North Wyke Farm Platform

Data Guide

User Guide

Version 1.0

The North Wyke Farm Platform: Data Guide

Description: The North Wyke Farm Platform (NWFP) was established in 2010 to study and improve grassland livestock production at the farm-scale. The NWFP uses a combination of environmental sensors, routine field and lab-based measurements, and detailed management records to monitor livestock and crop production, emissions to water, emissions to air, soil health, and biodiversity. The rich NWFP datasets help researchers to evaluate the effectiveness of different grassland (and arable) farming systems, which in turn, contributes to the development of sustainable, resilient and net zero land management strategies. This document serves as a user guide to the freely available data that can be downloaded from the data portal or accessed via API. It also indicates where other supplementary or complementary datasets, not available via the data portal / API routes, may be obtained.

This document is associated with other user guides that detail the design, establishment and development of the NWFP, dataset collection, field events, low and high spatial resolution field surveys, and the quality control process.

Site: North Wyke, Okehampton, Devon, UK. Geographic location: 50.76944, -3.90138; 50°46'10" N, 3°54'05" W.

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1 Introduction

➤ This document provides a user guide to data that are freely downloadable from the North Wyke Farm Platform (NWFP) data portal (https://nwfp.rothamsted.ac.uk/) or accessed via the API (https://api-nwfp.rothamsted.ac.uk/). An overview of the NWFP and a wealth of supporting information can be found on its dedicated website at https://nw-farmplatform.rothamsted.ac.uk.

➤ A list of all the dataset variables and dates of their collection can be found at https://nw-farmplatform.rothamsted.ac.uk/content/data_collection. An overview of the dataset categories is given in Table 1 below. Note that all collections have a delay in release while they are quality controlled and processed, or until the full set is collected. Some delays are longer than others, where for example, the field management data is always at least 1 year behind (from capture to release).

➤ Detailed information on the site characteristics, design and development of the NWFP can be found in the user guide entitled 'NWFP_UG_Design_Develop.pdf' available at https://repository.rothamsted.ac.uk/item/98y1x/the-north-wyke-farm-platform-design-establishment-and-development.

➤ Information on the details of the methodologies used to collect the various datasets is provided in the individual user guides that are listed in Table 2.

2   The North Wyke Farm Platform

The North Wyke Farm Platform (NWFP) is a National Bioscience Research Infrastructure (NBRI) funded by the Biotechnology and Biological Sciences Research Council (BBSRC). The NWFP consists of three individually managed systems or 'farmlets' each of which is approximately 21 ha. The design allows for the productivity and environmental sustainability of different temperate grazing livestock and arable systems to be tested at appropriate land and farm management scales. All data produced on the NWFP are freely available.

Each of the three outdoor farmlets contains five (sub-) catchments (15 in total), with each catchment hydrologically isolated through a combination of topography and a network of French drains [French, 1859] constructed around the perimeters of each catchment (Figure 1).
A catchment is usually 1 field but sometimes a catchment consists of 2 separately fenced fields. It could be that one field is used for silage production whilst the other field is used for livestock grazing. Collected data can be at the sub-field-scale, field-scale, catchment-scale, farm-scale and NWFP-scale; it can also be at the individual animal-scale.

From April 2011 to March 2013, all three farmlets were permanent pasture-based livestock farming systems with no separate treatments in operation. This is the baseline period. Subsequent system change periods have followed for one or two farmlets.

For the first system change period (approximately 2013 to 2019), the three farming systems (or treatments) on the platform were:

  i.   Permanent pasture: improvement through use of inorganic fertilisers (**Green farmlet**) – i.e. no change from baseline.

  ii.   Increased use of legumes: replacing nitrogen fertilisers with biological fixation using sown legume and grass mixtures (**Blue farmlet**).

  iii. Planned reseeding: regular renewal, providing opportunities for introducing innovative grass varieties with desirable traits such as high sugar and deep roots (**Red farmlet**).

