User Guide to Field Survey Data

Version Number: 1.8

Document Description
This document is a user guide to the field (or sub-catchment) high-resolution (spatial) and low-resolution surveys collected on the North Wyke Farm Platform (NWFP). Most spatial surveys are site-wide across all the NWFP fields, while some are specific to a given triplet or small group of NWFP catchments. Low resolution surveys are site wide and are carried out routinely as a management guide.

Associated Documents	**Description**
FP_UG.Doc.004_FieldEvents&LivestockData	User Guide to field events and livestock data
Technical Case Study No. 1	Determination of areas using GPS and GIS
Technical Case Study No. 2	Field spreading area calculations

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Change Record

Version Number	Date	Changes Made
1.1	08 May 2017	Figure 2 added as omitted in version 1.0. Full list of vertebrate data available in Data Portal added to Table 1. Release date added for extra invertebrate data. Insect survey references added.
1.2	28 Nov 2018	Table 2 edited to include 2016 soil survey data. Section 6 & Table 3 added with further information about the 2016 soil survey. Section 10 added with information about 2016 botanic survey.
1.3	22/04/2020	Preface rewritten to accommodate new treatments Information on 2018 botanical survey added. Addition of information on collection and analysis of samples from low resolution surveys (Table 1 & Section 15). Appendices added that detail analytical methods for low resolution samples.
1.4	25/06/2020	Replaced Fig. 9 (2013 dominant botanic species) with a higher resolution version. Inclusion of limits of detection for low resolution survey of soil and herbage.
1.5	01/02/2021	Preface updated.
1.6	14/04/2021	Details on timing of Quarterly Low-Resolution Surveys (Section 15) updated –archiving of individual soil samples moved from Mar/Apr (up until 2020) to Sep/Oct (2021 onwards).
1.7	22/06/2021	Preface updated – blue treatment transition timeline to multi-species sward deleted.
1.8	03/08/2021	General re-vamp and details on the 2019 survey of saturated soil hydraulic conductivity (KSAT) on catchment 2 (Section 9).

Preface

Overview

The North Wyke Farm Platform (NWFP) represents a large investment by BBSRC in the future, to not only study but also improve grassland livestock and arable systems in a national and global research asset linked to real-world farming. It is a world-class facility and a key member of the Global Farm Platform network http://www.globalfarmplatform.org/ which attracts researchers from different communities and disciplines seeking to develop sustainable ruminant production systems. The NWFP provides access to a range of in situ state-of-the-art instrumentation in hydrologically isolated (sub-) catchments to better address key issues in sustainable agriculture related to:

- A reduction in energy and greenhouse gas emissions for both environmental and economic reasons.
- Using plants to manage soils and hydrology.
- Efficient nitrogen and phosphorus cycling in grassland and arable systems.
- Resilience of soil biota and their functions in land-use change.
- Impact of land management on carbon cycling and storage.
- Water resource use efficiency.
- Systems modelling to design optimal grassland and arable production systems.

Past, Current and Planned Treatments

The platform currently consists of 2 pasture-based livestock systems and 1 arable system, each of which consist of five component catchments over 21 ha. Catchments comprise single or multiple fields, that are heavily monitored to provide fine resolution data on all inputs, outputs and events. In addition, there is a housed system where cattle are reared indoors from weaning to slaughter.

The timeline of each system's treatment are as follows:
• From April 2011 to March 2013, all three pasture-based livestock farming systems were as one (permanent pasture) with no separate treatments in operation. This is the baseline period.

• From April 2013 to September 2015, two of three systems gradually transitioned into the first post-baseline phase, one re-sown with high sugar grasses (**red system**), the other re-sown with high sugar grass, white clover mix (**blue system**). The third continued as permanent pasture (**green system**) and will always do so, for long-term monitoring.

• From September 2015 to April 2019, the first post-baseline phase was in full operation across all three livestock farming systems and pasture treatments.

• From April 2019, the first post-baseline phase embarked on a transition to a second post-baseline phase, where the **red system** transitioned to an arable system growing human edible crops. Given the transition to arable cropping, cattle and sheep production are no longer associated with this system. Instead, cattle previously linked to the system are permanently housed from weaning to slaughter. This represents a fourth (**brown system**) treatment for evaluation of more intensive finishing. Sheep production is only focussed on the green and blue systems.

For more information, click on the links below:
- Core Remit and Hypotheses
- North Wyke Farm Platform Website

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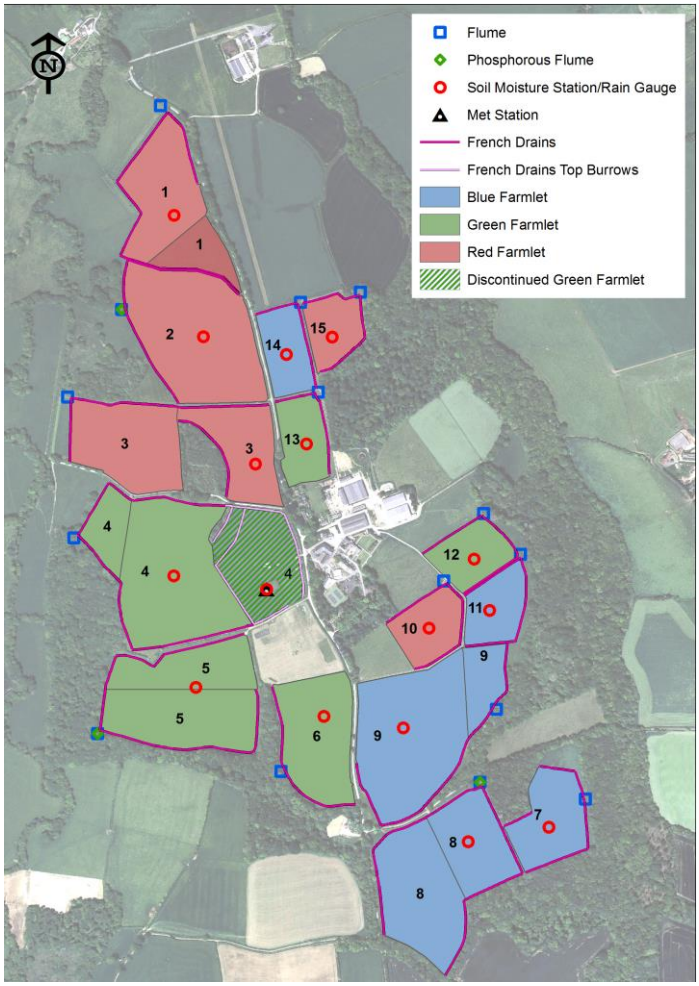
1 Introduction

The NWFP is located on a ridge at 120 – 180 m above sea level, where the land slopes down on the west to the River Taw and on the east to one of its tributaries, the Cocktree stream. Over a 30-year period from 1982, the mean annual precipitation at the North Wyke site was 1044 mm; with the first, second and third quartiles of this annual distribution given at 924 mm, 1031 mm and 1158 mm, respectively. A significant feature of the site is the presence of clay-rich subsoils beneath the sub-surface horizons. Below the topsoil layer, the subsoil is highly impermeable to water and is seasonally waterlogged with most excess water leaving by surface and sub-surface lateral flow across the clay layer. This pattern in the movement of water allows for interception by a bounded drainage system and was a key factor in making this farm-scale experiment viable.

Figure 1. Map of NWFP showing farmlets (as of 2015)



The NWFP consists of three individual 'farmlets' each of which is approximately 21 ha and has been designed to test the productivity and environmental sustainability of contrasting temperate grassland beef and sheep systems at appropriate farm and land management scales (Figure 1). The main farming systems or treatments on the platform are:

1. Permanent pasture: improvement through use of inorganic fertilisers (Green farmlet).
2. Increased use of legumes: replacing nitrogen fertilisers with biological fixation using sown legume and grass mixtures (Blue farmlet).
3. Planned reseeding: regular renewal, providing opportunities for introducing innovative varieties with desirable traits. Currently, high sugar and deep rooting grasses are studied (Red Farmlet).

Each of the three farmlets contains five catchments (15 in total), with each catchment hydrologically isolated through a combination of topography and a network of 9.2 km of drains constructed around the perimeters of each catchment. The drainage network is made up of 800 mm deep trenches containing perforated drainage pipe and backfilled to the surface with 20-50 mm clean, carbonate-free granite chips. This type of construction is commonly referred to as a French drain [French, 1859]. Each of the catchments was allocated to one of the three farmlets according to some or all of the following conditions: (i) expert knowledge of the physical properties of the North Wyke site; (ii) the need for a degree of spatial connectivity between the five catchments of each farmlet; (iii) historical farm practice; and (iv) farm/research operational requirements.

