UK Natural Capital: Ecosystem accounts for farmland (Experimental Statistics)

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Main points

- This article presents the first experimental farmland physical ecosystem accounts for the years 1998 to 2014. These accounts form part of a suite of ecosystem accounts being compiled for different habitats within the UK as part of a strategy to incorporate natural capital into the UK Environmental Accounts by 2020.
- The extent of farmland coverage in the UK was relatively stable between 1998 and 2014, although the types of land use within the broad habitat farmland have changed significantly.
- Land used for cropped and uncropped arable land and rough grazing has declined. The abolition of the statutory set aside scheme, under the Common Agricultural Policy and changing prices for cereals are likely to have contributed to this decline.
- Land used for permanent grassland, has increased in this time. This likely contributed to the increase in regulating services, as measured by global climate regulation and waste mediation.
- The condition accounts show that the condition of farmland is falling in quality, in terms of soil carbon concentration and specialist bird populations.

Collaboration

The Department for Environment Food and Rural Affairs (Defra) contributed the data for this article.

DEFRA logo

Introduction

This article sets out initial physical habitat accounts for UK farmland for the years 1998 to 2014 and discusses possible methods for valuing the physical flows of ecosystem services. Some discussions around producing monetary accounts are also given in Annex 4.

The habitat accounts are part of a strategy to incorporate natural capital into the UK Environmental Accounts by 2020. These accounts form part of a suite of ecosystem accounts, which are being compiled for different habitats within the UK. When all habitat accounts are taken as a whole, the accounts will not overlap and will form aggregate UK ecosystem accounts.

The purpose of national level ecosystem accounts is to provide evidence to inform and improve decision making by integrating environmental and economic information. The accounts can be a tool to help decision makers understand the trade-offs between different ecosystem services and between alternative land uses.

By providing a link between the ecosystem and the benefits which humans receive from the natural environment, the accounts help us to understand the contribution the environment makes to economic activity and human well-being. Further, by valuing the stocks of these natural assets and the flows of benefits, the accounts facilitate comparison with other economic and social information and help to emphasise the importance of maintaining and improving the stock of natural capital.

More information on our programme of work in this area can be found on the natural capital accounts webpage.

Structure of the article

The next section explains the type of ecosystem accounts given in this article, and is followed by a section covering the scope of the accounts and data used to produce the accounts. Each physical account is then presented in a summary table, followed by definitions and discussion, including discussion on elements not omitted.

The final section of this article presents conclusions and recommendations for future work to develop the accounts.

Aggregate UK farmland monetary accounts have not been included in this article, however, services which could be included in the valuation are discussed in Annex 4.

Types of ecosystem accounts

Ecosystem accounting is a conceptual framework that treats an ecosystem as an economic asset providing a range of services that benefit society. It distinguishes between the stock of the assets, the flows of services provided and the final good or service which benefits people.

Ecosystem assets

Ecosystem assets are environmental assets that represent the stock of ecosystems within an accounting framework. The United Nations System of Environmental-Economic Accounting (UN SEEA) defines ecosystem assets as, “spatial areas containing a combination of biotic and abiotic components and other characteristics that function together.” Ecosystem assets are what the ecosystem functions on to provide ecosystem service flows.

An ecosystem asset account needs to account for changes in both the extent of the ecosystem and the characteristics, or indicators of condition. The condition of the asset is critical to the provision of ecosystem services.

Ecosystem services

Ecosystem services provide the link between ecosystem assets and the benefits received by society. People benefit from both the materials that ecosystems provide (such as the grass grazed by sheep) and from the outcomes of natural processes (such as the benefits from clean air that has been filtered by an ecosystem).

Ecosystem services that contribute to human well-being are classified into:

- provisioning services – products such as: food (crops, animal fodder, fish and honey); water; fibre (timber); and fuels (wood fuel)
- regulating services – benefits such as: water purification; climate regulation; noise and air pollution reduction and flood hazard reduction
- cultural services – non-material benefits, for example: through cultural heritage; recreation or
- aesthetic experience

Scope of the accounts and data sources

Ecosystem accounts focus on the services we receive from the natural environment and distinguish between the benefits the services provide and any dis-benefits resulting from agricultural production activities. Some of the dis-benefits from agricultural production are accounted for within the wider UK environmental accounts, such as emissions from agriculture, so are not duplicated here.

The benefits received from ecosystem services are not always entirely natural and it is difficult to draw a clear boundary between the environment and the economy. For farmland, this is especially true, as agricultural production depends heavily on the interaction between farming activities and ecosystem services. UN guidance on ecosystems accounting (UN SEEA)[1], advocate the separation of ecosystem services and environmental impacts. The main benefit of this approach is it presents a

clearer picture of the potential benefits of protecting and enhancing the natural environment and the trade-offs involved.

This article presents accounts for enclosed farmland broad habitat, which encompasses the cropped and grass fields that cover much of the UK's lowlands, along with the networks of hedges and ditches and the small woodlands interspersed among them[2]. This account uses the June Survey of Agriculture and Horticulture (June Survey)[3] to determine the extent of the farmland ecosystem in the UK.

The June Survey is an annual survey of farms in the UK and includes a full census every 10 years. Both the survey and the census collect data on the type of land held as well as the uses of the land within farms. For example, the type and number of crops grown as well as types and number of cattle reared. The land use classifications can broadly be grouped into 'arable and horticultural land', 'improved grassland' and 'other agricultural land', which approximates to the 'enclosed farmland' habitat of the UK National Ecosystem Assessment (NEA, ,plus rough grazing. A full explanation of how these categories related to the UK NEA can be found in Annex 1.

The UK NEA[1] and other ecosystem accounts are based on land cover data sourced from the Land Cover Map (LCM) and the Countryside Survey. The June Survey is used over the LCM or Countryside Survey, as it is the primary database on land use in agriculture and provides a consistent, detailed and coherent time series.

The condition accounts for the extent of farmland and the ecosystem service accounts use a variety of data sources; each data source is given in the discussions following the summary tables.