Post 2019, a second treatment change period was introduced, where the **Red farmlet** transitioned to an arable system with the aim of growing human edible crops. Additionally, a new fourth system was established where cattle that would have grazed the **Red farmlet** are permanently housed from weaning to slaughter (**Brown farmlet**).

The timeline of system changes and land management is given in Appendix A. Details of the catchments and their fields are given in Appendix B and Appendix C.

On occasions it is necessary to subdivide fields into temporary fields. Typically, this is done during years where the rate of grass growth is more than grazing requirements and was set in operation from 2017. When this occurs, the field is divided into two using a temporary fence. One area is grazed, whilst the other is used for silage production. The area of each temporary field is made up from a number of predefined strips, the coordinates of which are recorded. **Note, this is not to facilitate strip grazing, but to just divide fields into two**. Each temporary field and field strip is

allocated a unique identifier in the database, and these are shown Appendix D. Area details of the individual field strips are given in Appendix E. The temporary fields and field strip allocations are available in the metadata.txt file that accompanies the data file downloaded from the data portal.

Figure 1. Map of NWFP.
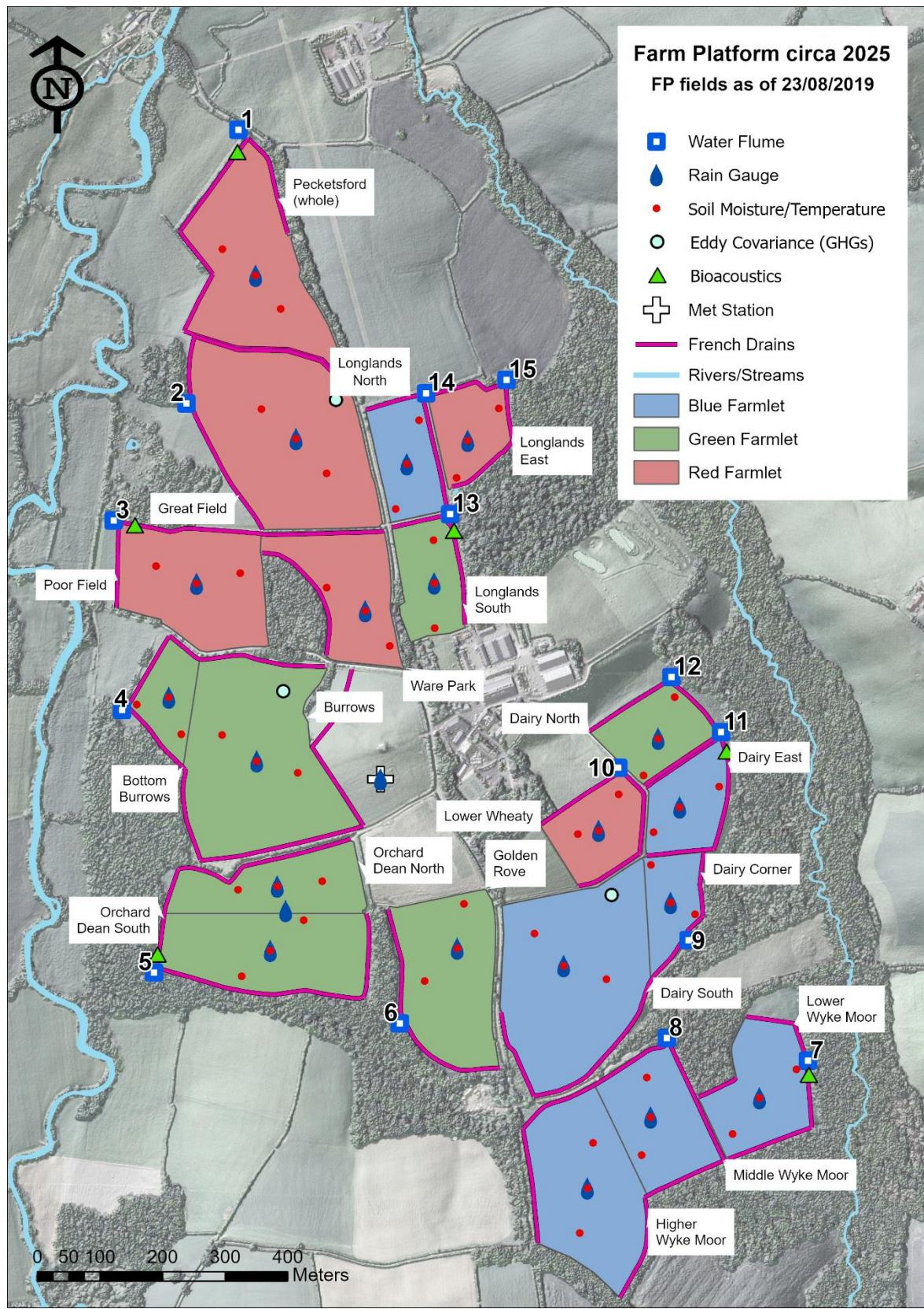
3 Dataset Types and Availability