2 LiDAR, soil classes and other contextual spatial data sets

For the NWFP site, LiDAR data [Ferraccioli et al., 2014] provides both a digital surface model (DSM) and a digital terrain model (DTM) of the NWFP (see representations given in Figure 2). The soil is predominantly of two similar series, Hallsworth and Halstow, that comprise of a slightly stony clay loam topsoil (approximately 36% clay) overlying a mottled stoney clay (approximately 60% clay), derived from carboniferous culm measures [Harrod T.R and Hogan D.V, 2008]. The subsoils data are depicted in Figure 3, together with the 15 NWFP catchments and 21 field boundaries. All such contextual spatial data sets are available to registered Data Portal users via an HTTPS download. This includes the shapefiles necessary to produce the NWFP map in Figure 1.

Figure 2. Elevation for NWFP site

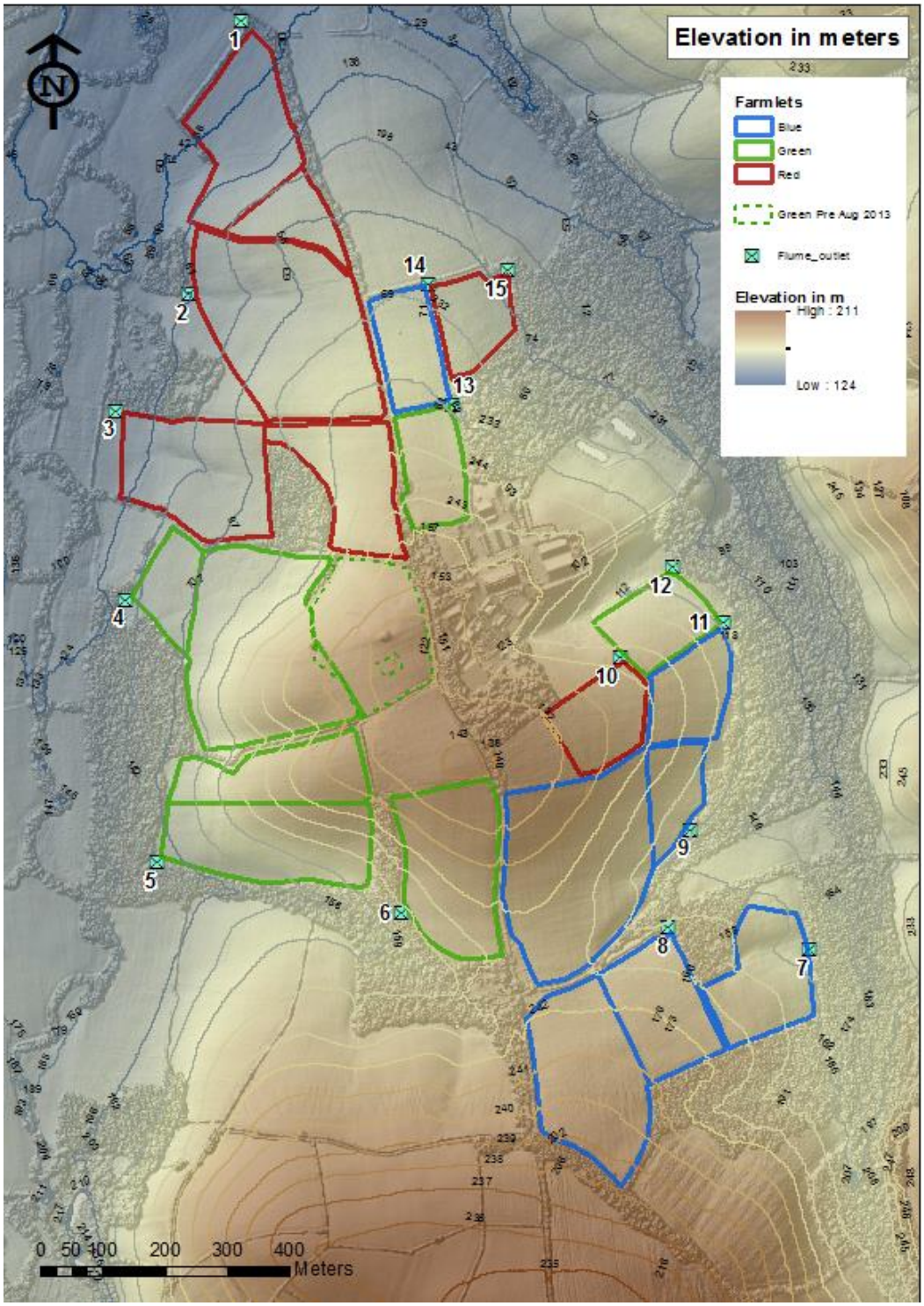
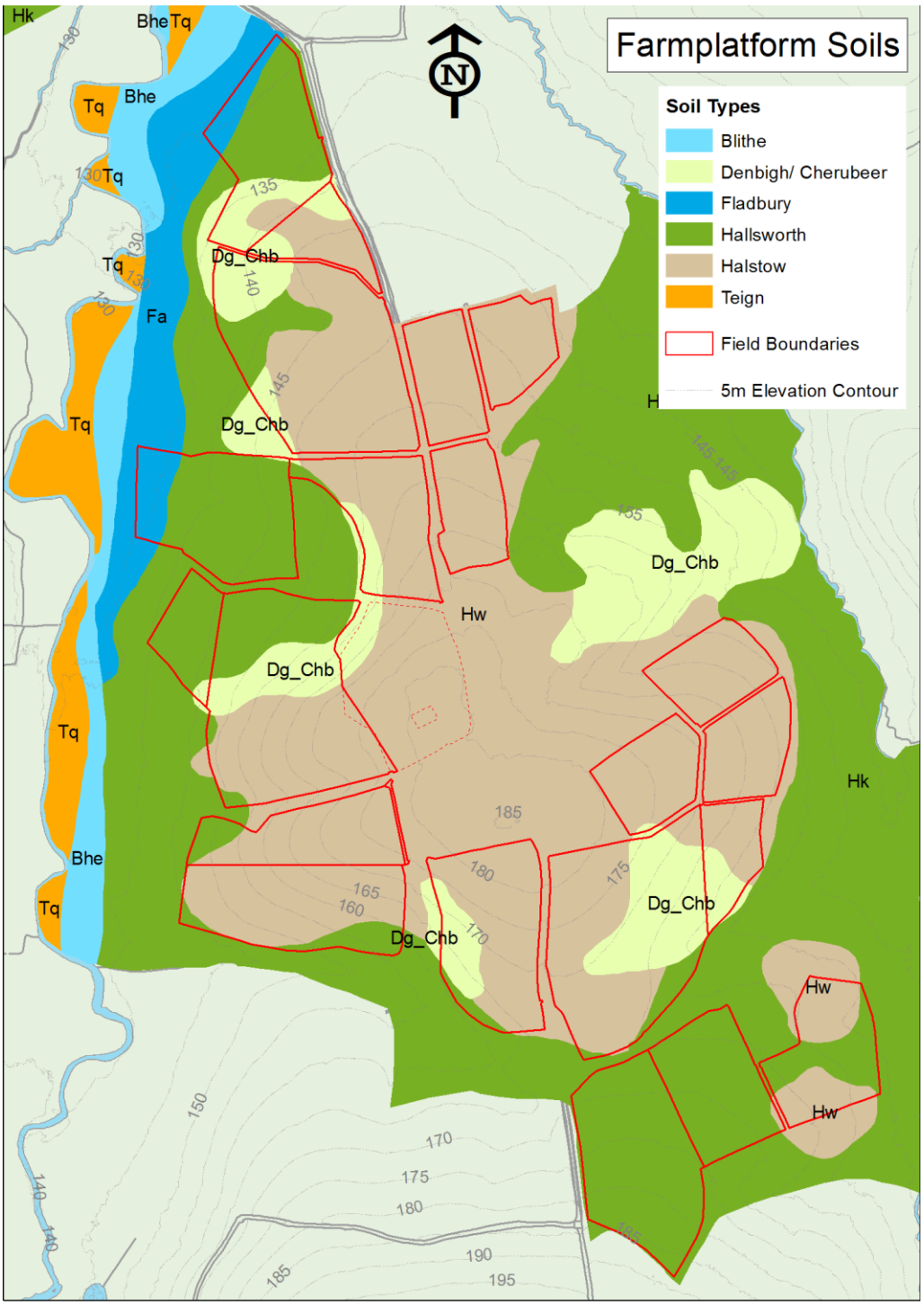