Notes for Scope of the accounts and data sources

1. Also adopted by Edens and Hein (2013) 'Towards a consistent approach for ecosystem accounting'.

2. Chapter 5, National Ecosystem Assessment.

3. Formally called the 'Structure of the agricultural industry in England and the UK at June'.

Asset accounts: extent and condition accounts

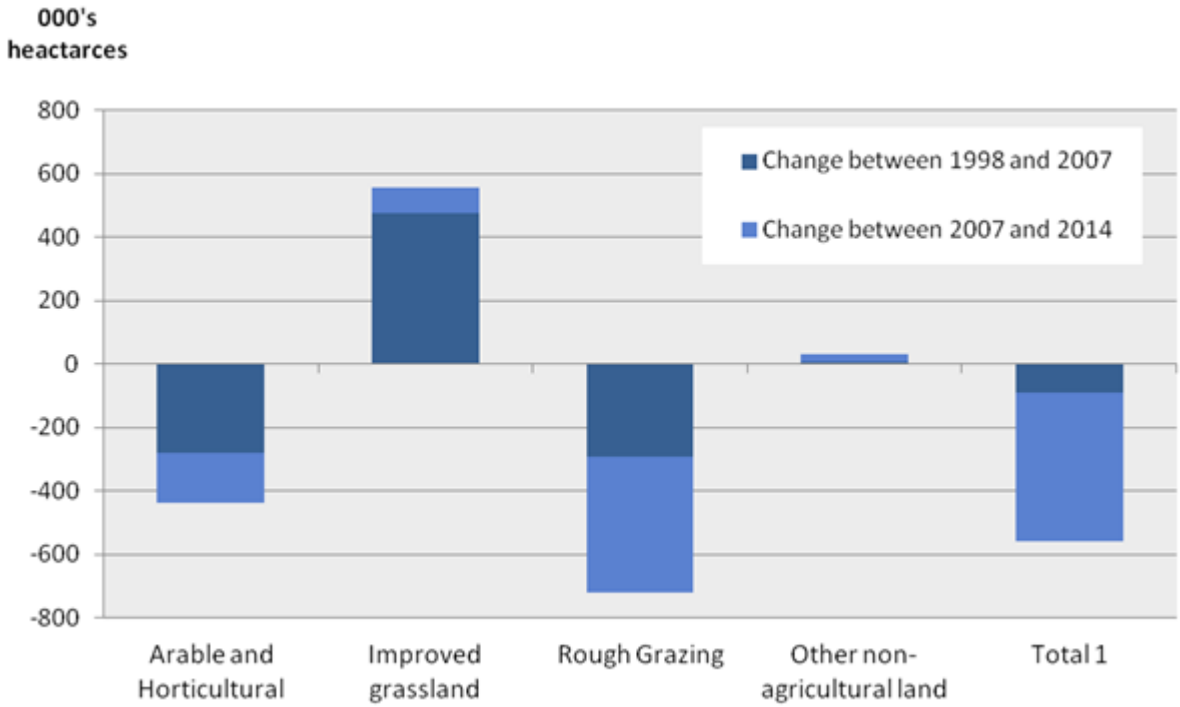
Extent account

The June Survey gives information about the activities that take place on the land (referred to as land use) as well as some information on the vegetative cover (land cover). Land uses do not always match up with vegetative covers, so the farmland account may cover some broad habitats outside of the 'enclosed farmland' habitat assessed in the UK National Ecosystem Assessment (NEA) (see Annex 1 for more information). The land cover classifications of the June Survey that are within the scope of the farmland ecosystem account, together make up approximately 70% of land in the UK.

Table 1 summarises the extent of each of these land use types for the years 1998, 2007 and 2014 and Annex 1 gives definitions for each land use. Table 1 shows agricultural land use has been largely stable over time, falling about 3% in coverage between 1998 and 2014. Part of this fall can be attributed to a slight decline in 2009, which is largely due to a register cleaning exercise in advance of the census year in 2010 and a change in coverage to commercial holdings only.

Although the change in the extent of total farmland has been relatively small, how the land is used has changed more substantially, as shown in Figure 1. Between 1998 and 2014, there has been sustained decline in land used for ‘arable and horticultural’ and ‘rough grazing’, whilst an increase in land used for ‘improved grassland’ and ‘other non-agricultural land’.

Figure 1: Change in Farmland use between 1998 and 2014, UK



Notes:

1. Source: Department for Environment and Rural Affairs

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Table 1: Farmland ecosystem summary extent account for 1998, 2007, 2014, UK

Thousand hectares	Arable and Horticultural			Improved grassland		Rough Grazing		Other non-agricultural land			Total
	Arable Crops	Horticultural Crops	Uncropped arable land	Temporary	Permanent	Sole right	Common	Linear Features	Land for outdoor pigs	Other	Woodland	
Opening Stock 1998	4,791	180	347	1,301	5,364	4,621	1,227	0.19	-	285	-	18,116
Net additions (+)/ Reductions(-)	-520	-11	252	-125	601	-302	11	-0.002	-	6	-	-88
Stock 2007	4,271	169	599	1,176	5,965	4,319	1,238	0.188	-	291	-	18,029
Net additions (+)/ Reductions(-)	287	-5	-439	220	-141	-389	-39	-	-	27	-	-470
Closing stock 2014	4,559	164	160	1,396	5,824	3,930	1,199	-	8	318	-	17,559

Table notes:

1. Source: Department for the Environment, Food and Rural Affairs
2. This data is sourced from the Countryside Survey, it has been taken out of ‘all other agricultural land’ classification to avoid double counting.
3. In 2009 there was a register cleaning exercise in advance of the census year in 2010 and a move to consider commercial holdings only.
4. Does not include Land used for pigs in the total.
5. NB, totals may not equal due to rounding.

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Arable, horticultural and grassland

‘Arable and horticultural’ land use, which is land used to grow vegetables, fruit, mushrooms and flowers and includes uncropped arable land, covered over 6 million hectares (ha) in the UK in 2014.

Both arable and horticultural lands have shown significant net decreases since 1998, although arable land has seen recent growth between 2007 and 2014.

Uncropped arable land also declined in coverage, this decline occurred between 2007 and 2014. Uncropped arable land fell from nearly 600,000 ha in 2007, to 160 ha in 2014. This can be attributed to change in world grain prices and the abolition of the compulsory Set-aside Scheme in 2008 under the Common Agricultural Policy[1]. The scheme paid farmers to set aside a proportion of arable land, previously used for growing crops. Land which is not cropped is likely to have higher levels of biodiversity, less soil erosion and sequester more carbon, so the reduction in uncropped land will have implications on ecosystem services.

Temporary grassland, grassland under 5 years old, increased over the period between 2007 and 2014. It is likely the abolition of the set-aside scheme resulted in some uncropped arable land being turned into temporary grassland.

Permanent grassland, grassland over 5 years old, increased by 460,000 ha between 1998 and 2014. Permanent grassland does not require tilling[2], so an increase in regulating services, such as carbon sequestration, would be expected. However, the net impact on ecosystem services of the change in land use change is difficult to determine. For example, grassland can be very intensively managed where the grass is effectively taken as a crop. In this instance, the level of regulating services is unlikely to change significantly.

Rough grazing

Land used for ‘sole right rough grazing’ declined 15% between 1998 and 2014, reducing by almost 700,000 hectares. Rough grazing is used for low intensity farming and by avoiding negative environmental impacts of intensive farming, benefits from regulating services are expected to be more significant. The large reduction in sole right rough grazing, it is likely to lead to a reduction in carbon sequestration and other regulating services from farmland in the UK.

Rough grazing within the June Survey, is most similar to the ‘semi-natural grassland’ broad habitat reported on in the UK NEA. A substantial element of rough grazing classified by the June Survey will be ‘semi-natural grassland’ habitat and some ‘mountains, moorlands and heaths’ (MMH) broad habitat within the UK NEA, as discussed in Annex 1. Further work is needed to clarify the relationship between the broad habitats of semi-natural grassland, Mountains moorlands and heaths and the coverage of the June Survey.

Other features of non-agricultural land

Approximately 477,000 kilometres of hedges are in Great Britain (not all of these are on farmland)[3]. Linear features, such as hedgerows, provide biodiversity benefits and are valued for their contribution to the landscape. Margins and woody linear features also provide soil erosion, flood management and water quality benefits.

The June Survey does not separate linear features. To calculate the data in Table 1 it is assumed the above extent of hedges in Great Britain, as well as other linear features such as lines of trees, shrubs and walls, were all contained on farmland and have a width of 2 metres. Based on these assumptions, linear features account for a total of 190 ha for the UK as a whole.

Estimates of the amount of land used for outdoor pigs are separately available and estimated to be 8,000 ha in 2014. Based on this, total 'other agricultural land' covered approximately 326,000 ha in 2014.

Potential characteristics not included and areas of further research

Woodland enclosed within farms and horse paddocks have not been included within the extent accounts. The reasons for which are given below.

Woodland: The June Survey finds there to be 897,000 ha of woodland on farmland in 2014. These areas are potentially significant providers of ecosystem services; however, they are currently also included within woodland ecosystem accounts. This is because the National Forest Inventory (NFI), the source for the woodlands ecosystem account, contains all woodland if larger than 0.5 ha. In order to be consistent with other accounts, farm woodlands, together with the ecosystem services provided by these woodlands, have been excluded from the farmland ecosystem accounts.

Horse paddocks: Farmland used for horses accounts for approximately 5% of land across the UK as a whole. Significant areas of horse paddocks are not included in the June Survey as they are not on working farms, so horse paddocks are excluded from the accounts. Additionally, the nature of the ecosystem services provided by land used for horses is sufficiently different from other grazed land to warrant separate treatment within the accounts. Some horse paddocks could also be captured in urban ecosystem accounts and it will be necessary to ensure there is no double counting with other accounts. At present this remains an area for further research, as we do not have sufficient data to separate out the use of this type of grassland.

Condition accounts

The condition of an ecosystem asset, in terms of its characteristics, reflects its overall quality (UN SEEA, 2.34). The condition of an ecosystem asset plays a large part in determining the quantity and quality of services the asset provides and its capacity to provide those services into the future. For example, if the asset is in a degraded state, over time the ecosystem services provided will be less than if the asset was in good condition and being used sustainably.

The condition account presented in Table 2, can be used in its own right as a measure of the state of the ecosystem asset, and as a means of informing projections of ecosystem services in the future. For example, rights of way in good condition will attract visitors to farmland and provide recreation services. If rights of way and rambling routes through an area of farmland are sparse or in poor condition, potential visitors may be put off and choose other recreational activities. This would lead to a lower recreational value for that area of farmland.

