Forgotten fields: mid-nineteenth century land use and characterisation in the South Downs National Park using the tithe surveys of England and Wales.

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ABSTRACT
The map and underlying geodatabase presented here at a scale of 1:25,000 (Main map) covers approximately 300 km² of the catchment of the lower Rother valley in West Sussex, within the South Downs National Park, southern England. It offers a unique view of land use based on the Tithe Surveys created during the early part of 1840s. This new and rigorously compiled empirical material serves as an exceptionally robust research resource to inform river catchment management planning, with potential to guide landscape restoration, steer sustainable farming activities and, conceivably, to facilitate scenario modelling of plausible land use futures during a period of great uncertainty regarding rural land management in the United Kingdom. The current map and geodatabase are the products of the Forgotten Fields Project, the intention being to extend the coverage to neighbouring catchments and thus provide a large-scale mapping resource and information portal for wide-ranging land management applications.

1. Introduction
Re-envisioning the historical landscape provides insights into the cultural, economic and physical processes that have shaped the contemporary geography of an area, enabling lost, marginalised, emergent and proliferating features to be recognised and investigated. Moreover, mapping and characterisation of historical land use and analysis of the changing nature of land cover can provide critical baseline data to inform river catchment management planning, with potential to guide landscape restoration and sustainable farming activities. The ‘Forgotten Fields’ project aims to construct, for the first time, a seamless map and geodatabase of past land use and land ownership based on the manuscript maps and accompanying documents of the tithe surveys of England and Wales (c. 1840s). The intention is to extend coverage across the Arun and Western Streams catchments of the South Downs National Park (SDNP), southern England. The first phase of the project, reported herein, focuses on the valley of the River Rother through West Sussex.

Situated at the western edge of the Weald, the lower Rother catchment that comprises the study area (approx. 300 km²) lies to the north of the chalk escarpment of the South Downs and includes the market towns of Midhurst and Petworth (Main map). The physical character of the area is detailed by Cox and Soar (2017) and the historical context of the river and floodplain is discussed by Pearson and Soar (2018). The SDNP (and the Rother catchment is no exception) is unique among Britain’s 15 National Parks in that it is an extensively and intensively farmed and managed rural landscape. This brings many socio-economic benefits but also a range of challenges in meeting strategic goals of land management and wildlife conservation policies, including preserving and, where possible, restoring significant features of the historical environment, resilient to the impacts of climate change and ever-demanding pressures on the landscape. The current vista of the Rother valley reveals only remnants of the Victorian countryside where fringe habitats, grasslands and meadows, hedgerows and seasonal habitats have made way for larger fields with poor conservation value and supporting low biodiversity with crop types and tilling practices prone to soil erosion, particularly within the characteristic sandy and loamy soils developed in the Lower Greensand lithologies of the valley (Boardman & Favis-Mortlock, 2014; Boardman, Shepheard, Walker, & Foster, 2009).

As large arable fields are connected hydrologically to watercourses by field drains, ditches and roads, sediment runoff can remain largely unchecked without the field boundaries and depositional sites afforded by small fields of the historical farming system. As a result, rates of soil loss monitored by Boardman et al. (2009) are exceptionally high in comparison with records from other UK sites and it is no surprise, therefore, that periodic muddy flooding is a contributing factor to siltation, fisheries and water quality problems within the Rother channel network (Cox & Soar, 2017).
presenting numerous challenges for sustainable river, floodplain and catchment management.

In September 1991, a UK Government White Paper, ‘This Common Inheritance’, invited English Heritage to create an inventory of landscapes of historic importance in order to conserve and manage England’s historic landscape assets (Edwards, 2007). Subsequently, local authorities, in partnership with English Heritage (later Historic England), have employed landscape characterisation as a planning tool. Similar programmes have been initiated in Scotland, Wales and the Republic of Ireland. The systematic classification of historic landscapes has resulted in the creation of a Historic Landscape Characterisation (HLC) dataset, available in a GIS-ready form. The HLC provides broad estimates of period and antiquity of identifiable landscape units based on desktop studies of key historic attributes that have shaped the landscape (Bannister, 2010). As such, it offers a first step to understanding the evolution of the landscape and is designed to be used in conjunction with other data sets. It is not to be taken as definitive, it simply offers an interpretation that can be modified in the light of new research.