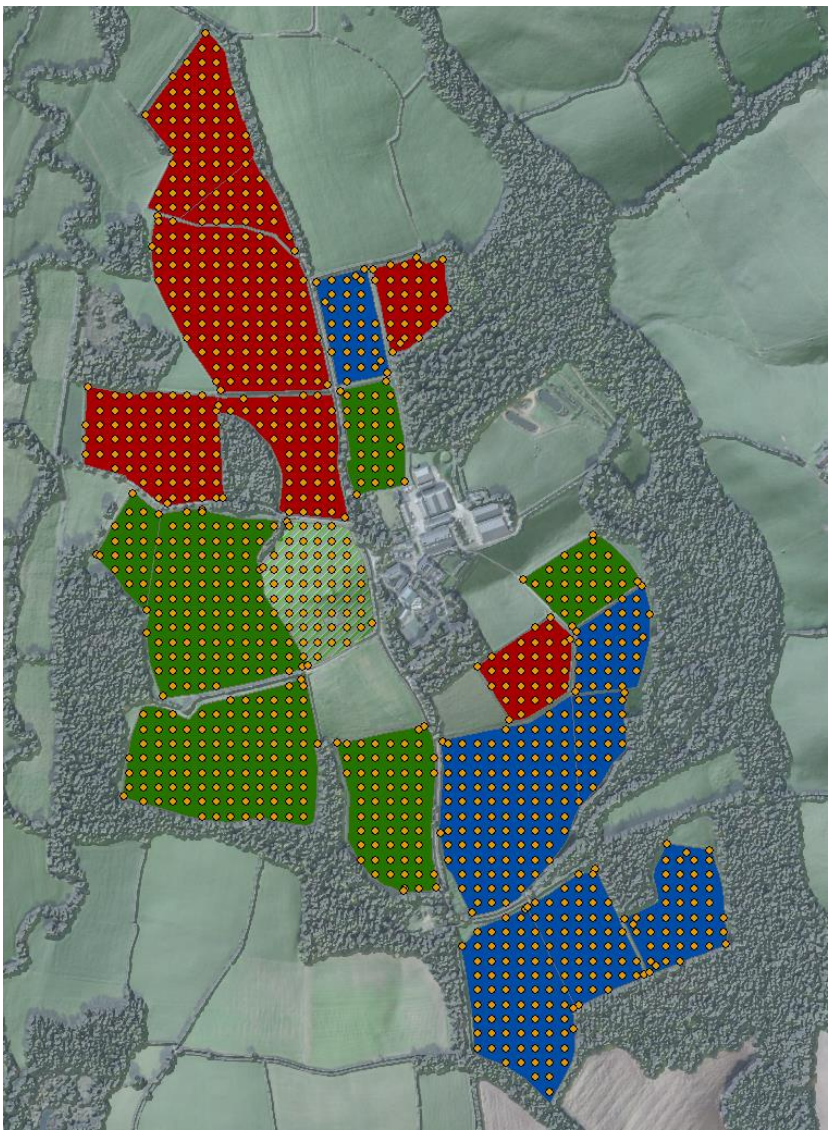
Figure 4. Map of the soils of the NWFP



3 Spatial Survey Sample Locations

A number of field surveys have taken place since 2011 on the NWFP, ranging from soil nutrients to soil fauna to botanics The surveys have been predominantly carried out on pre-established grid locations, or occasionally on 'off-grid' sampling locations (especially when a good assessment of small-scale spatial variation is required). In both cases, RTK GPS equipment was used locate and record the sampling locations. For the grid, a 25 m resolution is used that covers the entire NWFP site. This enables sampling surveys to be performed consistently on any 25, 50, 75 or 100 m interval (Figure 5)[1]. All sampling points and their coordinates are stored in the NWFP database, together with the survey measurements.

Figure 5. The 25m sampling grid of the NWFP



[1] Note that the 50 m grid is not fully-regular in that it is shifted by 25 m along a vertical line between catchments 6 and 9 (see Figure 1). This affects several surveys.

4 Spatial Survey Data Releases

Registered users can download the survey data in the form of a csv file, which will contain the survey results for each sampling point, the OSGB36 grid-coordinates[2] for that point and a sampling ID (but only if the sampling point coincides with an existing 25 m grid-location). The data contain the Experiment ID, which can be used to identify a specific survey (e.g. the Experiment ID of the 2012 Soil nutrients survey is FP003). The data download file will contain the whole dataset of the selected surveys during the selected time-interval, including data that fall outside that time-interval. Note that even if one sample point falls within the time-interval selected for the data-download, the WHOLE dataset will be returned. Also provided in the data download is the UTC-timestamp, as the time and date of sampling are essential. For example, a field could have been treated with fertilizer a few days before the samples were taken. As the fertilizer application would affect the results of the soil sample, it is vital to record the sample date. Livestock movement is also an important consideration in this respect too [see, FP_UG.Doc.004_FieldEvents&LivestockData]; as are times when fields or catchments were ploughed and reseeded – moving from baseline to post-baseline status. Further documents of note are how the field polygons are created and the field spreading area calculations [see Technical case studies 1 and 2, respectively]. Additionally, each listed survey parameter will have a traffic light flagging system for quality control (QC), together with the date of this QC. Currently the traffic light quality flag assignment consists of the following 6 levels: Not Set; Good; Acceptable; Suspicious; Highly Suspicious; and Reject.

For field survey data **released on the 29/02/2016 & 17/07/2018,** and soils invertebrate survey data **released on the 30/09/2016**, the baseline surveys are summarised in Table 1. All survey parameters have been flagged as “Acceptable”.

[2] Details on the coordinate systems that are used are available on request. It is also useful to link to https://www.ordnancesurvey.co.uk/business-and-government/help-and-support/navigation-technology/os-net/surveying.html

Table 1. Field survey data released 29/02/2016, 17/07/2018, 19/04/2020

Survey	Year(s)	Experiment ID	Parameters measured†
High (within-field) Resolution			
Site-wide (most fields)			
Soil nutrients	2012	FP003	Bulk Density, pH, SOM, Total N, Total C, δ^{13}C, δ^{15}N
	2016	FP059	Bulk density, pH, SOM, Total N, Total C ^{13}C, ^{15}N, AL, As, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Ti, Zn (mg/kg DM soil), Olsen extractable P (mg/kg DM soil), water extractable PO_4 (molybdate-reactive PO_4 by discrete photometric analysis; mg/kg DM soil); water extractable total phosphorus (by discrete photometric analysis; mg/kg DM soil)
Soil invertebrates (soil fauna)	2012 2013	FP002	Anthomyiidae, Bibionidae, Cantharidae, Carabidae (adult & larvae), Chironomidae, Chrysomelidae, Dolichopodidae (A&B), Elateridae, Muscidae, Noctuidae, Psychodidae, Scatopsidae, Sciaridae, Stratiomyidae, Tipulidae, Unknown Coleoptera
Herbage (plant nutrients)	2013	FP010	Total N, Total C, δ^{13}C, δ^{15}N, Average Sward Height
Botanics (floristics)	2013 2016 2018	FP013 FP061 FP098	Cover of plant species
Limited (few fields)			
Soil nutrients	2013	FP008	pH, SOM, Total N, Total C
Soil pH	2013	FP012	pH
Saturated Soil Hydraulic Conductivity	2019	FP106	KSAT
Silage Cuts (resolution dependent on grazing management)			
Silage cuts	2011 2012 2013 2014 2015 2016 2017 2018 2019	NW558 NW569 NW583 NW600 NW621 NW626 NW653 NW686 NW702	Silage Dry Matter Yield
Low (field-level) Resolution			
Site-wide (all fields)			
Soil nutrients	2018 2019 2020	NW686 NW702 NW735	See section 15, Table 7
Herbage nutrients	2018 2019 2020	NW686 NW702 NW735	See section 15, Table 8

†See Table 2 or Table 3 for acronyms used

5 Soils Nutrients: Site-wide Surveys (2012 and 2016)

The first soil nutrients survey was carried out during the summer of 2012 on the 50 m sampling grid [e.g. Noacco 2012; Harris et al. 2014]. This is viewed as the main baseline survey for soil nutrients and sampled for the parameters listed in Table 2. This data's sampling period ran from 01st June 2012 to 31st July 2012. All 15 catchments were sampled. Figure 6 displays an example map of these data.