Farmland is distinct from other ecosystems because much of the land is intensively managed for the production of agricultural outputs such as dairy, sheep, and food and other crops. This large scale land management shapes the main characteristics of the farmland broad habitat.

Table 2: Farmland ecosystem condition accounts for 1998, 2007, 2014, UK

Thousand hectares	Biodiversity		Soil quality (soil carbon concentration for topsoil (0-15cm) in GB)				Conservation
	Specialist birds (1970=100)	Species richness score[1]	Arable and horticultural[2]	Improved grassland[2]	Neutral grassland[2]	Acid Grassland[2]	% land in protected areas
Opening Stock 1998	18,116	38	7.9	33.5	58.3	70.1	256.7	-
Net additions (+)/ Reductions(-)	-87	-3	2.4+	-2.8*	-1.4	-2.1	-28.2*	-
Stock 2007	18,029	35	10.3	30.7	56.9	68	228.5	-
Net additions (+)/ Reductions(-)	-470	-5	-	-	-			-
Closing stock 2014	17,559	30	-	-	-			10.5

Table notes:

1. Source: Soil carbon and species richness score taken from countryside survey. Specialist bird population sources are Royal Society for the Protection of Birds, British Trust For Ornithology, Joint Nature Conservation Committee, Department for the Environment, Food and Rural Affairs
2. This indicator relates only to arable and horticultural land in GB. It is measured as the average number of species per plot.
3. Soil carbon is measured in terms of grams per kilogram. Soil Carbon- taken from countryside survey.
4. *net change is statistically significant for soil carbon.
5. + net change is statistically significant for species richness.

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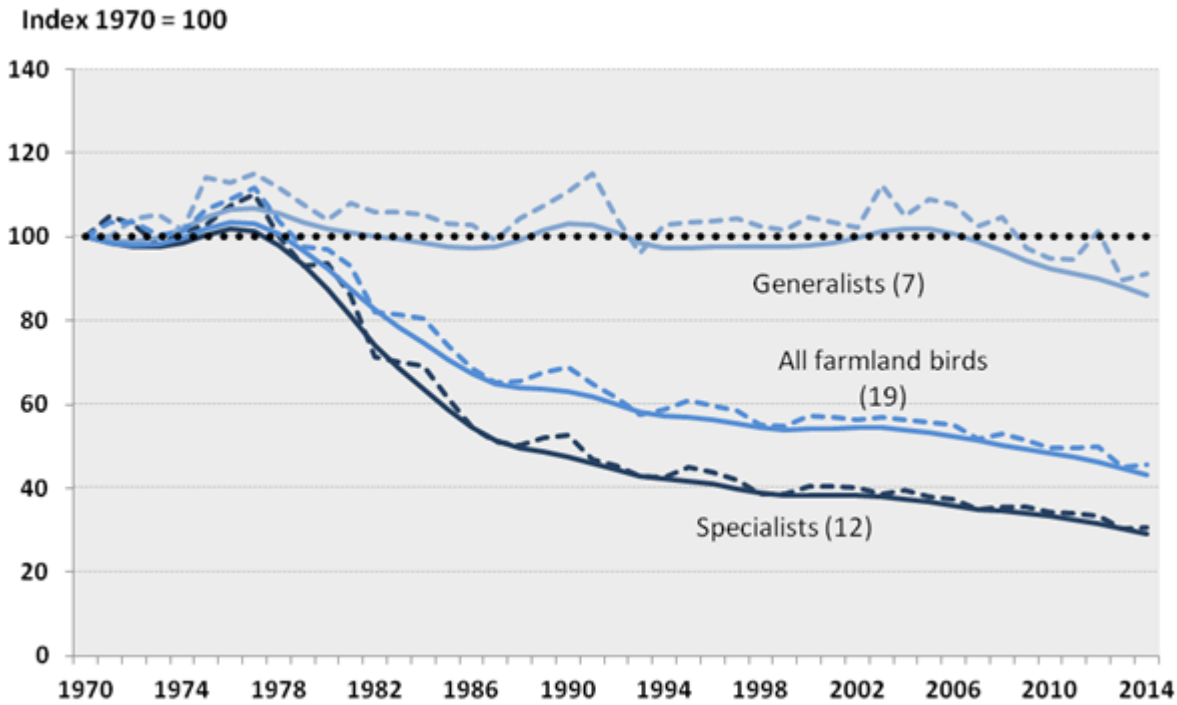
Biodiversity

Biodiversity is a characteristic of ecosystems which is valued in its own right but also has a functional role in the provision of other ecosystem services. Indicators of the state of biodiversity are important in assessing the overall condition of the ecosystem. For the farmland ecosystem, a regularly updated index of specialist farmland birds is taken as an indicator for biodiversity.

Bird populations provide a good indication of the general state of biodiversity for a number of reasons. Firstly, there are considerable amounts of long-term data collected on bird populations in the UK, making it easier to establish trends. Secondly, the drivers of change for wild bird populations are well understood. Finally, birds are of significant cultural importance to the general public who place a high value on them[4].

Farmland specialist bird populations (those species that are restricted to, or highly dependent on, farmland habitats) are taken as an indicator, as they are less likely to be affected by changes in other habitats outside the scope of these accounts.

Figure 2: Populations of farmland birds in the UK, 1970 to 2014



Notes:

1. Sources: Royal Society for the Protection of Birds, British Trust For Ornithology, Joint Nature Conservation Committee, Department for Environment and Rural Affairs
2. Graph shows unsmoothed trends (dashed lines) and smoothed trends (solid lines).
3. Figures in brackets show the number of species.

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Figure 2 depicts the change in specialist farmland bird population between 1970 and 2013, compared with generalist bird population. It shows a clear decline in specialist bird population since 1970 believed to be primarily caused by the intensification of farming over that period. In particular, the loss of mixed farming, a move from spring to autumn sowing of crops, a change in grassland management, the increased use of pesticides and fertilisers and the removal of non-cropped field margins such as hedgerows have affected specialist bird populations.

Table 2 records a separate biodiversity indicator by a mean plant species richness score. The mean richness score is taken from the Countryside Survey and calculates the average count of plant species per 10 metres by 1 metre plot surveyed in the Countryside Survey. It can be seen, between 1998 and 2007 the mean species richness score increased. Mean richness score is also available for linear features in the reference tables of this publication.

Soil quality

Soil carbon is used as an indicator for soil quality. Research has indicated organic carbon levels within soil impact on its structural condition[5]. The structural condition determines the soil's resilience to runoff, ability to retain water, nutrient cycling and it is also a primary source of energy. Soil carbon levels are relevant to the provision of a number of ecosystem services including carbon sequestration, flood mitigation, water quality and water quantity.

The Countryside Survey provides measures of soil carbon for 2 different types of grassland within the 'semi-natural grassland' category, as well as for 'arable and horticultural' soils and 'improved grassland'. The categories of 'semi-natural grassland' covered are 'acid grassland' and 'neutral grassland', however, as already noted, the extent to which these land cover types are included within the June Survey is not clear.

Table 2 shows soil carbon concentration levels for arable and horticultural land in 2007 were lower than soil carbon concentrations levels in 1998. The change was statistically significant for 'arable and horticultural' and 'acid grassland' categories.

Recent Department for Environment, Food and Rural Affairs (Defra research)[6] analysed trend carbon levels in arable soil in England. It concluded the conversion of land from permanent grassland to arable has driven long-term decline in soil carbon levels. However, recent management trends such as shallow tillage and returning unused harvested residuals to the soil, may help to maintain and even increase levels of carbon in farmland soils.

Conservation

Land under protection is often protected for biodiversity and geological diversity. Protecting the land enhances the provision of recreation and other cultural services by maintaining valued landscapes.

Sites of Special Scientific Interest (SSSIs) are one category of statutorily protected land and have been shown to provide cultural services, such as ‘sense of place’ and important regulating and provisioning services[7]. Estimates of protected areas of farmland, including SSSIs, by devolved administration are provided in the datasets accompanying this publication.