The tithe surveys offer a rich supplement to the HLC. Conducted between 1836 and 1850, they provide a comprehensive inventory and picture of agricultural land in over 11,000 parishes across England and Wales (Kain & Prince, 1985, 2000). The surveys offer the most complete characterisation of past land use of any period and therefore significant potential as a benchmark dataset for analysis of land use change and exploring implications for land degradation and ecological quality. In completing the seamless tithe map of the lower Rother Catchment, a citizen science approach was employed with GIS students digitising tithe parcels as integral to their university coursework, with student work then assimilated and meticulously checked and corrected for consistency and quality.

It is envisaged that the tithe map and auxiliary data will provide a rich additional resource for better understanding the evolution of this dynamic and complex landscape. With uncertainty ever present in the eco-political framework supporting agriculture and rural land management in the UK, the resource provides indispensable evidence and, conceivably, a transferable approach to inform current and future management and planning where retrospective analysis of landscape character and change is required.

2. The Tithe Surveys of England and Wales

2.1. Historical context

Payment of a ‘tithe’ was common throughout Europe during the Middle Ages though it began to be replaced in England and Wales during the sixteenth century. Typically, a vicar or rector of a parish received payments in kind in the form of one tenth (tithe) of the profits of the land (a tenth of wheat, barley, oats etc.) for his living and the upkeep of Church assets. Large tithe barns were built to accommodate the produce prior to sale at market. Tithe payments would be adjusted in line with the prevailing market price of grain, though more closely when prices rose than when they fell (Barber, 1992).

Tithes were viewed as an iniquitous tax, an unnecessary burden on farmers who viewed payments as a disincentive for land improvement. Prior to the turn of the nineteenth century, the tithe had been grudgingly but nevertheless routinely paid by farmers (Kain & Prince, 2000). The early part of the nineteenth century, however, was a period of considerable social and economic change in Britain and Europe. Despite the brief expansion of farming and high grain prices during the Napoleonic Wars (1803–1815) agriculture fell into a deep depression. Between 1820 and 1836 Parliamentary select committees heard evidence of distress in rural areas, where farmers were overtaxed and oppressed by poor-rate assessments and tithe payments to the Church (Evans, 1976). Rural poverty became a focus for radical left-wing politicians such as William Cobbett (1763–1835) who encouraged the impoverished agricultural workers to rise up in protest at their own plight (Cobbett, 1830; Nattrass, 1995). The ‘Swing’ disturbances of 1830–31 swept across the rural counties of Southern England, spreading to East Anglia and as far as Carlisle, fuelled by the anti-clerical, anti-aristocratic and anti-corruption sentiments of the radicals (Hobsbawm & Rudé, 1969). Such disturbances, though, were minor in comparison to the so-called ‘Tithe Wars’ between 1830 and 1836 in Ireland in response to the imposition of tithes on the Roman Catholic majority for the upkeep of the established protestant Church of Ireland (Owens, 2004). The payment of tithes thus became a focus for serious levels of discontent over a wide area of Great Britain and Ireland.

The Government responded with a series of measures aimed at centralising the control of the state and thus maintaining order. The Reform Act of 1832 began a decade of reform that sought to counter growing dissatisfaction at age-old corruption and privilege. Together with the establishment of the Poor Law Commission in 1834 and Civil Registration in 1837, the Tithe Commutation Act of 1836 extended and centralised government responsibility during a period of extreme change and initiated a new land utilisation survey of unprecedented coverage and detail (Prince, 1959), comprising land use maps and extensive auxiliary information on land ownership, productivity and farming systems in the form of tithe apportionment data and reports.

2.2. The tithe surveys

The Commutation Act replaced payments in kind with a new pecuniary payment scheme, which minimised
sudden fluctuations by adjusting the payment based on the seven-year rolling average of the prices of wheat, barley and oats. Owners of not less than a quarter of the land by acreage or two thirds of the land by value were permitted to agree a rent-charge in lieu of tithes, a value that would be binding on all the other landowners (Kain & Prince, 2000). The global sum was apportioned amongst the landowners according to the relative value of their land, each parcel listed on a schedule of apportionment. Tenant farmers would typically pay the tithe as part of their rent to the landowner.

Apportioning the payment fairly was a challenging task as estimating the value of a field was made difficult by the frequency with which land use could change and by local variations in farming practices. Accurate measurement of the acreage of each titheable land parcel and recording of the ‘state of cultivation’ (whether arable, pasture, meadow, wood, etc.) were thus essential elements of the survey process. Firms that were familiar with the local farming practices were generally employed by the landowners to complete the surveys (Kain & Prince, 1985, 2000).