Table 2. 2012 Soil Nutrient Parameters

Parameter	Units
Bulk Density	g dry soil/cm^3
pH	-
Soil Organic Matter (SOM)	% of Dry Matter
Total Carbon (Total C)	% of Dry Matter
Total Nitrogen (Total N)	% of Dry Matter
δ^{13}C (isotope of C)	delta vs air
δ^{15}N (isotope of N)	delta vs PDB†

†Pee Dee Belemnite

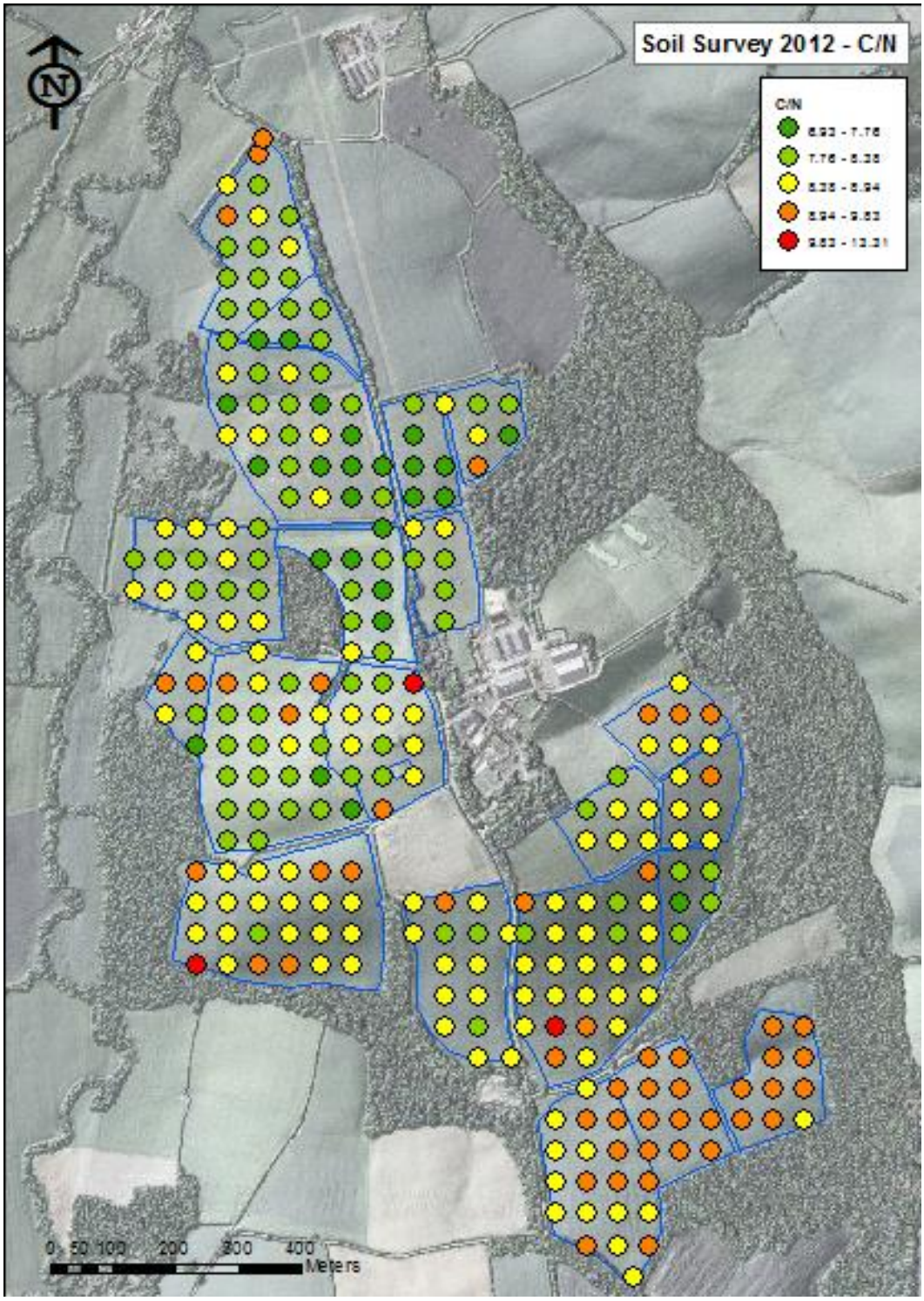
A secondary soil nutrients survey was carried out between 01st July to 21st July 2016. All the NWFP fields were surveyed (21fields in total). Most were sampled on the 50 m sampling grid, but some were sampled on the 25 m grid (Longlands North, Longlands South, Longlands East, Dairy North, Dairy South, Dairy East and Lower Wheaty). The samples were analysed for the parameters listed in Table 3.

Table 3. 2016 Soil Nutrient Parameters

Parameter	Units
Bulk Density	g dry soil/cm^3
pH	-
Soil Organic Matter (SOM)	% of Dry Matter
Total Carbon (Total C)	% of Dry Matter
Total Nitrogen (Total N)	% of Dry Matter
Olsen P, Total P & PO_4	mg / kg Dry Matter
δ^{13}C (isotope of C)	delta vs air
δ^{15}N (isotope of N)	delta vs PDB†
Major & Trace Elements	mg / kg Dry Matter

†Pee Dee Belemnite

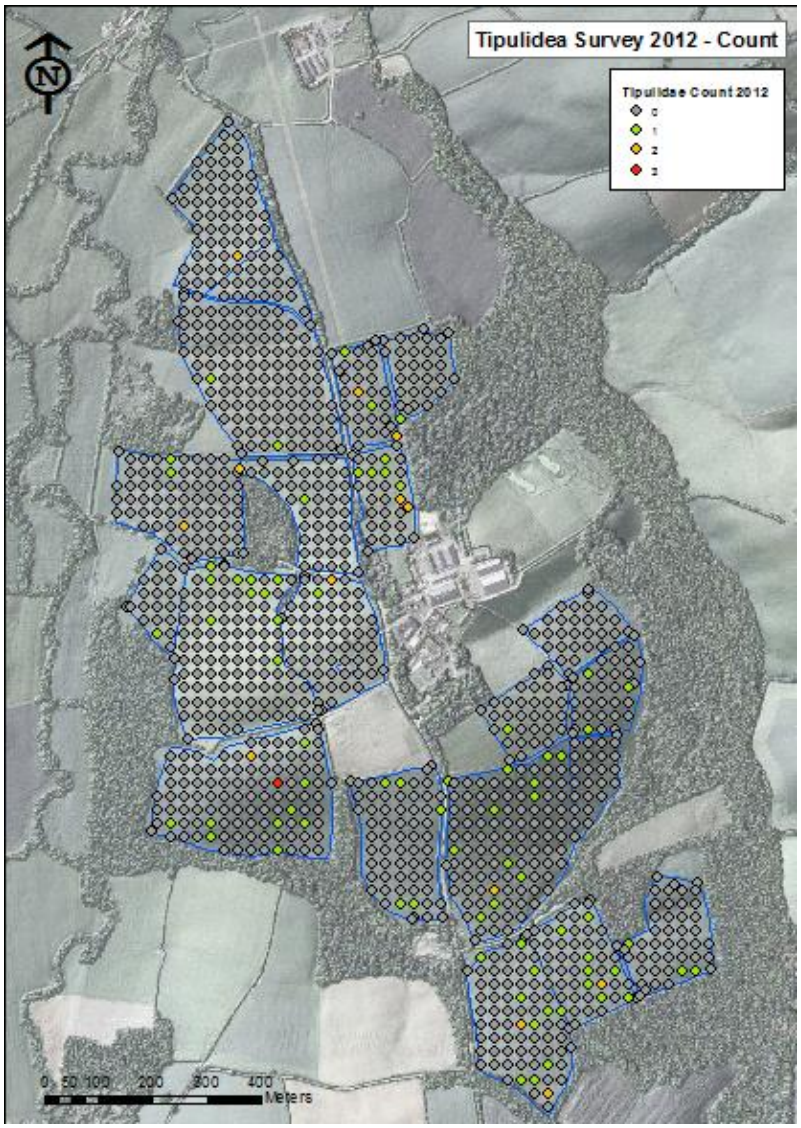
Figure 6. Example map for the 2012 soils nutrients survey – the Total C to Total N ratio



6 Soils Invertebrates: Site-wide Surveys (2011 to 2013)

Soil fauna (insect taxa) surveys were conducted over a three-year period starting 15/11/2011 and ending on 08/04/2013 (see Table 1). This resulted in two site-wide surveys covering all 15 catchments on the 25 m grid. One survey was aligned to 2012, the other 2013. Both surveys can be viewed as baseline. Details of this fuller sampling campaign can be found in Ahmed (2013), Benefer et. al. (2016) and Wei et. al. (2016). An example map of these data for 2012 is given in Figure 7.