Land managed under agri-environment schemes such as the Countryside Stewardship could also be a useful indicator of condition. However, current statistics available on agri-environment schemes do not make the distinction between land being actively sustainably managed and the total area of the farm or field involved in the scheme. Additionally, voluntary agri-environment schemes are not always effective at improving or maintaining condition, meaning available data are likely to overestimate the area of land actively managed through the scheme.

Potential characteristics not included and areas of further research

Access for recreation: Access is a main characteristic for farmland broad habitat. The UK National Ecosystem Assessment (NEA) identifies ‘sense of place and aesthetics’ as main cultural service of farmland. Good access to farmland, for example through public walkways, can improve the enjoyment of landscapes. The condition of footpaths and the proximity of these routes to centres of population plays an important role in determining the level of cultural services provided by the farmland ecosystem. The Ramblers Association (RA) lists around 650 rambling routes through farmland in Great Britain[8], however, does not have information on condition or proximity. Countryside rights of way data could be drawn on in the future to develop an indicator for recreation, although is currently available for England.

Soil nutrient balance: Data on soil nutrient levels are heavily influenced by the use of fertilisers. Due to this, soil nutrient levels are seen as an unreliable indicator of the ecosystem itself providing provisioning services. However, the nutrient balance will affect the impact farming activities have on other ecosystems (for example, through run-off to water courses, or by generating atmospheric emissions) and are relevant to the wider environmental accounts which report on anthropogenic interactions (those resulting from human activities) between the economy and the environment. For accounting purposes, such flows could also be recorded as flows between ecosystems.

Grade of agricultural land: The grade of land is mostly determined by climate, site and soil quality and relate to the capacity to deliver provisioning services. Some assessments of the grade of agricultural land are available. Soil quality is in turn determined by a complex set of ecosystem processes, thus the grade of agricultural land also acts as a proxy for continuing functioning of these processes. However, the last national scale assessment[9] was undertaken in 1974 and there are no plans for another assessment. It is also not clear how much of the farmland area included in this account would be covered by the indicator.

Tranquillity and light pollution: Levels on tranquillity and light pollution are linked to cultural services such as recreation and aesthetics. Tranquillity can also contribute to the heritage of an area whilst dark skies can attract visitors for educational purposes. Data on both tranquillity and light pollution are available from the Campaign to Protect Rural England, who conducted surveys in 2006 and 2003 respectively. However, the data for tranquillity is only available for England and there are no plans to update either source of data in the future.

Organic farming: The amount of land which is used for organic farming may be an option for an indicator of farmland condition in the future. Certain conditions have to be met in order to qualify for the status of organic produce and often the type of land management practices allowed to be employed are stipulated[10]. For crops, these practices aim to maintain soil quality which, as previously discussed can impact on a number of other services. This is an area for future research.

Notes for Asset accounts: extent and condition accounts

1. More details on the Set-aside scheme are available at http://www.hmrc.gov.uk/manuals/ihtmanual/ihtm24064.htm

2. Tilling is the preparation of soil for agriculture by various means, such as digging, stirring and overturning.

3. Countryside Survey 2007, Chapter 5 'Boundary and linear features broad habitat'. Available at, http://www.countrysidesurvey.org.uk/outputs/uk-results-2007

4. Wild bird populations in the UK, 1970 to 2013 (Defra, 2015). Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/471745/UK_Wild_birds_1970-2014__2_.pdf

5. Countryside Survey 2007, Soils report. Available at: http://www.countrysidesurvey.org.uk/outputs/soils-report-from-2007

6. Defra Research Project SP0533. Available at: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=11506&FromSearch=Y&Publisher=1&Search

7. Benefits of sites of special scientific interest in England and Wales (Defra, 2011) Available at: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=1&ProjectID=17005

8. Ramblers Association Routes Map. Available at: http://www.ramblers.org.uk/go-walking/find-a-walk-or-route.aspx?layer=routes

9. The Provisional Agricultural Land Classification map covering the whole of England and Wales is based on reconnaissance field surveys (1966 -1974) and contemporary climate data. Currently Agricultural Land Classification surveys are carried out on sites which are being considered for development. There has been no national scale assessment since the 1974 exercise.

10. More information available at http://adlib.everysite.co.uk/resources/000/264/735/guidance-document-jan2010.pdf

Ecosystem service accounts

The physical ecosystem services account captures the services society receives from farmland broad habitat in non-monetary or physical terms. At present, there is no standard classification of ecosystem services available, but the emerging classification system Common International Classification of Ecosystem Services (CICES)[1] and the UK NEA can be used as a checklist of potential services to be included within the account. CICES follows the same grouping of ecosystem services as the UK National Ecosystem Assessment (NEA), covering:

- provisioning services – all material and energetic outputs from the ecosystem; these are tangible things that can be exchanged, consumed and traded – products include food (crops, animal fodder, fish and honey), water, fibre (timber) and fuels (wood fuel)
- regulating services – the ways the ecosystem helps to control the natural environment and are not directly consumed.; examples include water purification, climate regulation, noise and air pollution reduction and flood hazard reduction
- cultural services – non-material benefits, for example cultural heritage, recreation or aesthetic experience

Certain services, such as pollination and biodiversity, which are referred to in the UK NEA, are not covered in these accounts. These services can be viewed as inputs to the production of final ecosystem services and their inclusion would lead to double-counting in the final value of ecosystem services from farmland. The physical flows of such services are still important and are recognised in the discussion following the table.

Additionally, an important challenge in measuring ecosystem services relating to farmland comes from the complex relationship between the farming activity and the ecosystem. As farming has developed, it has become less and less dependent on the natural state of the ecosystem in which it operates. Separating ecosystem services from human induced or anthropogenic, impacts in farmland ecosystem accounts is tricky and this is discussed in Annex 2.

Physical

The majority of the farmland broad habitat is managed to produce food for either human or animal consumption, meaning provisioning services are dominant in these accounts. For simplicity, the accounts draw the boundary between the ecosystem and the economy at the harvesting (including grazing) of vegetable matter. Therefore, livestock is not viewed as a final ecosystem service within the accounts but feed stocks produced in the UK, which go into livestock's rearing, are included as an ecosystem service of the farmland broad habitat.

Table 3 summarises the physical ecosystem service accounts for farmland. On the whole, total provisioning service of farmland has fallen between 1998 and 2013, whilst regulating services of waste mediation and carbon sequestration have increased.

Table 3: Summary of the physical flows of ecosystem services from farmland, 1998 to 2013, UK

Type of service	Provisioning	Regulating		Cultural	
	Crops, horticultural and feed stocks (thousand tonnes)	Grasses / Grazed Biomass (thousand tonnes)	Global climate regulation (thousand t CO2)	Waste mediation (million tonnes)[1]	Recreation [2] (million visits/ year)
Opening Stock 1998	94,492	24269	3074	-	-
Net additions (+)/ Reductions(-)	-7,655	-10,698	762	-	-
Stock 2007	86,837	13571	3836	75.4	-
Net additions (+)/ Reductions(-)	11,049	-8,210	-548	10	-
Closing stock 2014	97,886	5361	3288	85.2	235

Table notes:

1. Source: Countryside survey, Monitor of Engagement with the Natural Environment, Department for the Environment , Food and Rural Affairs
2. Great Britain only
3. First year of data collected used as data point. Data collected for years 2009 to 2010, 2010 to 2011, 2011 to 2012, 2012 to 2013, 2013- to 014. Represented by 2009, 2010, 2011, 2012, 2013 respectively. England only.