A map was required of each tithe district, typically a parish, to identify each individual titheable land parcel. Parishes were the product of centuries of change that often resulted in complex and fragmented boundaries (Figure 1). Each parcel or field shown on the map would be given a reference number unique within the tithe district that could be cross-referenced to an accompanying apportionment schedule that listed each field, its owner, tenant, acreage, state of cultivation, and the amount to be paid as tithe rent-charge (Figure 2) – a sort of Victorian land information system. The manuscripts associated with each tithe survey comprised three main elements; the map, the apportionment and papers associated with the process of commutation contained within the tithe files.

2.3. The tithe maps

Although the tithe maps were clearly a vital part of the process of commutation, the quality varied across the country. The Commission focused mainly on the planimetric accuracy of the map by comparing the position of lineework with the field books supplied by the surveyor. Those maps deemed to be of high quality in terms of accuracy and completeness were given a seal denoting first class by the Commission and deemed sufficiently accurate to serve as legal evidence of boundaries and areas (Kain & Prince, 2000). Second class maps met the minimum standard but were either compiled mainly from existing sources or of sub-standard accuracy relative to the first class maps.

For the county of Sussex, one-third of the maps were deemed to be first class, a proportion apparently only exceeded by Kent and Monmouthshire (Kain, Oliver, Fry, & Wilmot, 1995). For the study area, 16 of the 43 tithe maps are first class, the rest meeting the standard set by the Commission for second class (Table 1). Over three quarters of the maps in the study area were completed between 1837 and 1842, with scales ranging from one inch to three chains (1:2,376) to one inch to six chains (1:4,752). The primary purpose of the tithe map was to act simply as an index to the apportionment schedule and many maps appear quite plain, showing titheable parcels with their numbers. Attempts to standardise the map specification prior to the Act had failed due to the high cost, which resulted in marked variation in design and content between maps. Some maps are rich in cartographic detail including ornamental gardens, hedges, fences, ditches and gates along with roads, canals, tracks and footpaths (Figure 3). Coniferous and deciduous woodland, heaths, common lands, orchards and marshes are identifiable on many maps, together with detailed depictions of dwellings, farm buildings, gardens and yards.

2.4. The tithe apportionments

The richness of detail contained on the maps is more than matched by the wealth of information relating to each agricultural field contained within the apportionment. The names of land owners and occupants were recorded but were not to be considered as proof of ownership or tenancy, simply an identification of who would be liable to the tithe rent-charge. Critically, the total acreage and amount to be paid as rent-charge are listed together with a name and description of each field with a broader land use or ‘State of Cultivation’ provided in a separate column (Refer back to Figure 2).

The tithe surveys were never intended to provide a systematic classification of land use and so reconstruction of the maps and standardisation of the metadata are complicated by inconsistency in the description of state of cultivation between tithe parcels; indeed the state of cultivation for the study area is described in 171 unique ways. Broad entries such as arable, pasture, meadow and woodland are frequently intermingled with more precise definitions such as copse, coppice and fir plantation and buildings typically have very precise functions such as beer shop, church, and public house. Realising the complete picture of land use across a parish is further hindered by apportionments missing information for some fields, such as church lands, that were not liable to tithe rent-charge. However, this constitutes only a small amount, some 465 acres (0.01%) of the total study area.

2.5. The tithe files

The tithe files contain documents and correspondence relating to implementation of the Act for each tithe district (for details, see Cox & Dittmer, 1965; Kain &
An assistant tithe commissioner or local tithe agent would complete a structured report where commutation of the tithe was by agreement, addressing a series of questions relating to local farming practices, quality of the farmland and agricultural productivity (Figure 4). Occasionally, where disputes arose over the commutation, the files can reveal fascinating insights on the tensions within the farming community and how commutation was resolved and implemented.

3. Methods

3.1. Reconstructing the Tithe Map

Creating digital facsimiles of historical surveys and maps is not new. The high genealogical value of the surveys has resulted in the scanning of all the surviving tithe maps and input of the apportionment data to enable access for subscribers through The Genealogist website (The-genealogist.co.uk, 2018). The National Library of Wales, through its Cynefin Project, surface-cleaned, repaired and digitised 1224 tithe maps held in its archives. Volunteers used a crowdsourcing website to transcribe and georeference the maps which now form a central part of the Library’s ‘Places of Wales’ website. Where possible, county record offices have enabled online viewing of digital copies of the maps in order to enhance accessibility, while preserving the fragile originals. For the study area, West Sussex Record Office (WSRO) commissioned high resolution digital image capture of the tithe maps as part of a project funded by the Heritage Lottery Fund, West Sussex Archives Society and The Golden Trust. In addition, WSRO organised the painstaking transcription of the apportionment data by nearly 100 volunteers. The tithe maps and apportionments are now available from WSRO on CD.