As an NBRI funded by BBSRC, all NWFP data is made freely available. Where possible, much of the quality controlled core data are downloadable via the dedicated data portal or via the API. However, other supplementary or complementary data sets are available via other sources. The different dataset types and their availability (**Open; Closed**) are as follows:

1. **Open core data from the NWFP data portal / API**: These are routinely collected, monitoring datasets (aside from a few stand-alone spatial surveys in the early years).

2. **Closed core data not yet openly released on the NWFP data portal / API**: Typically, these have time lags of a couple of months to a year from data collection to data quality control, to open release.

3. **Open data released outside of the NWFP data portal / API**: These are either non-core data from individual NWFP experiments (> 150 experiments to date) that are typically campaign based in nature (e.g., one field only over a given grazing season), or core data that has been processed in some way (e.g. 15-minute water data aggregated to daily). These datasets are available from the Rothamsted Research repository hosted on CKAN (https://data.rothamsted.ac.uk/dataset/?groups=north-wyke-farm-platform) or a data journal where a dataset typically relates to the data used in a published journal article. The data journal datasets can be found on the NWFP publications webpage (https://nw-farmplatform.rothamsted.ac.uk/publications).

4. **Closed NWFP experiment data**: These are non-core datasets that still reside with the project lead of the given NWFP experiment and are either awaiting analysis for a journal paper or are no good in some way.

5. **Open fixed data**: Data such as topography, soil classes, field and farm boundaries are available from the NWFP file store at: https://nwfp.rothamsted.ac.uk/fpdownload/showfiles.aspx

6. **Other data**: This includes financial data and veterinary data (or any other data that any farm is legally obliged to collect). These are available on request.

7. **Open external data**: Such as satellite remote sensing products for the NWFP, from say Google Earth Engine (https://earthengine.google.com/).

4 Datasets Available via the Data Portal & API

Full details and descriptions of all the NWFP data available via the data portal or API can be found at https://nw-farmplatform.rothamsted.ac.uk/content/data_collection.

A summary of the main dataset category, spatial unit, temporal frequency of collection, and start date of collection is given in Table 1. This table only lists the main collections. Other collections also exist in the data portal, including a few within-field spatial surveys from 2012 to 2016 only. Collections are continually being enhanced and refined, meaning this table tends to expand year on year.

Table 1. Summary of category, spatial scale, temporal resolution and start dates of datasets.