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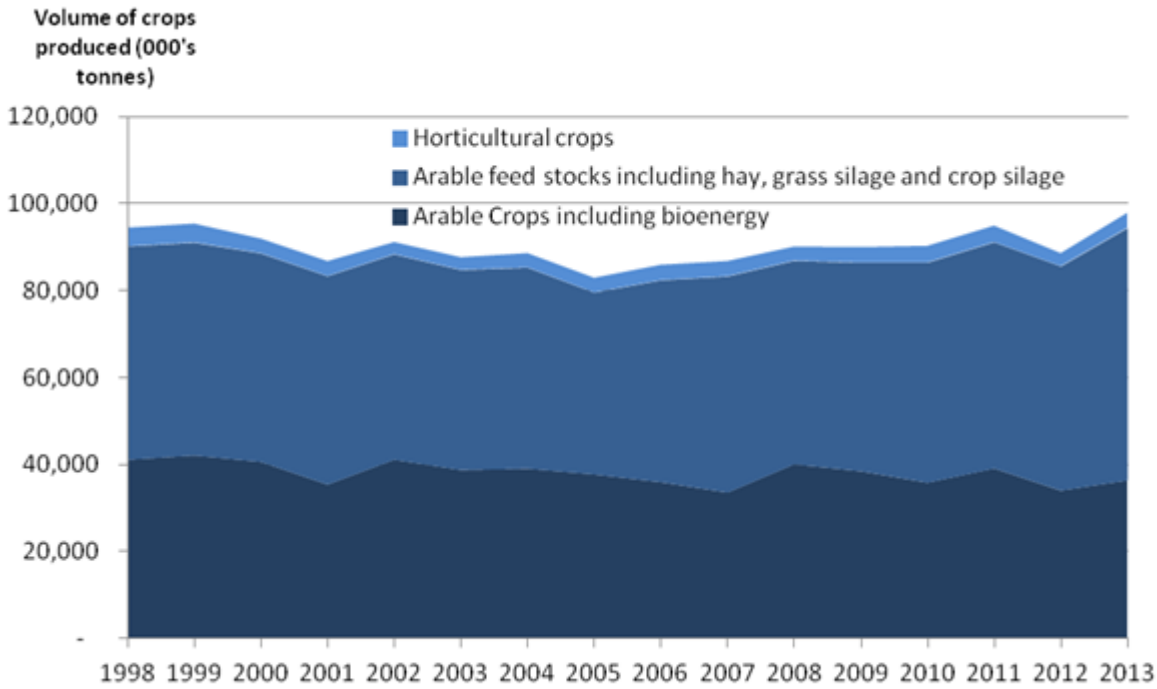
Provisioning services: crops and cut grass

Over half of the land in the farmland broad habitat is used for arable and horticultural crops, including energy crop production. The volume of crops produced has increased by 3.5% since 1998. Figure 3 gives more detail on what is driving this change[2]. The volumes presented are sourced from the ‘Agriculture in the UK’ dataset. In the absence of absolute stock figures, unit prices and total values were used to estimate a total volume produced.

Figure 3: Breakdown of Crops, horticultural and feed stocks, 1998 to 2013, UK



Notes:

1. Source: Department for Environment and Rural Affairs

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The increase in crop production is mostly accounted for by large increases in cut grass and silage volumes. Both arable and horticultural crop volumes have decreased slightly since 1998, though yields per hectare have remained static over this time[3]. For the full data set see the dataset.

Provisioning services: grazed grass

Grass extracted through grazing, is a feedstock but is not harvested so included in the crops section. Table 3 gives the estimated volume of grass which is consumed by livestock in the UK.

Estimates of grazed biomass are based on demand and were calculated using a tool developed by Eurostat. Specifically, animal population data and annual feed intake factors were used to calculate roughage requirements. The quantity of animal feed crops available was then subtracted from the roughage requirement to give an estimate of the demand for grazed biomass.

Grazed biomass has been decreasing due to the increase in animal feed crops. Between 1998 and 2013, demand for grazed biomass fell on average 7% a year. It is important to note, the fall in

grazed biomass does not indicate a fall in the amount of area supplied by farmland for grazing, but provides an indication of the fall in the amount of grazed biomass demanded by livestock.

Other food grown for livestock consumption includes barley, oats, peas and beans including the silage used for feed stocks. All these food sources are included in the arable crops estimated volumes in the section above.

Provisioning services not included in the services account

Timber: In 2014 ,the June Survey estimated there was 897,000 hectares (ha) of woodlands on farms. Woodlands are planted and maintained on farms for a number of reasons, including shelter for livestock and recreation. Timber is also produced from farm woodlands, though they are often isolated and rarely planted specifically for this purpose. As previously discussed, distinguishing farm woodland from other forms of woodland covered by the woodland ecosystem accounts is not possible from the available data sources.

Water provisioning: Bodies of open water often form part of the land used by farmers and can be found in the form of ponds as well as rivers and streams. However, such water bodies are included within the accounts for freshwater ecosystems we have already developed and are not therefore measured or valued within the farmland ecosystem accounts to avoid double counting.

Pollinators: Pollinators are important inputs to the production of crops and horticultural produce. Pollinator populations in the UK are in decline. Between 1985 and 2005, honey bee colonies decreased by 54% in England, 15% in Scotland and 23% in Wales[4]. A main driver of this decline is the loss of flower rich semi-natural grassland in farmland, for example, through the loss of field margins.

For accounting purposes, pollination services are viewed as intermediate services, supporting the production of a number of final ecosystem services (primarily crops but also wider biodiversity). It is possible to develop supplementary accounts to provide an insight into changes in the level and value of pollination services, but they will not be shown separately within the final ecosystem services account.

Regulating services

The extent accounts have shown farmland broad habitat covers a large area of UK land, so it might be expected there are strong benefits through regulating services. However, current farming practices often limit these benefits; for example, short crop cycles can limit the amount of carbon that can be sequestered.

External impacts are treated as inter-ecosystem flows within the accounting context, and would show up as a change in condition within the relevant account. Other impacts of farming activities – for example the releases of carbon through tilling – are viewed as manmade, or anthropogenic, and are accounted for within the UK's atmospheric emission accounts[5].

Regulating service: global climate regulation

Farmland ecosystems help to regulate the climate primarily by storing greenhouse gases (GHGs), principally carbon dioxide. Farmland soils act as carbon stores, with grassland soils containing more carbon than arable soils. Frequent tilling of soil and the conversion of permanent grassland to cropland causes a loss of soil carbon and reduces the carbon storage service. As discussed in the condition account section, soil carbon in cropland has declined since 1998.

UK Greenhouse Gas Emissions Inventory[6] records net greenhouse gas emissions from cropland,and net sequestration (removals) from grassland. The removals mainly relate to the ongoing gain in soil carbon relating to historic land use change from cropland to grassland. Removals resulting from farmland (whether cropland or grassland) in a long-term steady state are not thought to be significant. The Emissions Inventory estimates can only be taken as indicative of the carbon sequestration service provided by the farmland ecosystem as the category of grassland may include estimates of removals by other land cover types such as moorland and heaths. Further work is needed to identify the element relating to grassland on farmland and to clarify the extent to which sequestration relating to past land use change can be regarded as an ecosystem service.

Regulating service: mediation of waste

Manure, sludge left over for water treatment and other forms of waste biomass contain valuable nutrients and are often spread within the farmland broad habitat as a fertiliser. A total of 95 million tonnes were spread on farmland in 2014[7] and the benefit to society can be seen as an ecosystem service because, in the absence of spreading this waste, other, potentially costly methods of disposal would have to be used. For example, sludge from water treatment works is often incinerated if it is not used for fertiliser, this is costly and damaging for the environment. In addition, recent data suggests in cases where waste biomass is spread there is overall less nitrogen used in the fertilising process[8]. This could help decrease the runoff of nitrogen into local water courses.

The vast majority of the waste spread is dairy farmyard manure and cattle slurry (41% and 48% respectively[9]). In the absence of farmland, such quantities of waste would have to be disposed of elsewhere.

Regulating services not included in the service account

Air quality

Air quality services are provided by ecosystems through the absorption of air pollutants by vegetation, primarily hedgerows and trees and to a more limited extent by grasses and crops. It is difficult to disentangle these benefits from the negative impacts of farming practices on air quality, in particular the high levels of methane and ammonia emitted by manure spreading and livestock housing. In 2012, agriculture accounted for 82% of UK ammonia emissions[10]. These emissions are recorded in the UK atmospheric emissions accounts[11].

Some limited estimates of the filtration services are available. For example, a recent Department for Environment, Food and Rural Affairs (Defra) research study of the Dorset Area of Outstanding

Natural Beauty[12] estimated that farmland within the protected area absorbed 578 tonnes of particulate matter (PM_{10}) per year from 2007 to 2014. Further work is needed to determine how these rates of filtration might be applied to the wider cropland and grassland.

Water flow regulation (flood control) and control of soil erosion rates

Any vegetative cover, such as that on farmland, helps to reduce flood risk compared with compacted or otherwise sealed surfaces. Soil structure (that is the spaces between particles of soil) is important in determining how much water runs off into rivers and streams, increasing the likelihood of flooding. As discussed previously, soil carbon in cropland is decreasing; as soil carbon (in the form of organic matter) is an important factor determining soil structure, this may result in decreased water storage and increased soil erosion and flood risk.