Whilst high resolution digital images of the maps provide high quality copies of the original manuscripts, they do not offer the analytical capabilities of a vector data model in a GIS and are thus of limited utility in a research capacity. Conversion of the images to lines and polygons was largely undertaken by students studying undergraduate and postgraduate courses in GIS at the Department of Geography, University of Portsmouth. The approach to teaching GIS at Portsmouth is to provide students with intellectually stimulating challenges to enhance their skills acquisition and engage them in research through enquiry-based learning. On the face of it, the task set for the students might be of dubious intellectual value, however, the ultimate aim for students was to assess the past land use of a parish and suggest ways that this new knowledge might impact on catchment policy into the future. Operating in groups, students were assigned one of the tithe maps to digitise by

Figure 1. The 43 tithe districts contained within the study area presented a complex cartographic jigsaw that had to be completed through a careful process of connecting, associating and merging data after the initial digitising to generate the seamless land cover map.
carefully tracing geo-rectified images at a viewing scale no smaller than 1:5,000 for reproduction at 1:10,000 scale, the approximate scale of the original tithe maps.

No automatic generalisation routines were employed as the manual digitising process would naturally involve subjective generalisation by the operator. All digitising was meticulously quality checked, corrected where necessary and completed across the study area for all remaining parishes by experienced staff.

The main software requirements were met by Environmental Systems Research Institute’s (Esri) ArcMap® as it possesses sufficient data input, digitising, editing and analysis capabilities. In order to use the tithe data in conjunction with other spatial data, the images were georeferenced to the Ordnance Survey of Great Britain’s (OSGB) National Grid using existing large-scale 1:2,500 vector data (target data) in the form of the OSGB Mastermap® (OSMM).

Between eight and twelve control points, such as road intersections, significant buildings and intersections of walls and field boundaries were selected if they could be identified both on the tithe map and on OSMM to transform the scanned images to OSGB National Grid coordinates with a first order polynomial affine transformation. The root mean square error (RMSE) varied between tithe maps depending on the scale of the map and on its state of preservation. The mean RMSE for all the tithe maps was 11.7 m following the georeferencing process. Field boundaries were initially captured as lines and later transformed into polygons using specific topological rules then linked to the apportionment data using a standard relational join.

The most challenging task was ensuring that the individual tithe maps were edge-matched across parish boundaries, an undertaking never envisaged by the original map makers. Furthermore, parish boundaries are very often formed by poorly surveyed streams and rivers, features that were not a high priority for the tithe surveyors who were more focused on defining individual agricultural fields. Despite these shortcomings, a seamless map of the area emerged through patient reference to modern mapping and imagery.

Tabulation of total acreages of specific land uses or landowners is straightforward as is the integration with other georeferenced data sets such as geology, topography and terrain surface data captured through LiDAR and other national datasets. Given the wider emphasis of this research on catchment change and sustainable river basin management, the LiDAR data were used to demarcate the Rother catchment boundary by employing the Hydrology Tools module in ArcGIS. The data set was then clipped to this boundary.

![Figure 2. Extract from the tithe map of the parish of Harting together with an extract from the apportionment schedule.](image-url)
and then further clipped to the West Sussex county boundary which forms the western edge to the map. The tithe map apportionments for neighbouring Hampshire have yet to be input, so completion of the upper reaches of the Rother will form part of a future stage of the project.

The final map (Main map) is unique in illustrating the seamless distribution of mid-nineteenth century land use for this region whilst retaining a mapping style sensitive to the design and historical elegance of the original artefacts yet rectified to the contemporary mapping reference system of Great Britain and thus suitable for employment in a wide-range of GIS applications.

The accompanying geodatabase holds tithe records for over 27,000 agricultural fields in 43 tithe districts for the West Sussex part of the Rother catchment. It contains details on the holdings of 839 individual landowners and 1550 occupants covering nearly 300 square kilometres of agricultural land in various states of cultivation. Attribute table definitions listing the name of the attribute, its type, length and description are provided in Table 2.

### 3.2. Land use characterisation

As there is insufficient room here to provide a detailed analysis of the land use map, what follows is a broad summary of its main characteristics.