Figure 7. Example map for the 2012 soils invertebrates survey



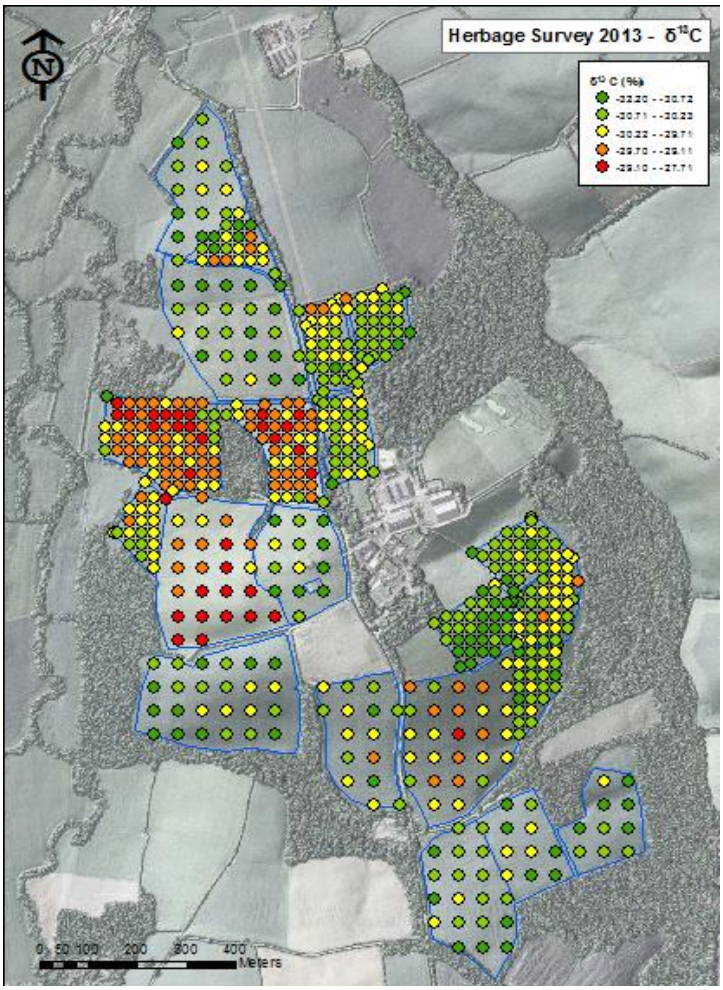
7 Herbage Nutrients: Site-wide Survey (2013)

A plant nutrients (herbage) survey was carried out during the summer of 2013 on a mixture of the 25 and 50 m sampling grids [e.g. Kear 2013]. Sampled parameters are listed in Table 4. These data's sampling period ran from 12/06/2013 to 2/07/2013. All 15 catchments were sampled. An example map of these data is given in Figure 8.

Table 4. 2013 Plant Nutrient Parameters

Parameter	Units
Total Carbon (Total C)	% of Dry Matter
Total Nitrogen (Total N)	% of Dry Matter
δ^{13}C (isotope of C)	-
δ^{15}N (isotope of N)	-
Average Sward Surface Height	cm

Figure 8. Example map for the 2013 plant nutrients survey - δ^{13}C



8 Botanics: Site-wide Surveys (2013, 2016 and 2018)

Botanical assessments of the NWFP fields were undertaken during the summer of 2013 on a mixture of the 25 and 50 m sampling grids [Tozer 2013]. A quadrat consisting of a 50x50 cm metal frame was used to assess the botanical composition. The frame was placed on the ground with the SW corner directly on the sampling point; using a compass to align the edge in a Northerly direction. The botanical composition was assessed in these 0.25 m^2 quadrats at each of 293 sampling locations and species were scored according to the Domin Scale. The National Vegetation Classification: Users' Handbook [Rodwell 2006] describes the Domin Scale in the following manner: "For every species recorded in the sample, an estimate should be made of its quantitative contribution to the vegetation. Cover is a measure of the vertical projection on to the ground of the extent of the living parts of a species." Cover is defined according to the following categories given in Table 5. Domin scale data can be converted to a linear scale using a suitable conversion (Tozer 2013).

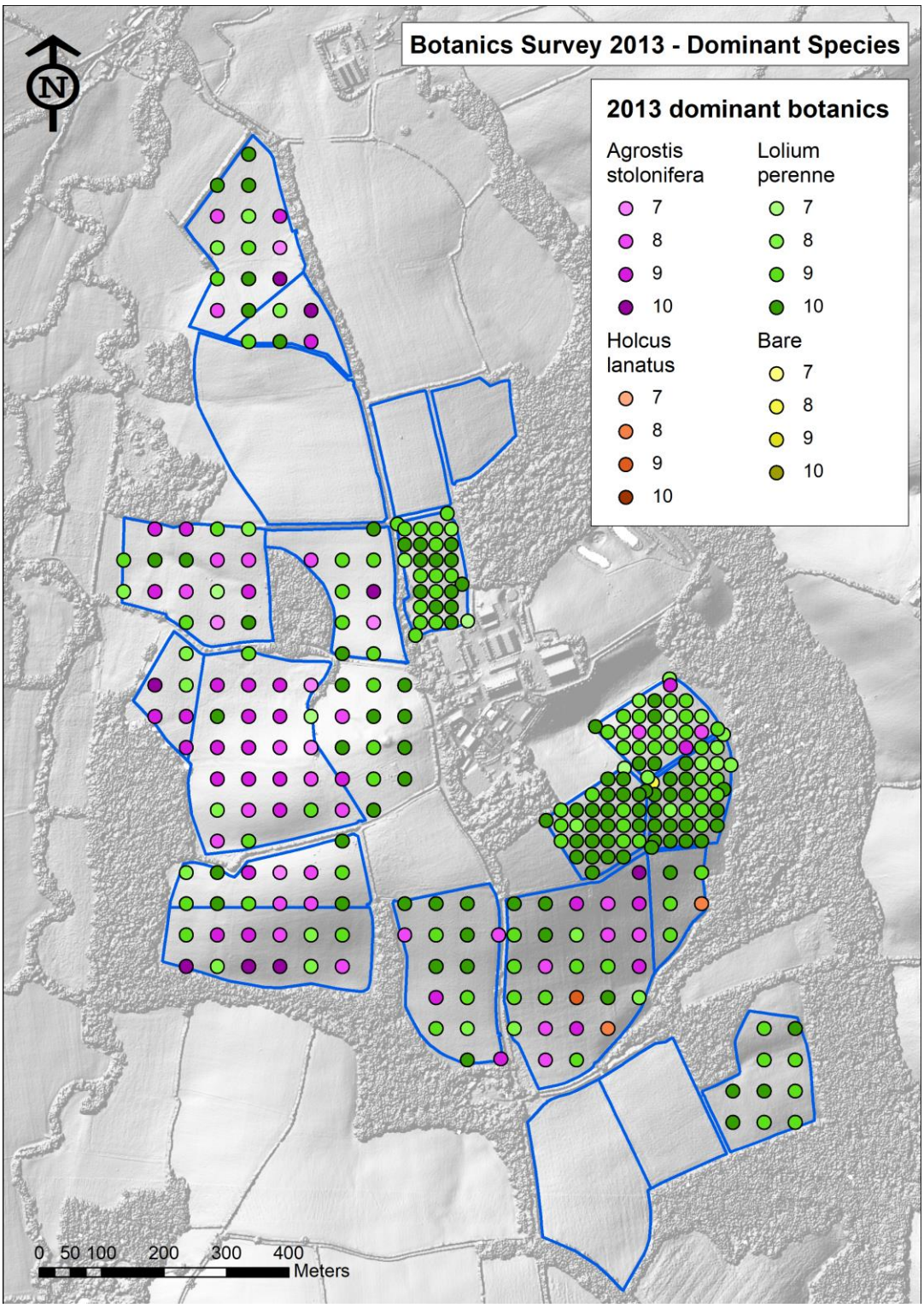
Table 5. Domin Scale used to classify grassland vegetation

Cover	Domin Score
91–100%	10
76–90%	9
51–75%	8
34–50%	7
26–33%	6
11–25%	5
4–10%	4
<4% (many individuals)	3
<4% (several individuals)	2
<4% (few individuals)	1

Rodwell's handbook explains that "Even when vegetation does not appear to be considerably layered, the sum of all the Domin values for a species can be greater than 100% cover because of structural overlap of the plants." The species observed were: Agrostis stolonifera, Alopecurus geniculatus, Dactylis glomerata, Holcus lanatus, Lolium perenne, Phleum pratense, Poa annua, Poa trivialis, Cardamine pratensis, Cerastium fontanum, Cirsium arvense, Juncus effuses, Ranunculus repens, Rumex crispus, Rumex obtusifolius, Veronica serpyllifolia, Taraxacum officinale, Trifolium repens, and also 'Bare' and 'Dung'. This data's sampling period ran from 22/07/2013 to 07/08/2013. The study is considered site-wide, but

only 11 of 15 catchments were sampled due to re-seeding in some catchments. Figure 9 displays an example map of this data.