Dataset category	Spatial Unit	Temporal Frequency	Start Date
Water flow and chemistry	Catchment-scale	15-minute	2012
Soil Moisture, Temperature & Rainfall	Field-scale (1 in 15 of 20 fields)	15-minute	2011
Rainfall	Field-scale (1 in 15 of 20 fields)	15-minute	2011
MET data	Platform-scale	15-minute	2011
Farm management activities (e.g., fertilizer application, cultivation)	Farm-scale	Variable	2011
Livestock data (e.g. liveweight gain, condition scores, location, sales & carcase quality data)	Individual animal	2- to 4-weekly, end of life	2010
Forage quality (grazing)	Field-scale	2-weekly	2015
Forage yield (silage cuts, as trailer loads)	Field-scale	2-cuts per grazing season	2011
Forage quality (silage)	Farm-scale via Clamp / Bale	2-weekly	2015
Arable crop yield (as trailer loads)	Field-scale	Annual Harvest	2020
Arable crop quality	Field-scale	Annual Harvest	2020
Low resolution field surveys (soil & herbage nutrients)	Field-level (bulked samples)	Quarterly	2018
Eddy Covariance GHG (CH_4 & CO_2 from soil, plant & livestock).	Sited in 3 of the 20 fields (CH_4 measured in 2 fields only)	30-minute	2017
Housed Greenfeed GHG (CH_4 & CO_2 from cattle)	Farm-scale (individual animal)	Variable	2017
Housed Greenfeed GHG (CH_4 & CO_2 from sheep)	Farm-scale (individual animal)	Variable	2022

5 Using the API

The API can be accessed via this link: https://api-nwfp.rothamsted.ac.uk/ and demo jupyter notebooks can be found at: North-Wyke-Farm-Platform/NWFP-API-Demo: NWFP API Demonstration Jupyter Notebooks.

6 Using the Data Portal

Register for access to the NWFP data portal (Figure 2) by visiting here (https://nwfp.rothamsted.ac.uk/) and emailing nw.farmplatform@rothamsted.ac.uk. Once registered you are required to re-set your password within 24 hours and this will give you access to all the NWFP data.

Figure 2. Data Portal registration and login page.
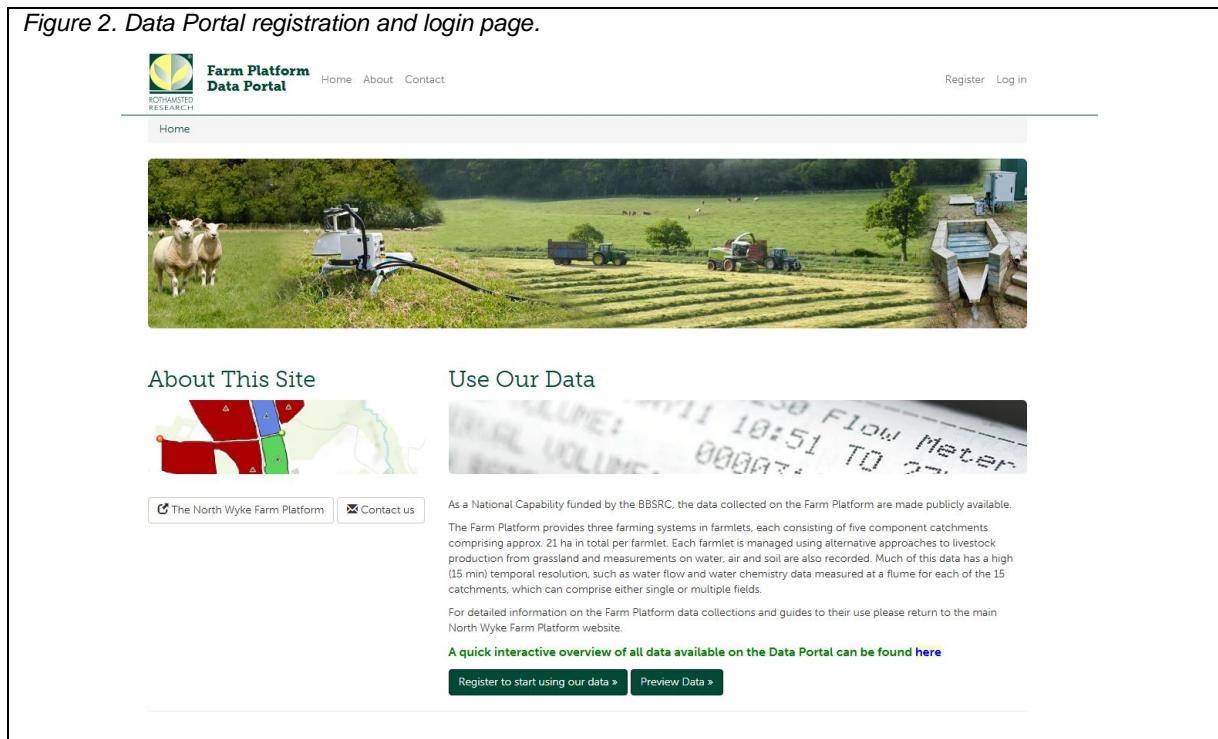
Once logged in, click on the Download button which will take you to the Dataset Download page (Figure 3). Click on each of the catchments you require on the map and select the required variables from the relevant sections by selecting the tick boxes. Note that Precipitation (mm) from the MET station is ticked by default. You can untick this if not required. Select the required start date and end date. **Note that you can only download one years' worth of data at a time.**