#### 3.2.1. Arable

Just over 41% of the land was classed as arable. However, maintaining consistency of the classification of the state of cultivation was made difficult by the broad definitions provided by the Commission and subsequent inconsistency of their interpretation by the tithe surveyors. What constituted ‘arable’ varied from the place to place and differs from modern interpretations. According to the commissioners, those lands that were ploughed within the previous three years for crops or fallow were to be classed as arable. Those lands not ploughed were to be classed as grass (Kain & Prince, 1985). However, long-ley pastures are often classed as arable. As a result, significant tracts of land were classed as arable even though they may have been ploughed only once in ten years. What

| Parish                          | App. Date | Map Date | Scale  | Surveyor               | Class | NA Ref |
|--------------------------------|-----------|----------|--------|------------------------|-------|--------|
| Barlton or Barlavington         | 1839      | 1840     | 1:3960 | Anon.                  | 2     | IR 30/35/19 |
| Bepton                          | 1838      | 1838     | 1:2376 | Thomas Baker           | 1     | IR 30/35/26 |
| Bignor (except Buddington)      | 1844      | 1843     | 1:4752 | Henry Salter           | 2     | IR 30/35/29 |
| Buddington (Tithing in Bignor Parish) | 1841    | 1840     | 1:2376 | Fredk & Henry E. Drayson | 1   | IR 30/35/47 |
| Bodecoton or Burton             | 1843      | 1841     | 1:3960 | Anon.                  | 1     | IR 30/35/37 |
| Bury                            | 1839      | 1850?    | 1:4752 | Henry Salter           | 2     | IR 30/35/50 |
| Chithurst                       | 1840      | 1840     | 1:2376 | Fredk & Henry E. Drayson | 1   | IR 30/35/62 |
| Coates                          | 1840      | 1839     | 1:2376 | William Bridge         | 1     | IR 30/35/66 |
| Cocking                         | 1842      | 1840     | 1:2376 | Fredk & Henry E. Drayson | 1   | IR 30/35/67 |
| Coldwaltham                     | 1841      | 1841     | 1:3168 | J. Butler              | 2     | IR 30/35/68 |
| Diddling                        | 1843      | 1840     | 1:2376 | Henry Hull             | 2     | IR 30/35/79 |
| Duncton                         | 1837      | 1837     | 1:3960 | William Knight         | 2     | IR 30/35/82 |
| Easebourne                      | 1847      | 1840     | 1:2376 | Anon.                  | 1     | IR 30/35/86 |
| Egdean                          | 1837      | 1837     | 1:3960 | William Knight         | 2     | IR 30/35/94 |
| Elisted                         | 1843      | 1840     | 1:4752 | Henry Hull             | 2     | IR 30/35/95 |
| Farnhurst [Fernhurst]           | 1846      | 1841     | 1:2376 | Fredk & Henry E. Drayson | 1   | IR 30/35/100 |
| Fittleworth                     | 1839      | 1839     | 1:3960 | Anon.                  | 2     | IR 30/35/105 |
| Graffham                        | 1842      | 1841     | 1:4752 | J.W. Blackman          | 2     | IR 30/35/115 |
| Hardham                         | 1849      | 1851     | 1:3168 | Anon.                  | 2     | IR 30/35/124 |
| Harting [East and South Harting]| 1841      | 1840     | 1:4752 | D. Ayling              | 2     | IR 30/35/126 |
| Heyshott                        | 1839      | 1840     | 1:3960 | Anon.                  | 2     | IR 30/35/135 |
| Ipning                          | 1842      | 1840     | 1:2376 | Fredk & Henry E. Drayson | 1   | IR 30/35/149 |
| Kirdford                        | 1845      | 1841     | 1:3168 | Anon.                  | 2     | IR 30/35/159 |
| Linch (tithable parts only)     | 1848      | 1848     | 1:4752 | Anon.                  | 2     | IR 30/35/166 |
| Linchmere                       | 1846      | 1846     | 1:2376 | Alfred Mellersh        | 2     | IR 30/35/167 |
| Lodsworth                       | 1841      | 1839     | 1:2376 | Thomas Baker           | 1     | IR 30/35/172 |
| Lurgashall                      | 1841      | 1840     | 1:3960 | Anon.                  | 2     | IR 30/35/174 |
| Midhurst                        | 1841      | 1841     | 1:2376 | Henry E. Drayson       | 1     | IR 30/35/183 |
| North Ambersham (tithing in the parish of Steep) | 1847 | 1840     | 1:2376 | Fredk & Henry E. Drayson | 1   | IR 30/35/7  |
| Northchapel                     | 1837      | 1839     | 1:3960 | Anon.                  | 2     | IR 30/35/192 |
| Petworth                        | 1837      | 1838     | 1:3960 | Anon.                  | 2     | IR 30/35/206 |
| Rogate                          | 1844      | 1843     | 1:4752 | Henry E. Drayson       | 2     | IR 30/35/221 |
| Selham                          | 1847      | 1840     | 1:2376 | Fredk & Henry E. Drayson | 1   | IR 30/35/231 |
| South Ambersham (tithing in the parish of Steep) | 1847 | 1848     | 1:2376 | William Bridge         | 1     | IR 30/35/8  |
| (tithable parts only)           |           |          |        |                        |       |        |
| Steedham (tithable parts only)  | 1845      | 1839?    | 1:4752 | Anon.                  | 2     | IR 30/35/247 |
| Stopham                         | 1838      | 1839     | 1:3960 | Anon.                  | 2     | IR 30/35/251 |
| Sutton                          | 1837      | 1840     | 1:3960 | Anon.                  | 2     | IR 30/35/256 |
| Terwick (in two parts)          | 1839      | 1837?    | 1:2376 | One part by W.H.H. Shorts | 2   | IR 30/35/262 |
| Tillington                      | 1837      | 1839     | 1:2376 | Thomas Baker           | 1     | IR 30/35/265 |
| Treyford                        | 1839      | 1840     | 1:4752 | Henry Hull             | 2     | IR 30/35/267 |
| Trotton cum Tuxlith             | 1840      | 1840     | 1:2376 | Fredk & Henry E. Drayson | 1   | IR 30/35/268 |
| Woolavington (4 parts)          | 1841      | 1839     | 1:4752 | J.W. Blackman          | 2     | IR 30/35/303 |
| Woolbeding                      | 1839      | 1839     | 1:2376 | Thomas Baker           | 1     | IR 30/35/304 |
constitutes ‘pasture’ or ‘arable’ is therefore not unequivocal. The distinction between permanent grassland and rotation grasses is also not clear-cut. The tithe files, though, provide some reassurance that such inconsistencies were not a major issue in the study area with arable being described as either a four or five course rotation.