Figure 9. Dominant botanical species for the 2013 survey



In 2016, a second survey was carried out using the same methodology as that for the 2013 survey except that the SW corner of the quadrat frame was placed exactly 1 m due north of the sampling grid points to avoid freshly trampled areas resulting from a different type of field survey that had used the same grid points.

In 2018, a third survey was carried out This was carried out using the same methodology as that for the 2013 and 2016 survey i.e. the SW corner of the quadrat frame was placed exactly 1 m due north of the sampling grid points to avoid trampled areas from a different types of field survey that had used the same grid points.

9 Limited Surveys (2013 and 2019)

9.1 Soil nutrients

A soils nutrients survey was carried out during the summer of 2013 on the 25 m sampling grid [Baldet 2013]. The soils nutrients parameters that were sampled are listed in Table 6. This data was sampled in one day on 01/06/2013. Only 3 catchments were sampled (Longlands East, South and North) provided 89 sampling locations in total.

Table 6. 2013 Soil nutrient parameters

Parameter	Units
pH	-
Soil organic matter (SOM)	% of Dry Matter
Total Carbon (Total C)	% of Dry Matter
Total Nitrogen (Total N)	% of Dry Matter

9.2 Spatio-temporal soil pH

A spatio-temporal soil pH survey was carried out during the summer of 2013 on the 25 and 50 m sampling grids in order to inform a precision application of prilled lime. The pH data werr collected at sites in Longlands East, Longlands South, Longlands North and Higher Wyke Moor (one field of catchment 8). Ten different sampling times were used, thus providing a spatio-temporal data set for pH. First days sampling was conducted on the 08/08/2013 and the last on the 14/10/2013.

9.3 Soil physics

A soil physics survey was carried out in 2019. Soil hydro-physical properties are essential in understanding key processes of the hydrological cycle and in turn can ensure an efficient management of water resources. Saturated soil hydraulic conductivity (KSAT) is one such variable where it typically exhibits high within-field spatial variability. However, for calibrating a process-based model, such soil hydro-physical properties are commonly taken at the field level only. To address this shortfall, within-field KSAT measurements were taken from Great Field of the Farm Platform and thus this data has the potential to improve the simulation accuracy of a process-based model when the model is specified in a within-field form (i.e. a grid-to-grid form).

For this survey, KSAT was measured by the falling head technique. Twenty-seven points at 0–10, 10–20 and 20–30 cm soil depths were measured on a 50 m sampling grid for Great Field (catchment 2) over the period March to July 2019 (where the field was still under the high sugar grass treatment). Thus, eighty-one KSAT measurements were taken in total. Undisturbed soil samples were taken using a 250 ml volume steel cylinder with 8 cm inner diameter and 5 cm length (cores were taken in the middle of each soil layer). The KSAT measurement was performed using a KSAT® device (METER Group AG, Munich, Germany). Each soil core was covered by a saturation plate with a filter paper at the cutting side, then placed into a water pan keeping the cutting side at the bottom. The water pan was filled with approx. 2 cm degassed tap water and tilted so that air bubbles could escape. The water level then was raised almost to the sample height in which the water table was raised from the bottom for 2 weeks, then the pan was filled with at least 12 cm water so that the sample is flooded. The saturated porous plate on top of the sampling ring was sealed by turning the setup under water upside down and removing the saturation plate as well as the filter paper. After equilibration, the core was affixed with a collar and an appropriate upper and lower screen (all included with the device) to prevent particles from escaping. This ensured all water was passed through the substrate instead of passing outside of the core. The sample was then affixed into the device and again saturated from the base to replace any water lost during preparation. Using the device, KSAT was measured three consecutive times in the constant head measurement mode before being removed from the device. Both KSAT (cm d^{-1}) and time (minutes) to saturation (Duration) measurements are given at three soil depths.

10 Silage Cuts (2011 onwards)

On the NWFP, grass for silage is cut approximately twice a year when not needed for grazing. To determine the dry matter yield, cuts of 1.5 m wide and approximately 10 m in length (measured accurately), with a sample point (or predefined GPS location) at its centre are made. Fresh samples are dried, and the dry matter yield is calculated and expressed in kg per hectare. For example, Figure 10 maps the field locations of the cuts for 2011, 2012 and 2013. Figure 11 provides an example output of this data.