The data will download as a comma separated (.csv) file alongside an accompanying metadata file (metadata.txt) which contains essential information that should be used alongside the data when understanding and processing it.

Figure 3. Data portal download page.
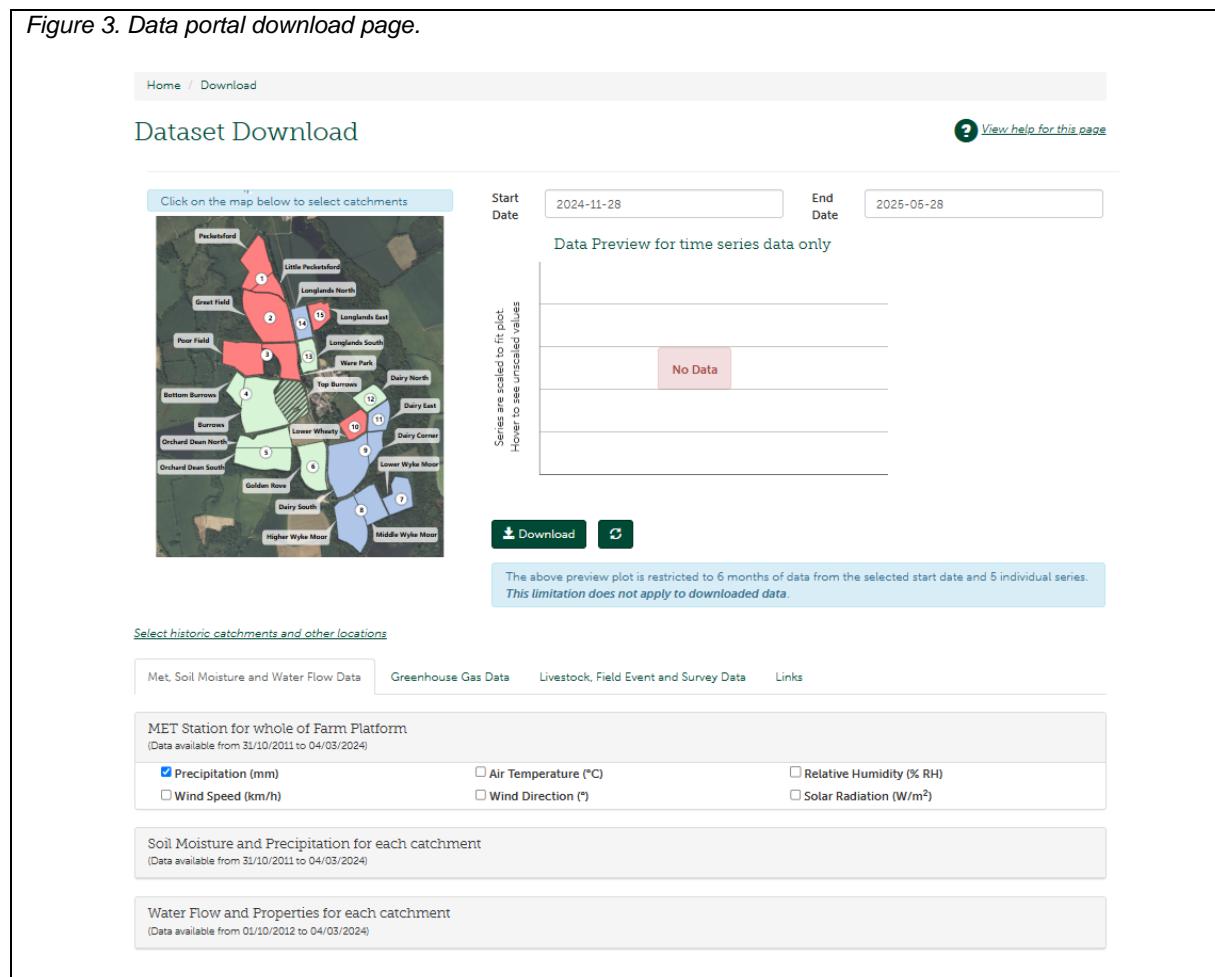
7 Supplementary Data

