farmer-friendly technology and rapid learning to use the future payment scheme so that farmers do not have to depend upon outside hired help to participate.
    - **Surveys/data collection.** Build local farmer capacity to conduct simple, time and cost-effective surveys that can easily gather and record data in a standardized, accurate and systematic manner. Multiple citizen science platforms such as Cornell's eBird, allow a variety of mobile and desk-based input by amateurs to professionals and have scientifically credible measures in place to verify data and allow analysis.
- **Trust.** All aspects of the new scheme need to be based on trust between Defra and the farmers participating in true partnership. If an option is not working, then the farmer must be trusted to be able to change it to achieve results. Flexibility in trying new practices and measuring their success will be required.
- Beyond the Test
    - **Learning within and across the region.** Measuring the impact from ecological, agronomic, social, and ecosystem services must happen through local to spatially based monitoring.
    - **Transparency and reducing uncertainty.** Defra must begin to roll out test version of ELMs and describe better what the future scheme will look like and how it will operate. At the heart of the matter is Defra needs to start actively listening to farmers and incorporating their recommendations into the future scheme.

APPENDICES

Guidelines for Botanical Surveys (FEP)

Lowland calcareous grassland

1. Cover of undesirable species (creeping thistle, spear thistle, curled dock, broad-leaved dock, common ragwort and common nettle) less than 5%.
2. Cover of wildflowers and sedges throughout the sward (excluding the undesirable species listed above and creeping buttercup and white clover) more than 30%.
3. Cover of bare ground (including localised areas, for example, rabbit warrens) should be less than 10%.
4. Cover of invasive trees and shrubs less than 5%.
5. At least two indicator species are frequent, and three occasional (see table 2 in Key 2b).

Lowland meadows

1. Cover of undesirable species (creeping thistle, spear thistle, curled dock, broad-leaved dock, common ragwort, common nettle, marsh ragwort, cow parsley and bracken) less than 5%.
2. Cover of wildflowers and sedges throughout the sward (excluding the undesirable species listed above and creeping buttercup and white clover) more than 20%.
3. Cover of bare ground (including localised areas, for example, rabbit warrens) less than 10%.
4. Cover of invasive trees and shrubs less than 5%, and indicators of water logging (such as large sedges, rushes, reeds) less than 30%.
5. At least two indicator species are frequent and two occasional (see table 4 in Key 2b).

Purple moor-grass and rush pastures

1. Cover of undesirable species (creeping thistle, spear thistle, curled dock, broad-leaved dock, common ragwort, common nettle, cow parsley, marsh thistle and marsh ragwort) less than 10%.
2. Cover of large sedge species less than 30%, and cover of large grasses such as tufted hair-grass and reeds, less than 20%.
3. Cover of invasive trees and shrubs less than 5%.
4. Cover of non-jointed rushes (soft, hard and compact) less than 50%.
5. At least two indicator species are frequent and two occasional (see table 5 in Key 2b).

Native semi-natural woodland

1. Native species are dominant. Non-native and invasive species account for less than 10% of the vegetation cover.
2. A diverse age and height structure.
3. Free from damage (in the last five years) from stock or wild mammals – there should be evidence of tree regeneration such as seedlings, saplings and young trees.
4. Standing and fallen dead trees of over 20 centimetres diameter are present.
5. The area is protected from damage by agricultural and other adjacent operations.

Broadleaved plantation

1. Native species are dominant. Non-native and invasive species account for less than 10% of the vegetation cover.
2. A diverse age and height structure.
3. Free from recent* damage from stock or wild mammals – there should be evidence of tree regeneration e.g., seedlings, saplings and young trees.
4. Standing and fallen dead trees of over 20 centimetres diameter are present.
5. The area is protected from damage by agricultural and other adjacent operations.

Pond

1. The pond should be set within a semi-natural habitat.

2. It should be within 500 m of another wetland feature (such as a pond, river or fen).
3. There should be no obvious sign of pollution or of inappropriate quality of the water supply.
4. There should be an absence of damaging non-native plant or animal species. (Damaging plants include water fern, Australian swamp stonecrop, parrot's feather, floating pennywort and Japanese knotweed (on the bank). Damaging animals include non-native crayfish, reptiles and amphibians.)
5. The pond should not be stocked with fish or support damaging numbers of wildfowl.
6. It should experience only natural fluctuations in water levels.