Figure 10. Location of silage fields for 2011, 2012 and 2013

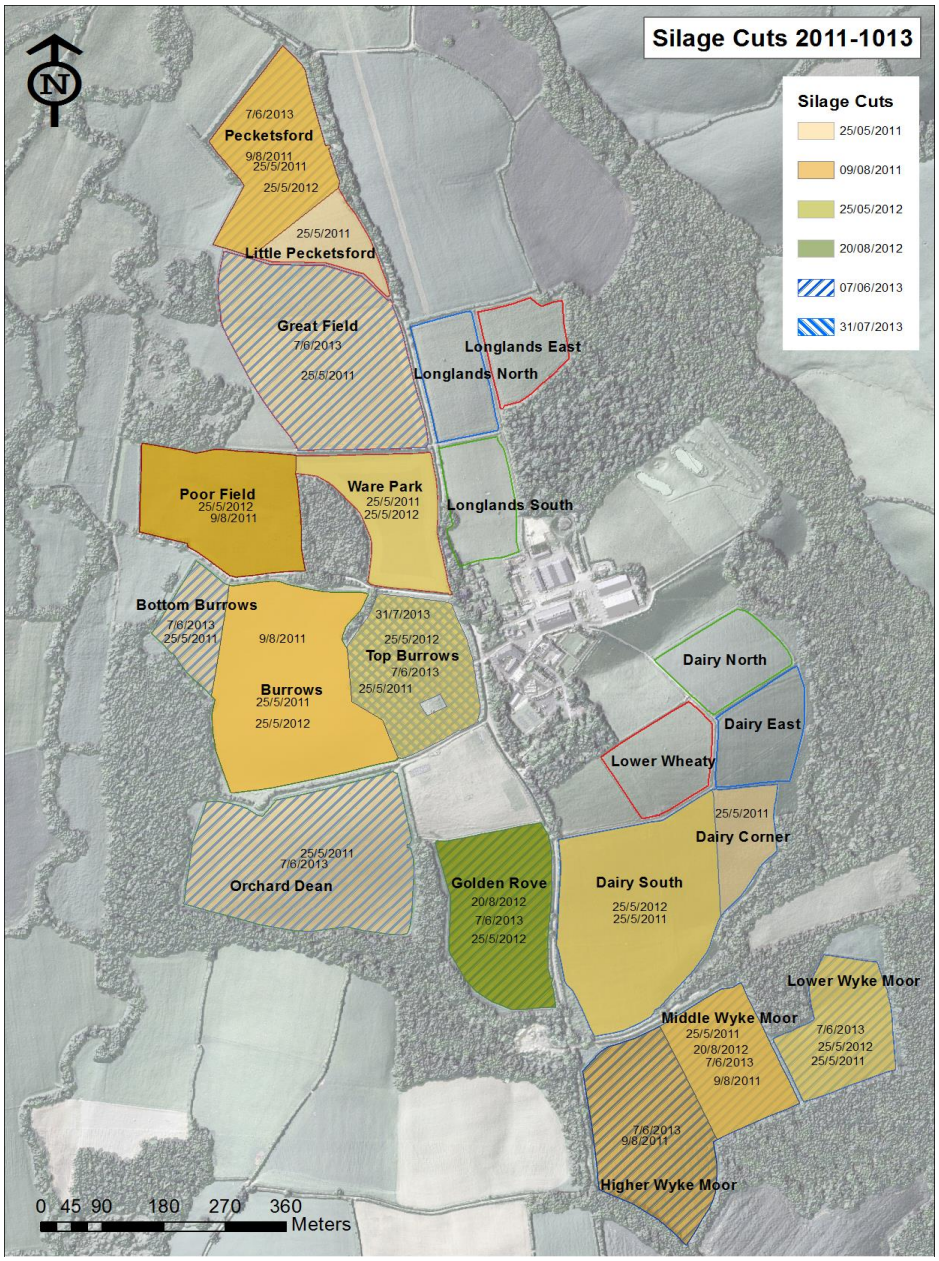


Figure 11. Example output from data portal for silage cuts

Experiment_Id	SP_ID	sample_ distance (m)	Field	Flume	Sample_date	Sample_time	comments	Start_Sample _Date	GPS_Sample _Nr	Easting	Northing	Silage Dry Matter Yield (kg/ha)	Silage Dry Matter Yield Quality	Silage Dry Matter Yield Quality Last Modified
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	1	265701.23	99027.88	6220.02	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	2	265621.36	99162.64	8335.66	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	3	265637.33	99038.39	7116.73	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	4	265595.77	99118.06	7003.35	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	5	265615.02	99241.73	8485.22	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	6	265637.09	98733.25	6037.3	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	7	265721.10	98793.43	7351.36	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	8	265672.90	98935.10	7192.93	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	9	265596.13	98952.16	7291.08	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	10	265616.02	98873.17	6595.04	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	11	265651.76	98817.32	6441.03	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	12	265776.81	98702.39	8375.28	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	13	265791.05	98485.19	6513.4	Not set	09/04/2015
NW558_SC1	NA	NA	NA	NA	25/05/2011	12:00:00		NA	14	265799.51	98624.97	7425.67	Not set	09/04/2015

11 Quarterly Low-Resolution Surveys (2018 onwards)

11.1 Aims

To complete a quarterly low-resolution bulked sample collection of soil and herbage samples from each of the 21 fields of the Farm Platform. These samples are analysed for macro and micronutrient contents. Results from these surveys aid management decisions, build a long-term record of nutrient values, and create an archive of samples which are available for future analysis. These quarterly collections commenced in April 2018.

11.2 Method

11.2.1 Timing

The low-resolution survey is completed every 3 months. Exact timings are influenced by annual ground and weather conditions, but are timed to be completed during:

1. March/April – (Prior to any fertiliser applications) Bulked and individual archived survey up until 2020 only.
2. June/July – Bulked sampling survey.
3. September/October – Bulked sampling survey and individual archived survey from 2021.
4. December/January – Bulked sampling survey.

Up until 2020, the March/April survey collected both bulked samples at a field scale for immediate analysis; and retained individual samples from each point to be stored in the Farm Platform archive for potential future analysis. The location of each of these individual sampling points are recorded using GPS. The 3 other sampling occasions are bulked samples at a field scale for immediate analysis only.

The archiving of individual samples was moved from the March/April survey to the September/October sampling from 2021 onwards.

11.2.2 Sample collection

Soil and herbage samples are collected at 20 locations within each of the 21 fields on the Farm Platform. A 'snake' pattern is followed across each field to give a representative sampling from the whole field, collecting 20 samples from each field in a 5 x 4 grid. Areas near gateways, water troughs, hedgerows, or areas where supplementary feeding may have occurred, or livestock congregate are avoided.

11.2.3 Soil sampling

Samples are collected using a 10cm deep soil pot corer.

All samplings: Bulked sample. At each of the 20 sampling points 2 x 10 cm deep soil cores are collected and added to the field scale bulked sample with a unique sample identification number. The total soil collected from each field weighs at least 600g fresh weight.

March/April sampling only: Individual sample. In addition to the bulked sample, at each of the 20 sampling points 6 x 10 cm deep soil cores are also collected and retained as an individual sample with a unique sample identification number. The GPS location of where these samples were collected from is recorded. The details of what soil parameters are measured, and methods of sample analysis are given in Table 7, Section 15.3.1. Data exceeding the limits of detection for the analytical methods are denoted by -99999 in the data portal.

11.2.4 Herbage sampling

Snip samples are collected using handheld scissors. Herbage snip samples are cut from the top two thirds of the plants available to represent the portion of the plant consumed by a grazing animal.

All samplings: Bulked sample. At each sampling point several snip samples are collected and added to the field scale bulked sample with a unique sample identification number. The quantity at each snip sample depends on the field conditions, but the total herbage collected from each field weighs at least 200g fresh weight.

March/April sampling only: Individual snip samples. In addition to the bulked sample, at each of the 20 sampling points 6 x snip samples are also collected and retained as an individual sample with a unique sample identification number. The GPS location of where these samples were collected from are recorded. The details of what herbage parameters are measured, and methods of analysis are given in Table 8, Section 15.3.2. Data exceeding the limits of detection for the analytical methods are denoted by -99999 in the data portal.

11.3 Sample analysis

11.3.1 Soil

Details of soil sample analysis are given in Table 7 below. Full details of analytical methods are given in Appendix 1.

Table 7. Low resolution survey soil parameters measured and methods of analysis

Soil Analysis	Method of analysis	Unit	Minimum Level of Detection†
pH	Measured in water (1:2.5)	pH	0.1
Available Phosphorus	Sodium Bicarbonate Extractable (Olsen)	mg/l dry soil	2.5
Available Potassium	Ammonium Nitrate Extractable	mg/l dry soil	15
Available Magnesium	Ammonium Nitrate Extractable	mg/l dry soil	5
Available Sodium	Ammonium Nitrate Extractable	mg/l dry soil	2
Extractable Calcium	Ammonium Nitrate Extractable	mg/l dry soil	200
Organic Matter	Loss on Ignition	% w/w dry soil	0.5
Extractable Manganese	DTPA	mg/l dry soil	0.5
Extractable Iron	DTPA	mg/l dry soil	0.1
Extractable Copper	DTPA	mg/l dry soil	0.3
Extractable Zinc	DTPA	mg/l dry soil	0.2
Soluble Boron	Hot Water	mg/l dry soil	0.1
Extractable Sulphate	Phosphate Buffer	mg/l dry soil	5
Available Molybdenum	Ammonium Oxalate Extractable	mg/l dry soil	0.05
Available Cobalt	Acetic Acid Extractable	mg/l dry soil	0.1
Total Selenium	Wet digestion with hydrochloric and nitric acids	mg/kg dry soil	0.09
Moisture or Dry Matter	Oven Dry Matter	% w/w	0.1
Nitrate Nitrogen	2M KCL extraction	mg/kg dry soil	0.05
Ammonium Nitrogen		mg/kg dry soil	0.05
Nitrite Nitrogen		mg/kg dry soil	0.1
Electrical Conductivity	Saturated Calcium Sulphate	uS/cm dry soil	1
Total Phosphorus	Aqua-regia digestion	mg/kg dry soil	50
Total N	DUMAS Technique	%w/w dry soil	0.02
Total C		%w/w dry soil	0.05

† Data exceeding the limits of detection for the analytical methods are denoted by -99999 in the data portal

11.3.2 Herbage

Details of herbage sample analysis are given in Table 8 below. Full details of analytical methods are given in Appendix 2.

Table 8. Low resolution survey herbage parameters measured and methods of analysis

Herbage Analysis	Method of analysis	Unit	Minimum Level of Detection†
Total Nitrogen	DUMAS Technique	% w/w dry herbage	0.1
Total Carbon		% w/w dry herbage	0.1
Total Phosphorus	Aqua-regia digestion	% w/w dry herbage	0.001‡
Total Potassium		% w/w dry herbage	0.005
Total Calcium		% w/w dry herbage	0.0015
Total Magnesium		% w/w dry herbage	0.0005
Total Sulphur		% w/w dry herbage	0.0005
Total Manganese		% w/w dry herbage	0.00003
Total Copper		% w/w dry herbage	0.00002
Total Zinc		% w/w dry herbage	0.00006
Total Iron		% w/w dry herbage	0.001
Total Boron		% w/w dry herbage	0.00007

† Data exceeding the limits of detection for the analytical methods are denoted by -99999 in the data portal
‡ For conversion of Aqua-regia data from %w/w dry herbage to mg/kg dry herbage, multiply by 10,000

12 Archiving of Samples

12.1 Soil samples

Individual samples are weighed for fresh weight, air dried, and their dry weight recorded. Each sample is then stored in a square bottom brown paper bag and put into a labelled cardboard archive box for storage in the Farm Platform sample archive.