A list of data publications can be accessed at https://nw-farmplatform.rothamsted.ac.uk/publications in the Dataset section. These publications are typically one-off campaign datasets, or datasets consisting of raw data that have been processed in some way. These collections include simulated datasets (e.g. climate scenarios for the NWFP site).

Some of the processed datasets are available on the Rothamsted Research data repository hosted on CKAN repository: https://data.rothamsted.ac.uk/dataset/?groups=north-wyke-farm-platform.

8 Sources of Information

8.1 NWFP Website

The NWFP dedicated website (https://nw-farmplatform.rothamsted.ac.uk) contains a wealth of complementary information and additional resources such as statistical data summaries, ArcGIS shapefiles, and soil maps can be found on the data portal file store at https://nwfp.rothamsted.ac.uk/fpdownload/showfiles.aspx

8.2 User guides

User guides have been developed to supplement and to help understand and interpret the data. Each data set has a dedicated guide, which are listed, and can be accessed using the DOI link in Table 2. Please refer to these guides and reference them in any resulting output publication.

Table 2. User guides to the NWFP data.

Data used	Main title of User Guide PDF document	DOI
All datasets	NWFP_UG_Design_Develop.pdf	https://doi.org/10.23637/rothamsted.98y1x
All datasets	NWFP_UG_Data_Guide.pdf	https://doi.org/10.23637/rothamsted.99440
15-minute time-series datasets (water, soil moisture, meteorology)	NWFP_UG_Hydrology&WaterQuality_Data.pdf	https://doi.org/10.23637/rothamsted.98y34
	NWFP_UG_SMS_Data.pdf	https://doi.org/10.23637/rothamsted.98y4x
	NWFP_UG_MET_Data.pdf	https://doi.org/10.23637/rothamsted.98y4w
Greenhouse gases	NWFP_UG_GHG_Data.pdf	https://doi.org/10.23637/rothamsted.98y52
	NWFP_UG_GreenFeed_Data.pdf	https://doi.org/10.23637/rothamsted.98y53
Field surveys	NWFP_UG_FieldSurvey_Data.pdf	https://doi.org/10.23637/rothamsted.98y51
Livestock	NWFP_UG_Livestock_Data.pdf	https://doi.org/10.23637/rothamsted.98y50
Field events	NWFP_UG_FieldEvents_Data.pdf	https://doi.org/10.23637/rothamsted.98y4z
Forage quantity and quality	NWFP_UG_Forage_Quantity&Quality_Data.pdf	https://doi.org/10.23637/rothamsted.992wy
Biodiversity	NWFP_UG_Biodiversity_Data.pdf	https://doi.org/10.23637/rothamsted.993x2

8.3 Journal Publications

Journal articles can be found on the website publications page at https://nw-farmplatform.rothamsted.ac.uk/publications and provide useful context to the rationale for the NWFP experiment and its data.