It is very difficult to measure this service and specific models may well be needed to understand the contribution which farmland makes to regulating water movement and stabilising soil. A further difficulty lies in differentiating between the service as currently provided, and the potential capacity of the land under different land use regimes to provide an increased level of service. If the land was not used for cropland, for example, it's likely that some at least would be woodland or permanent grassland. Both of these land cover types have better soil structures with higher carbon concentrations so would probably hold more water and have lower rates of soil erosion than cropland soils.

Water quality

Water quality services provided by ecosystems relate to the filtering and absorption of pollutants before they reach water bodies. The service may in some respects be viewed as a supporting service for the provision of clean water for abstraction by economic users. For farmland ecosystems, the measurement of the service is made more complex by the impact that diffuse pollution from farming practices has on water quality. This pollution includes nitrates and phosphorus from excess fertilisers which have not been absorbed by the crops, as well as sediment and parasites. Diffuse pollution from agricultural practices is a significant contributor to poor water quality: in 2013 the Environment Agency estimated that diffuse pollution from agriculture is the likely cause of 31% of failures of water bodies to meet 'good status.' Diffuse pollution from farming has recently fallen; between 2000 and 2012, the soil nutrient balances for nitrogen and phosphorus fell by 17% and 25% respectively[13].

Although diffuse pollution from farmland has a negative impact on water quality, the flows of disservices are viewed as being due to human practice and not caused by the ecosystem itself. For this reason, they do not form part of the account for ecosystem services.

Biological pest control

This service relates to the natural control of pest species by their predators and parasites. For example, spiders play an important role in keeping down certain pest populations, such as flies. Natural pest control is also a service because it decreases the need for pesticides which are both costly and environmentally damaging.

The measurement of biological pest control is challenging because it is hard to establish the relationship between increased food yields and populations of natural enemies of pests. Yields vary from field to field and are subject to a range of other factors so it is difficult to attribute any yield changes specifically to increases in pests' natural enemies. In addition, when pesticides are used they eliminate both the pest and its natural enemy, making the service even harder to measure. Finally, insofar as pest control supports the service of providing crops, it should be regarded as a supporting service rather than as a final ecosystem service.

Cultural services

The UK NEA Follow-on studies[14] describe cultural services as the "individual or shared benefits to human wellbeing that arise from the interactions between environmental spaces (for example, gardens, parks, beaches and landscapes) and cultural practices (for example, gardening walking, painting, and watching wildlife)". Cultural services can be subjective and context specific, making them difficult to measure and assess. Cultural services include recreation, heritage and education. These benefits do not just accrue to those living and working within the landscape but also indirectly to others through art, television and any other goods and services with a positive association to farmland.

Cultural services: recreation

The ecosystem provides the environmental setting and characteristics which allow a number of cultural activities to take place. Farmland attracts millions of visitors each year, who engage in recreational activities such as walking, cycling, horse riding, fruit picking and game-shooting. Data collected by the Monitor of Engagement with the Natural Environment (MENE) survey[15] shows that over 200 million visits are made to farmland each year in England. This represents 7 to 9% of all recreational visits in England. However, data is only available for the years 2009 onwards and does not contain data for Scotland, Wales and Northern Ireland. Some estimates for Wales and Scotland are available, although the methodology used is slightly different so are not comparable.

Cultural services not included in the service account

Education

Farmland provides a range of learning and development opportunities in education and academia. It is unclear how much of this education is relevant to the farmland habitat and how much of the education is geared towards learning about the manmade structures and inputs into crop production. For these reason the services recorded in Table 4 are not included in the final physical account of ecosystem services.

Table 4: Visits to farms under the Educational Access programme England between 2005 to 2006 and 2014 to 2015

Years	Number of visits to farms in Educational Access programme	Number of children visiting farms in the Educational Access programme
2005/06	5,570	55,000
2006/07	5,749	65,000
2007/08	7,040	90,000
2008/09	7,309	94,286
2009/10	8,684	112,024
2010/11	11,401	147,073
2011/12	11,402	147,086
2012/13	16,568	248,141
2013/14	18,125	310,059
2014/15	13,659	230,702

Table notes:

1. Source: Natural England

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The data in Table 4 relates solely to visits made to farmland through Natural England's educational access programme[16]. In 2007, 174,000 individuals visited farmland for educational reasons. Of this number, around 40% were school children.

Landscape amenity, 'Sense of Place' and spiritual values

Value is placed on the aesthetic quality of landscapes associated with different ecosystems. Research by Natural England into the cultural values of landscapes concluded the field systems which are associated with farmland are highly valued by society and are regarded as a 'key facet of the English landscape'[17]. This is particularly true of lowland landscapes with a patchwork of fields with linear/boundary features such as hedgerows and stone walls. Individuals interviewed in this project indicated that the farmland landscape was worth protecting. These landscapes are not only valued by those who live, work or visit these sites but also indirectly through pictures and television. It is expected that similar values will apply to other parts of the UK.

Measuring the amenity generated by farmland landscapes is very challenging and at the moment no systematic estimates are available. However, recent research commissioned by Defra[18] used the number of photos uploaded onto a site which hosts photographs of aesthetically valued landscapes

(Panoramio) as a non-monetary indicator of the level of aesthetic values. Changes in these numbers will reflect other factors besides the importance of the landscape itself, but comparisons between different habitats would be instructive.

There is no established definition of 'Sense of Place' although the UK NEA describes it as 'the degree to which agricultural landscapes provide meaningful places for individuals'[19]. This is also difficult to measure in a systematic way. It probably applies mainly to local residents as it would only be meaningful to a person who had visited, worked or lived within that landscape. It is also possible that the person for whom the landscape has meaning values it simply for existing and would continue to do so even if they were never to see that landscape again. It is doubtful whether these values can be effectively differentiated from landscape amenity and recreational values.

The service relating to 'spiritual values' can be broadly interpreted to refer to the wildness or naturalness of the habitat as well as to sacred places or species. There may be a few such places located on farmland in the UK but it will be difficult to identify them in a systematic way.

Notes for Ecosystem service accounts

1. For more information on CICES see http://cices.eu/

2. Arable crop volumes include volumes for cereals (wheat, oats, barley), energy crops (linseed and oilseed), sugar beet, peas, beans and potatoes. Horticultural crop volumes were estimated by summing volumes produced for fresh vegetables, plants and flowers and fresh fruit. Cut grass and crop silage data were taken from the Structure December 2014 database. This data includes hay, grass and crop silage.

3. Refer to Annex 3 for further information on yields per hectare.

4. Potts et al, 2010a, as found in the UK NEA 2007 available at: http://uknea.unep-wcmc.org/LinkClick.aspx?fileticket=dNp%2BvIjmXi4%3D&tabid=82

5. See UK Environmental Accounts available at http://www.ons.gov.uk/ons/rel/environmental/uk-environmental-accounts/index.html

6. UK Greenhouse Gas Emissions Inventory 1990 to 2013 (DECC, 2015)Available at http://uk-air.defra.gov.uk/assets/documents/reports/cat07/1512091113_ukghgi-90-13_Issue_1.pdf

7. British Survey of Fertiliser Practice 2014, Available at https://www.gov.uk/government/statistics/british-survey-of-fertiliser-practice-2014

8. British Survey of Fertiliser Practice 2014, Available at https://www.gov.uk/government/statistics/british-survey-of-fertiliser-practice-2014

9. British Survey of Fertiliser Practice 2014, Available at https://www.gov.uk/government/statistics/british-survey-of-fertiliser-practice-2014

10. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/458429/agindicator-dc1-03sept15.pdf

11. ONS UK Environmental Accounts available at http://www.ons.gov.uk/ons/rel/environmental/uk-environmental-accounts/index.html

12. Developing ecosystems for protected areas in England and Scotland (Defra, 2015). Available at http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=19271&FromSearch=Y&Publisher=1&Search

13. Agriculture in the UK datasets available at https://www.gov.uk/government/statistical-data-sets/agriculture-in-the-united-kingdom#history

14. UK National Ecosystem Assessment Follow-On (Defra 2014) available at http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=2&ProjectID=18081

15. Natural England (2015) available at http://publications.naturalengland.org.uk/publication/6579788732956672

16. More information on the Natural England educational access scheme can be found at this address: http://cwr.naturalengland.org.uk/educational-access.aspx

17. Natural England (2009). Experiencing landscapes: Capturing the cultural services and experiential qualities of landscape Available at http://publications.naturalengland.org.uk/file/71031

18. Developing ecosystems for protected areas in England and Scotland (Defra 2015) available at http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=19271&FromSearch=Y&Publisher=1&Search

19. UK NEA, Chapter 7, p.219

Conclusions and recommendations

Extent

The total extent of farmland in the UK has been relatively stable over the period 1998-2014, however, land use changes within the farmland ecosystem have been significant. Cropped and uncropped arable land and rough grazing land use have significantly declined in area. The abolition of the statutory set aside scheme, under the Common Agricultural Policy and changing prices for cereals are likely to have driven this decline. In comparison, temporary and permanent grassland have increased significantly.