3.3. Pasture and meadow

Grasslands, comprising pasture (15.6%) and meadow (10.2%) cover some 25% of the study area. However, by the time of the tithe surveys, the sowing of commercially-available grass and clover seeds led to many landowners treating pasture as just another arable crop (Rackham, 1986). The traditional grasslands held in common had gradually fallen under the control of private ownership largely through enclosure. The surviving ancient grasslands, rich in biodiversity and nutrients, continued to survive as ‘downland’ on the chalk hills of the South Downs and as meadow on the damp river floodplains and in areas immediately surrounding the villages and towns. The classification of meadow varies from one tithe district to another; some fields are simply classified as ‘grass’, despite the entry in the ‘name and description’ column describing them as ‘meadow’. For the purposes of consistency, where the name and description entry contains the word ‘meadow’ this has been taken as describing its land use.

3.4. Woodland, coppice, tree plantation, osier and orchard

Trees of some type contribute just over 19% of the study area. Despite the obvious value to the agricultural community of woodland, it was not subject to a tithe due to an ancient custom in the Weald area of southeast England. We should be mindful then that the surveyors were unlikely to have concentrated the same effort on mapping woodland as for arable or pasture. Coppice (8.8%), where naturally-growing trees have been harvested regularly for the supply of poles for fencing and other purposes, cover extensive areas of the Rother and Lod valleys. The term ‘plantation’ refers to areas of commercial planting of trees, typically of just one or two species. Very often these were conifers that would be replaced by new plantation following felling. The tithe surveys pre-date the widespread planting of conifers during the second half of the nineteenth century and contribute just 0.9% of the total land use. Osiers (0.04%) are beds of willow trees that were coppiced at one year’s growth to make such items as baskets. There are numerous areas of orchards (0.5%) shown.

Figure 3. An extract of the tithe map of the Parish of Coates of 1839, revealing detail of the Coates Castle estate gardens by William Bridger at a scale of 1:2,376. Embellishment with detail was common, especially if the property of wealthy landowners was contained within the map. Despite the level of useful ornamentation, the map was not deemed to be of ‘first class’ quality as it was based on an existing estate map and not originally constructed for the purposes of commuting the tithes.
on the map. These small orchards were far from being commercially viable and provided fruit or cider for family consumption. Though many areas of the map are designated as ‘unspecified woodland’ (9.2%), the tithe surveys do provide quantities and locations of other, more intensively managed wooded areas.