Flood plain grazing marsh

1. Cover of undesirable species (creeping thistle, spear thistle, curled dock, broad-leaved dock, common ragwort, marsh ragwort and common nettle) should be less than 5%.
2. In-field scrub cover should be zero and scrub cover over the ditches should be less than 10%.

Hedgerows

1. Height: The hedgerow must meet a minimum threshold of 2 m in height. Assess the height of the woody component of the hedgerow from the base of the stems to the top of the shoots of the woody species. This should be assessed along the whole length of the hedgerow and the most common height used. Gaps are not included, nor are hedgerow trees. Where a bank is present, the height of the bank must be excluded.
1. Width: The hedgerow must meet a minimum threshold of 1.5 m in width. Assess the width of the woody component between the shoot tips at the widest point. This should be assessed along the whole length of the hedgerow and the most common width used. Gaps are not included.
2. Gappiness: Assess the horizontal gappiness of the woody component. Gaps are complete breaks in the woody canopy of the hedgerow (see Figure 4). No more than 10% of the hedgerow length should be occupied by gaps and no one gap should be greater than 5 m wide (this excludes access points and gates). Where dormice or target species of bat are present in the hedgerow there must be no gaps.

Farm Scorecard

The original scorecard shared by our colleagues at Dartmoor National Park had 254 indicators. It is a well thought out and comprehensive list. We wanted to narrow the list to approximately 30 indicators of farm health that were the bare minimum and manageable to score and track by farmer. The final list reviewed by farmers in the Test is shown in the table below.

Public Good Targeted	Theme	Land Use	Indicator
Beauty Heritage and Engagement	Livestock Management	Dairy/beef	Stocking rate by field
Beauty Heritage and Engagement	Livestock Management	General	Number of rare or locally adapted breeds
Clean Air	Air Quality	General	Fuel/energy used to power and heat the farm
Clean Air	Air Quality	General	Lichen or bryophyte presence on trees
Clean Air	Nutrient Management	General	Slurry or FYM stores management
Clean Air	Nutrient Management	General	% crude protein and roughage present in supplementary feeds
Clean and Plentiful Water	Habitats	Grass/arable	Average riparian width by field, riparian vegetation quality
Clean and Plentiful Water	Soils	Grass/arable	Nutrients/fertilisers applied. Soil organic matter practices
Clean and Plentiful Water	Soils	Grass/arable	Earthworm count shovel test
Clean and Plentiful Water	Soils	General	Surface water infiltration/runoff
Clean and Plentiful Water	Water quality	Grass	Do you maintain watercourse fences to ensure they are stock proof
Clean and Plentiful Water	Water quantity	General	How much of the water you use on farm is harvested/recycled?
Clean and Plentiful Water	Water quality	Grass/arable	Field margins type and quality
Mitigation and Adaption to Climate Change	Flood resilience	Grass	Area of wetlands, levee setbacks or riparian areas, riparian veg quality
Mitigation and Adaption to Climate Change	Habitats	Grass/arable	Crop rotation regime
Mitigation and Adaption to Climate Change	Habitats	Grass/arable	Above and below ground carbon
Mitigation and Adaption to Climate Change	Soils	Grass/arable	Soils testing: carbon, organic carbon, invertebrates and major nutrients
Thriving Plants and Wildlife	Habitats	Grass/arable	Existence and quality of habitat corridors/landscape permeability
Thriving Plants and Wildlife	Habitats	Grass/arable	Hedgerow condition, #species/100m, cutting regime
Thriving Plants and Wildlife	Habitats	Grass/arable	Number of non-native invasive species
Thriving Plants and Wildlife	Wildlife	Grass/arable	Number of priority wildlife species
Thriving Plants and Wildlife	Habitats	Woodland	Acres or percent woodland cover on the holding
Thriving Plants and Wildlife	Water quality	Grass/arable	Herbicides/pesticides applied, timing, integrated pest management plan
Thriving Plants and Wildlife	Habitats	Woodland	Amount of standing/downed dead wood
Thriving Plants and Wildlife	Habitats	Woodland	Percent canopy cover
Thriving Plants and Wildlife	Wildlife	Grass/arable	Morpho species pollinator count