Further work is needed on establishing the link between UK National Ecosystem Assessment (NEA) land use classifications and land use categories given in the June Survey.

Condition

Condition of farmland on the whole is in decline. Indicators for biodiversity, soil carbon and land under statutory conservation in the asset account have all shown decreases over the 1998 to 2014 period. More research is needed in order to establish other possible indicators for condition including soil nutrient balances, organic farming and access for recreation as well as an update for the indicators for hedges and soil quality provided by previous Countryside Surveys.

Further work is needed to expand and refine the condition indicators. For example, indicators on light and tranquillity and access to farmland for recreational purposes are not included, but would provide useful indicators.

Provision of services

Despite the decline in condition of the farmland ecosystem, the majority of services received from the farmland habitat have not declined. Regulating services, as measured by global climate regulation and waste mediation, have risen between 1998 and 2013. The increase in global climate regulation may be explained by an increase in land used for permanent grassland. Though permanent grassland is cropped, it is not tilled so more carbon can be stored than in arable cropped land.

The volume of provisioning services provided by farmland has fallen over this time. The volume of arable and horticultural crops provided a slight increase, however the provision of grazed biomass decreased by 78% between 1998 and 2013. This corresponds with the switching in land use from uncropped arable and rough grazing towards permanent grassland. This trend suggests that livestock are increasingly being fed from cut feedstock, production of which in the UK has increased by 10 million tonnes (18%) between 1998 and 2012.

Cultural services, as measured by visits made to farmland, have also increased modestly over this time.

The physical ecosystem services account is currently missing estimates of the level of flood control and control of soil erosion services which would require complex modelling.

Annex 1: Comparison of June survey land use classes and UK NEA broad habitats

The UK National Ecosystem Assessment (UK NEA) classified land cover in the UK into a number of broad habitats, with the (enclosed) farmland broad habitat covering both ‘arable and horticultural land’ and ‘improved grassland’ as set out in the Countryside Survey and the Land Cover Map 2007 (LCM):

- ‘arable and horticultural’ is land cultivated to grow annually harvested crops and includes crops, grass leys, ploughed land and weedy vegetation

- ‘improved grassland’ is normally managed to provide food for livestock through the use of herbicides, pesticides, and ploughing – it occurs when 75% of the land is covered in palatable grasses and there is a restricted range of broadleaved species
- hedgerows, ditches, ponds, farm woodlands and buildings which are interspersed among arable land and grassland were also included within this broad habitat

These categories are not directly comparable to the June Survey categories which this account has used to determine extent of the farmland ecosystem as it an up-to-date annual source of data on relevant land uses. Classifications from the June survey can be broadly grouped into the categories used for the UK NEA Enclosed farmland broad habitat. Table A1 below shows the approximate structure of this grouping.

Table A1: Classification Mapping

UK NEA Classification	Land Cover Map Classifications	June Survey Classifications
Enclosed Farmland	Arable and horticultural	Crops
		Uncropped arable land
	Improved grassland	Temporary grassland
		Permanent grassland
		Common and sole right rough grazing
	Other agricultural land	Other land on agricultural holdings
Some SNG and ‘Mountains Moorland and Heaths’		Common and sole right rough grazing

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Common and sole right rough grazing categories used in the June Survey need to be included to properly cover the ‘improved grassland’ classification within farmland. However, rough grazing land overlaps with the UK NEA category of ‘semi-natural grassland’ (SNG).

‘Semi-natural grassland’ (SNG) is defined as the land cover which results from low intensity traditional farming or natural vegetation on poor soils and in exposed locations. However, some low intensity rough grazing land is also located in highland areas, overlapping with ‘mountains moors and heaths’ (MMH) broad habitat defined by the UK NEA.

It is not possible to reconcile these different sources at the moment. Once initial ecosystem accounts have been developed for the full range of broad habitats, it will be necessary to review the coverage of each account to ensure that they are comprehensive and that there is no double-counting.

Annex 2: Separating ecosystem services from anthropogenic impacts in farmland ecosystem accounts

A n important challenge in measuring ecosystem services relating to the farmland habitat comes from the complex relationship between the farming activity and the ecosystem. As farming has developed, it has become less dependent on the natural state of the ecosystem in which it operates. Plants can now be grown in a climate controlled greenhouse, without soil, under ‘grow lights’ which simulate the sun’s rays and allow plants to grow all day around. In these cases, the crops that result can no longer be said to be a provisioning service of the ecosystem. This is an extreme example of intensive management.

Not all farmland is so intensively managed (for example, organic farming, farming on semi-natural grassland, and on other sites of special scientific interest (SSSIs)). In these cases the role of the ecosystem in the production of agricultural outputs are clearer. Most farms do not operate at either of these extremes and the use of fertilisers, pesticides and crop cycle manipulation is widespread. According to the Farm Practices survey, 83% of holdings spread nitrogen-based fertilisers on their cropland[1]. This means that identifying the contribution of the ecosystem to the growing of crops is hard to assess.

The intensification of livestock farming has also led to a diminishing reliance on the natural environment for the provision of the final product (the animal itself, which then provides dairy products, meat, wool etc.). The extent to which the ecosystem provides main inputs to the production of this final product will vary depending upon the type of livestock and the way in which it is managed.

Limiting the ecosystem boundary to the provision of vegetation can simplify the problem of distinguishing anthropogenic impacts, although does not solve it.

This boundary can be explained as land managers impact on the ecosystem through the physical inputs of fertilisers and sowing, and through management practices. This interaction provides the grass and crop residue on which animals graze. However, the final product also requires further human inputs in the form of veterinary care and herding. Hence, although for intensive livestock practices the provision of grass for grazing might best be regarded as the final ecosystem service, for livestock which is kept predominantly on the open land, it would be possible to view the animal itself as the final ecosystem service. In practice little information is available on the extent of different farming practices and for convenience the boundary between the ecosystem and the economy has been drawn at the point at which the crop is harvested or the grass is grazed. Generally speaking, this is the approach advocated in the United Nations system of environmental-economic accounting (UN SEEA) and adopted by Edens and Hein (2013) in their paper ‘Towards a consistent approach for ecosystem accounting’.)

Notes for Annex 2: Separating ecosystem services from anthropogenic impacts in farmland ecosystem accounts

1. Farm practices survey 2011 (Defra). Available at https://www.gov.uk/government/collections/farm-practices-survey

Annex 3: Land use definitions

Table A3: Land use definitions

Land Use	Description
Arable crops	Vegetables grown outside including cereals, oilseed rape, potatoes
Horticultural crops	Fruit, mushrooms, and flowers grown outside along with produce from greenhouses.
Uncropped arable land	Arable land not in production, including farmland managed for environmental benefits (including single payment and rural development schemes), wild bird cover and game cover.
Temporary grassland	Grassland under 5 years old. Temporary grassland can be assumed to form part of 'Improved Grassland' UK NEA definition as it is often in rotation, so is likely still to be under management and have been the subject of intervention.
Permanent grassland	Grassland more than 5 years old. Ecosystem service provision from this type of land is dependent on the management practices but this land will probably not be tilled
Common and sole right rough grazing	Habitats created by low-intensity, traditional farming.
Linear features in farmland (taken from the Countryside Survey)	Such as dry stone walls and hedges, a line of woody vegetation that has been subject to management so that trees no longer take their

Land Use	Description
	natural shape and dry stone walls. A highly valued feature of natural capital and key to the delivery of some important ecosystem services. Data taken from the countryside survey as linear features are not separated in the June survey.
Land used for outdoor pigs and other non-agricultural land	Land which is not covered by vegetation but which still lies within the boundaries of a farm. Barns, bed and breakfast accommodation, dairy sheds and other farm buildings are included in this category.