3.5. Common, heath, waste and water

Common land (5%) formed a vital part of the agricultural economy enabling farmers to graze their livestock on land held in severalty. Common land had been under the close control and protection of the manorial courts but with the gradual demise of these courts, the piecemeal enclosure of the commons was already underway by the time of the tithe surveys. Descriptions contained within the tithe files portray commons as areas largely consisting of rough heathland or waste on poor soils. Whilst we can assume that most areas of common were heathland we cannot assume that all areas of heathland were held in common. Those areas classed as heath cover 3.3% of the study area. A number of small ponds are scattered across the landscape, many of which were associated at one time with the important iron industry of the Weald, known locally as hammer ponds. Some provided a source of power for flour mills as well as supporting stocks of freshwater fish.

3.6. Buildings, gardens, roads and other minor land uses

Human activity in the area is clearly geared to agricultural production and the settlement pattern reflects this. To the south of the Rother, small villages such as South Harting, Elsted, Treyford, Bepton and Cocking nestle along a fertile spring line at the foot of the South Downs. The two larger market towns of Midhurst and Petworth sit close to the Rother, providing...
Table 2. Attribute table definitions listing the name of the attribute, its type, length and description.

| Attribute     | Type       | Length | Description                                                                                                                                 |
|---------------|------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Field numb    | String     | 5      | Field numbers as appear on the map. Parcels that are visible on the map but not numbered or listed in the apportionment have been coded according to their map representation: 10000 = Building; 11000 = Water; 12000 = Road; 13000 = Other; 14000 = Wood.|
| Owner_s       | String     | 60     | Surname of the land owner according to the apportionment.                                                                                   |
| Owner_f       | String     | 60     | First name of the land owner according to the apportionment.                                                                                 |
| Title1        | String     | 60     | Title of the land owner according to the apportionment.                                                                                     |
| Occ_s         | String     | 60     | Surname of the land occupant according to the apportionment.                                                                                 |
| Occ_f         | String     | 60     | First name of the land occupant according to the apportionment.                                                                                 |
| Description   | String     | 100    | Name of the tithe area (typically a field) or description of the area according to the apportionment.                                           |
| Acres         | Numeric    | 12     | Statute acres according to the apportionment (1 acre = 4 roods or 160 perches).                                                             |
| Roods         | Numeric    | 12     | Roods according to the apportionment (1 rood = 40 perches).                                                                                  |
| Perches       | Numeric    | 12     | Perches according to the apportionment (1 perch = 16.5 square feet).                                                                        |
| Pounds        | Numeric    | 12     | Tithe rent charge according to the apportionment in pounds sterling (1 pound = 20 shillings or 240 pence).                                |
| Shillings     | Numeric    | 12     | Shillings according to the apportionment (1 shilling = 12 pence).                                                                         |
| Pence         | Numeric    | 12     | Pence according to the apportionment.                                                                                                        |
| Parish        | String     | 30     | Name of tithe district, typically the parish according to the apportionment.                                                                |
| State_of_c    | String     | 60     | The state of cultivation according to local agricultural practice for the purposes of valuation.                                             |
| Landuse1      | String     | 50     | A combination of the `Name and description', `State of cultivation' columns and the tithe map (see coding method in the Field numb field description above). |
| Landuse2      | String     | 20     | A reclassification of Landuse1.                                                                                                             |
| Score         | Numeric    | 12     | A reliability score: 1 = as written in the `State of cultivation' column; 2 = as depicted on the tithe map; 3 = derived from the `Name and description' column; 4 = those areas where the classification of land use is based on the characteristics of surrounding land parcels. |

important service centres for the agricultural community. North of the Rother, where the agricultural capability of the land is relatively low, the settlement is more scattered amongst areas of heath and woodland. The large landscaped gardens of Cowdray Park and Petworth Park are indicative of the continued dominance of the landed gentry in the landscape of the mid-nineteenth century. The grain of road infrastructure is oriented broadly north–south serving the long-standing needs of those transporting goods and droving animals from the south coast to the expanding market of London to the north.