12.2 Herbage samples

Individual samples are weighed for their fresh weight, oven dried at 60ºC for 24 hours until completely dry. The sample dry weight is recorded, and the sample ground and stored in a labelled plastic sample bag for storage in the Farm Platform archive.

13 References

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14 Appendices

Appendix 1. Details of methods used for analysis of soil samples from low resolution surveys

Soil Parameter	Methodology
pH	The pH of soil is defined as the pH, measured potentiometrically, of the suspension obtained by stirring soil with water. The ratio of soil to water is 1:2.5. Temperature is one of the factors that affects the measurement of pH so the measurement is carried out in a temperature controlled environment.
Available Phosphorus	The available phosphorus is extracted from the soil at 20°C by shaking with 0.5M sodium bicarbonate solution at pH 8.5 for 30 minutes. The concentration of phosphorus is then determined by flow injection analysis /colorimetry by reacting it with acid ammonium molybdate to form the phosphomolybdate ion, which, when reduced with ascorbic acid, forms a blue coloured complex. The blue colour is measured spectrophotometrically at 880nm. The instrument is calibrated using commercial phosphate standards traceable to the SI unit.
Available Potassium **Available Magnesium**	The available potassium and magnesium is extracted from the soil by shaking with 1M ammonium nitrate at 20°C for 30 minutes. After filtration, the concentration of potassium and magnesium in the extract is determined by atomic absorption spectrometry. The instrument is calibrated using commercial potassium and magnesium standards traceable to the SI unit.
Available Sodium **Extractable Calcium**	The available Calcium and Sodium is extracted from the soil by shaking with M ammonium nitrate at 20°C for 30 minutes. After filtration, the concentration of Calcium in the extract is determined by Atomic Absorption Spectrophotometry.
Organic Matter	The organic matter is destroyed by dry combustion at 430oC and the loss in weight of the sample is reported as % of the original sample as the organic matter content.
Extractable Manganese **Extractable Iron** **Extractable Copper** **Extractable Zinc**	The available elements zinc, manganese, iron and copper are extracted from the soil at 20ºC with DTPA solution, ratio 1:2.
Soluble Boron	The available boron is extracted by hot water extraction. The concentration of boron in the extract is determined using ICP-OES (Inductively Coupled Plasma Optical Spectroscopy).

Extractable Sulphate	The available sulphate is extracted from the soil under controlled conditions, using a phosphate buffer extracting solution ratio 1:2. The filtered extract of the sample is analysed by Inductively Coupled Plasma Emission Spectroscopy.
Available Molybdenum	Soil is shaken overnight with acid ammonium oxalate solution and filtered. Analysis is carried out by ICP-OES
Available Cobalt	Soil is shaken overnight with acetic acid extracting solution and filtered. Analysis is carried out by ICP-OES.
Total Selenium	The sample is digested in concentrated hydrochloric and nitric acids at elevated temperature and pressure using a temperature-controlled digestion block. The sample extract is then treated with hydrochloric acid to convert all Selenium present into Selenite (Se VI). Sodium Borohydride is continuously added to the treated sample to produce gaseous selenium hydride which is atomised using a hydrogen diffusion flame. Atomic fluorescence is the measured after excitation using a selenium boosted discharge hollow cathode lamp. The concentration of selenium present is then determined by comparison with a series of standards of known concentration.
Moisture or Dry Matter	As-received samples are homogenised and a representative sub-sample taken in a suitable tray. The weight is accurately recorded before and after drying in an oven at 105°C +/- 5 to determine the 'Oven Dry Matter' as a % weight loss. The drying time is at least 12 hours and samples are checked to ensure they are completely dry.
Nitrate Nitrogen **Nitrite Nitrogen** **Ammonium Nitrogen**	The soil is chopped and mixed to obtain a homogenous sample. A portion is shaken with 2M KCl to extract the mineral-N fractions and a dry matter determination carried out. Once in solution the Nitrate-N, Nitrite-N and Ammonium-N can be measured colorimetrically as follows: The determination of Nitrate-N and Nitrite-N is based on the formation of a diazo compound between nitrite and sulphanilamide. This compound is then coupled with N-1 Napthylethylenediamine dihydrochloride to give a red azo dye. The colour is measured at 540nm. In channel one, nitrate is reduced quantitatively to nitrite by cadmium metal in the form of an open tubular cadmium reactor (OTCR). The nitrite and reduced nitrate are therefore both measured as total oxidised nitrogen. In channel two, nitrite is measured. Nitrate-N is therefore determined by deducting the nitrite figure from the TON. In channel three, ammonium reacts with alkaline hypochlorite and phenol to form indophenol blue. Sodium nitroprusside acts as a catalyst in formation of indophenol blue which is measured at 640nm. Precipitation of calcium and magnesium hydroxides is eliminated by the addition of a combined potassium sodium tartrate/sodium citrate complexing reagent.
Electrical Conductivity	Soluble salts, other than calcium sulphate, are extracted from soil with saturated calcium sulphate solution, ratio 1:2.5. The specific conductivity of the extract at 20ºC is recorded as soil conductivity. Results are expressed as uS/cm at 20ºC.
Total Phosphorus	A representative portion of the prepared sample is digested in an open vessel with concentrated hydrochloric and nitric acid (aqua-regia) using a temperature-controlled digestion block. The formation of strong oxidising agents will destroy organic matter and break down the mineral matrix of the sample. The elements dissolved in the acid are analysed by ICP-OES / ICP-MS. Silicates present in the sample are not solubilised and are left as an insoluble residue in the digest.
Total N **Total C**	Samples are totally combusted in an oxygen enriched atmosphere in a reaction tube. Nitrogen & Carbon products are carried by a constant flow of carrier gas (helium) through an oxidation catalyst, and then reduced through copper wires, where excess oxygen is removed, and nitrogen oxides are reduced to elemental nitrogen. The nitrogen and carbon products are separated through a chromatographic column. As the products are eluted from this column, they pass through a T.C.D. detector, which generates an electrical signal proportional to the amount of nitrogen and carbon present. Various products can be eliminated if required using various traps, such as magnesium perchlorate trap to eliminate hydrogen. Peak elimination reduces the risk of overlapping peaks and shortens run times.

Appendix 2. Details of methods used for analysis of herbage samples from low resolution surveys

Herbage Parameter	Methodology
Total Nitrogen **Total Carbon**	Samples are totally combusted in an oxygen enriched atmosphere in a reaction tube. Nitrogen and carbon products are carried by a constant flow of carrier gas (helium) through an oxidation catalyst, and then through reduced copper wires, where excess oxygen is removed, and nitrogen oxides are reduced to elemental nitrogen. The nitrogen and carbon products are separated through a chromatographic column. As the products are eluted from this column they pass through a T.C.D detector, which generates an electrical signal proportional to the amount of nitrogen and carbon present. Various products can be eliminated if required using various traps, such as a magnesium perchlorate trap to eliminate hydrogen. Peak elimination reduces the risk of overlapping peaks and shortens run times.
Total Phosphorus **Total Potassium** **Total Calcium** **Total Magnesium** **Total Sulphur** **Total Manganese** **Total Copper** **Total Zinc** **Total Iron** **Total Boron**	A representative portion of the prepared sample is digested in an open vessel with concentrated nitric and hydrochloric acid (reverse aqua-regia) using a temperature-controlled digestion block. The formation of strong oxidising agents will destroy organic matter and break down the mineral matrix of the sample. The elements dissolved in the acid are analysed by ICP-OES / ICP-MS which gives an estimation of the 'total' content. Silicates present in the sample are not solubilised and are left as an insoluble residue in the digest. The elements in solution are then determined either by Inductively Coupled Plasma Mass Spectrometery (ICPMS), Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) or Atomic Fluorescence Spectroscopy (AFS). Elements determined by OES are Phosphorus, Potassium, Magnesium, Calcium, Sulphur, Sodium, Manganese, Zinc, Boron and Copper with Chromium, Lead, Arsenic, Cadmium, Molybdenum, Nickel and Cobalt by MS and Mercury and Selenium by AFS.