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Annex 4: Monetary accounts discussion

This annex discusses options for placing monetary values on some of the ecosystem services from farmland. Different types of services can be valued using different approaches, but the general aim is to maintain consistency with the monetary values incorporated within the standard National Accounts.

Provisioning services

It is possible to make an overall assessment of the monetary value of the provisioning service provided by the ecosystem by partitioning the economic surplus made by those harvesting the outputs from the ecosystem (known as the Gross Operating Surplus) between the owners of the capital employed in the operation and the ecosystem itself. The first is known as the return to produced capital, and is based on a standard rate of return to the estimated capital stock; the second is referred to as the Resource Rent (RR), and is calculated as a residual after the return to produced capital has been deducted from the Gross Operating Surplus.

Resource rents calculated for farmland tend to be relatively low and can be negative for some years. This is due to the amount of subsidies given and the level of produced inputs which go into the farming sector. Estimated resource rents may also vary between different sectors of the farming industry, so ideally it would be desirable to make separate calculations for the different types of

farming (for example, arable/horticultural and livestock) and match them to the different types of land cover (for example, cropland and grassland). A potential source of data is the Farm Business Survey[1] and detailed analysis of results would be required. This is an area for further work.

An alternative approach is to establish the value of the ecosystem product in situ. This is the approach taken for woodland accounts when valuing timber, where the stumpage price – the price paid for the right to harvest the timber – is used as a proxy for the resource rent. There is an implicit assumption that the economic inputs in bringing the tree to maturity are a relatively small part of the stumpage price.

For grass used for grazing, the equivalent to the stumpage price might be the price paid to the farmer for the right to graze livestock in a field. However, care is needed with this approach as the rental value may be affected by the subsidies received by the owner of the asset.

This approach is more robust than that of using the price of chopped feed stocks to estimate the value of grazed biomass, because the price of chopped grass is likely to reflect the extraction costs of harvesting, packaging and transporting the grass.

Pollination services

In 2007, approximately 20% of cropped area in the UK was covered by pollinator dependent crops[2]. Basing calculations on this dependence, the UK National Ecosystem Assessment (NEA) (updated for 2010 markets) found pollination services to be worth approximately £603 million to food production. Table A4 sets out the estimated values.

Pollinators are viewed as a supporting service; therefore they are only relevant to part of the production of provisioning services from farmland, so if the valuations were consistent with wider ecosystem valuation principles, these values would represent a bottom limit to the overall value of provisioning services.

Table A4: Pollination of crops (%) for 2010, UK

Crop	Dependence on Pollinators (%)	Production Value (£ millions) 2010	Pollination Value (£ millions) 2010
Oilseed Rape	25	674	169
Strawberries	45	261	118
Dessert Apples	85	63	54
Raspberries	45	103	46
Cucumbers	65	53	35
Culinary Apples	85	40	34
Tomatoes	25	115	29
Runner Beans	85	17	14
Pears	65	16	10
Plums	65	13	8
Other	5-85	285	88
Total			Approx. 603

Table notes:

1. Source: Status and value of pollinators and pollination services, Department for the Environment, Food and Rural Affairs

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Regulating services

Global climate regulation

Carbon sequestration and carbon storage are in principle two distinct regulating services. For carbon sequestration, standard methods exist for valuation using the non-traded price of carbon schedules published by the Department of Energy and Climate Change (DECC). These can be interpreted as simulated exchange values in that they are based on the marginal abatement costs of meeting UK policy targets.

Carbon storage can be seen as a separate service, and might be valued by reference to the cost of providing alternative sources of storage (rather than by the damage caused by releasing the stored carbon). The valuation of this service is relatively unexplored and will need to be the subject of further research.

Air quality

The value of air quality services received from the farmland ecosystem could be determined by reference to the damage costs avoided by the absorption of pollutants. One possibility is to use health damage cost values per tonne of particulate matter (PM_{10}) absorbed, from the Defra air quality guidance[3] on the assumption that the estimated cost is one that beneficiaries would be prepared to pay. Further work is needed to refine the assumptions about population exposure and to broaden the range of pollutants covered.

Mediation of waste

One possible approach to valuing the absorption of manure and slurry by the farmland ecosystem is to consider the costs of landfilling, mono-incineration and co-incineration of sludge with other wastes and deduct the cost of land spreading. This would provide a price per tonne which could be attributed to the service provided by the ecosystem.

There may also be a case for including the benefit of the avoided carbon emissions from spreading manure and slurry, given that cropland is recorded as a net emitter of carbon within the Greenhouse Gas Emissions Inventory.

Water flow regulation (flood prevention)

In principle the benefits of water flow regulation could be valued by reference to the damage costs avoided from reduced flood risk. However, the modelling required to establish the benefit is extremely complex and further research is needed.

There may also be a case for including the benefit of the avoided carbon emissions from spreading manure and slurry, given that cropland is recorded as a net emitter of carbon within the Greenhouse Gas Emissions Inventory.

Water flow regulation (flood prevention): In principle the benefits of water flow regulation could be valued by reference to the damage costs avoided from reduced flood risk. However, the modelling required to establish the benefit is extremely complex and further research is needed.

Cultural services

Recreation

The value of the farmland ecosystem as a setting for outdoor recreation can be estimated using a number of different approaches. One option is to use the travel costs revealed by the Monitor of Engagement with the Natural Environment (MENE) survey[4] as an indicator of willingness to pay. This method estimates the amount that visitors have paid to travel to a destination for recreational purpose, including the private motoring costs. The idea being the value of the recreational service which people receive from the site must be at least as much as the cost of travel to the site otherwise they would choose to go elsewhere. The data is available but the method is difficult to apply, this is an area for further work.

Another option would be to use Sen et al (2014)[5] estimates of recreational value per visit to grassland. Although the estimates are based on a meta-analysis of Willingness to Pay (WTP) studies, these can be taken as a proxy for exchange values.

A further option is to estimate the residual resource rent that accrues to those benefitting from visits to farmland. This would include those providing bed and breakfast accommodation, relevant catering services as well as the businesses supplying transport services.

Education

Education services may be valued using a version of the travel cost method described above, which would include the value of teachers' time as well as the costs of transportation. Some clarification on the extent to which the educational trip involves learning about the natural environment is needed before such values can be applied.

Conclusion

The provisioning services of crops and grazed grass provided by farmland are expected to be the most important ecosystem services in monetary terms. The total value for all provisioning services can be estimated using the resource rent method but further research needs to be conducted to be able to relate the values to the different types of land uses within the farmland ecosystem account.

Global climate regulation is relatively straightforward to value using Department of Energy and Climate Change (DECC) non-traded carbon prices for carbon sequestration but further work is needed to assess what proportion of the levels of removals reported in the Greenhouse Gas Emissions Inventory relate to farmland. Further work is also needed to identify suitable values for waste mediation and carbon storage services.

Avoided health damage costs and travel costs approaches both appear to be viable options for the valuation of air quality and recreation services respectively. More research is needed to assess how to estimate recreation values.

Notes for Annex 4: Monetary accounts discussion

1. Farm Business Survey available at http://www.farmbusinesssurvey.co.uk/

2. UK NEA 2011, Chapter 7

3. Defra (2015) available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/197893/pu1500-air-quality-greenbook-supp2013.pdf

4. Natural England (2015) available at http://publications.naturalengland.org.uk/publication/6579788732956672

5. Sen, A., Harwood AR, Bateman, I., Munday, P., Crowe, A., Brander, L., Raychaudhuri, J., Lovett, A., Foden, J., Provins, A.. 2014. Economic Assessment of the Recreational Value of

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Background notes

1. Details of the policy governing the release of new data are available by visiting www.statisticsauthority.gov.uk/assessment/code-of-practice/index.html or from the Media Relations Office email: media.relations@ons.gsi.gov.uk

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