4. Discussion and conclusions

The benefits of populating a GIS with tithe survey data were first demonstrated during the 1990s (see Pearson, Carter, & Gallmeier, 1994; Pearson & Collier, 1998) and later employed to tackle research questions in agricultural history (Pearson & Collier, 2002). The Forgotten Fields project extends the utility of the tithe survey data further to the level of the catchment. Here, the tithe survey of the lower Rother catchment has been developed as a GIS, rectified to the national coordinate system to enable its potential utility value to be realised and the seamless map designed in a style not insensitive to the original paper copies.

The outputs of the Forgotten Fields project provide us with baseline information to explore in detail the changing nature of land use and consider implications for broad-scale habitats and soil erosion risk within the catchment. Initial comparison of the Tithe Map (Main map) with the present-day landscape, inferred by the Land Cover Map of 2015 (Rowland et al., 2017), reveals a wholesale change in the land use distribution within the study area since the 1840s: (i) 30% reduction in arable (11,229 to 7,895 ha); (ii) 26% increase in pasture (7087 to 8995 ha); 83% reduction in heathland (2394 to 406 ha); (iv) 73% increase in woodland (5283 to 9158 ha); (v) 26% increase in built up area (but marginal in real terms at 591 to 747 ha). In summary, the catchment area has exhibited a contraction of approximately a third of arable farmland (largely converted to pasture) and decimation of the heathland and ancient grasslands (offset largely by the expansion of woodland plantations). The surprising feature of the Tithe Map (Main map) is the predominance of arable fields, which contrasts the delusory vision of widespread, rolling grasslands that one might evoke of the 1840s landscape. In seeking to provide some explanation for the observed soil erosion features and impacts of the contemporary arable landscape, reference has been made previously to a shift in agricultural landscape from pre-war grazing to post-war arable farming (e.g. Boardman & Vandaele, 2016) and intensification in arable from the 1970s (Sear, 1996). While the late nineteenth century might have witnessed an increase in pasture associated with arable farming falling into disuse or subject to reversion associated with the import of cheap grain from North America (Betsey, 1999), at the time of the tithe surveys, the Rother valley depicted a landscape of arable farming considerably more extensive than present. Indeed, documented dredging activities
on the Rother Navigation Channel since its construction in 1791 (Vine, 1995) conceivably indicates that soil erosion and sediment runoff are not merely concerns of the contemporary landscape but were probably prevalent across the historical landscape too.

The project outputs also provide a unique opportunity to scenario model a range of plausible land use ‘futures’ and their impacts, informed by the conflation of observed near- and long-term historical land use change with speculative drivers that will shape the future of farming and rural land management in the UK. Filling this near-term research impetus, together with further scrutiny of historical land use characterisation, will provide an invaluable evidence base for enabling habitat conservation and restoration policies to be implemented sustainably, targeting future soil conservation and catchment sensitive farming initiatives (for context, see Pearson & Soar, 2018) and locations to be identified where environmental management resources should be directed and prioritised. The geodatabase for the lower Rother has already been instrumental in re-envisioning the character and features of a former floodplain meadow with significant potential as a tentative blueprint for re-establishment and future reconnection of the river to its floodplain, with soil conservation, biodiversity and societal benefits (Pearson & Soar, 2018).

This is particularly timely research as the UK navigates through an extended period of eco-political uncertainty in the farming sector associated with the prospect of transposition of European laws to UK jurisdiction. Transferring the approach adopted here to neighbouring catchment areas and beyond will provide a large-scale mapping resource and information portal to uncover and explore more fully the historical picture of land use and early Victorian practices of land utilisation within the South Downs National Park.

5. Data

The dataset is available in an Esri Shapefile (.shp) format.

6. Data availability

The data that support the findings of this study are openly available in the PURE repository at the University of Portsmouth (DOI: 10.17029/1c4ef491-e5f4-4d91-a9af-07b852443aee). A high-resolution PDF format version of the main map is also available at the same repository.

7. Geolocation information

The map area covers the River Rother catchment within West Sussex, southeast England and within the South Downs National Park.

Software

Data input, processing, editing and map design were performed using Environmental Systems Research Institute’s (Esri) ArcGIS 10.5.1.*

Acknowledgements

We would like to thank the South Downs National Park Authority and the National Trust for their financial support and encouragement. In addition, we are most grateful to the staff of West Sussex County Record Office for permitting us to use the scanned images of the tithe maps. We also thank the numerous undergraduate and postgraduate students of the Department of Geography, University of Portsmouth, who toiled over the digitising of the tithe maps. Finally, the authors are grateful to the editor and the referees for their very helpful comments and suggestions.

Disclosure statement

No potential conflict of interest was reported by the authors.

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