8.4   Rpubs

R markdown files published on Rpubs (https://rpubs.com/North_Wyke_Farm_Platform) contain useful code and full explanation for the advanced processing of various aspects of the raw data.

9 Citing the Data

If you choose to use any of datasets provided by the NWFP in a publication, please cite:

- *Orr, R. J., Murray, P. J., Eyles, C. J., Blackwell, M. S. A., Cardenas, L. M., Collins, A. L., Dungait, J. A. J., Goulding, K. W. T., Griffith, B. A., Gurr, S. J., Harris, P., Hawkins, J. M. B., Misselbrook, T. H., Rawlings, C., Shepherd, A., Sint, H., Takahashi, T., Tozer, K. N., Whitmore, A. P., Wu, L. and Lee, M. R. F. (2016). The North Wyke Farm Platform: effect of temperate grassland farming systems on soil moisture contents, runoff and associated water quality dynamics. European Journal of Soil Science, 67, 4, 374-385. (doi:10.1111/ejss.12350).*

In addition, if using data from the baseline period please cite:

- *Takahashi, T., Harris, P., Blackwell, M. S. A., Cardenas, L. M., Collins, A. L., Dungait, J. A. J., Hawkins, J. M. B., Misselbrook, T. H., McAuliffe, G. A., McFadzean, J. N., Murray, P. J., Orr, R. J., Rivero, M. J., Wu, L. and Lee, M. R. F. (2018). Roles of instrumented farm-scale trials in trade-off assessments of pasture-based ruminant production systems. Animal, 12, 8, 1766-1776. (doi:10.1017/S1751731118000502).*

- *Orr, R. J., Griffith, B. A., Rivero, M. J. and Lee, M. R. F. (2019). Livestock Performance for Sheep and Cattle Grazing Lowland Permanent Pasture: Benchmarking Potential of Forage-Based Systems. 9, 2, 101-118. (doi:10.3390/agronomy9020101).*

For the datasets used, please cite the latest version of the relevant User Guide PDF document(s), listed in the table below, that describe the establishment and development of the NWFP, and the various datasets produced in detail. The link to these can be downloaded from the NWFP website. Note that the User Guide entitled 'NWFP_UG_Design_Develop.pdf' should be cited irrespective of the dataset used.

Also, please include the following sentences in the acknowledgments section:

10 References

French, H. F. (1859). Farm drainage: the principles, processes, and effects of draining land with stones, wood, plows, and open ditches, and especially with tiles. New York: Orange Judd & Company.

11 Appendices

11.1 Timeline of land management changes

Appendix A. Timeline of land management and changes.

Date	Event
01 April 2013	Lower Wheaty and Longlands North swapped treatments
13 August 2013	Change in area of Catchment 4 (Burrows)
July – August 2013	Reseeding of Red farmlet catchments: 2 (Great Field) with perennial ryegrass (AberMagic); 15 (Longlands East) with festulolium (Prior)
	Reseeding of Blue farmlet catchments:8 (Higher & Middle Wyke Moor) with perennial ryegrass (AberMagic) & white clover (AberHerald); 14 (Longlands North) with festulolium (Prior) & white clover (AberHerald)
July – August 2014	Reseeding of Red farmlet catchments: 3 (Poor Field & Ware Park) with perennial ryegrass (AberMagic)
	Reseeding of Blue farmlet catchments: 9 (Dairy South & Dairy Corner) with perennial ryegrass (AberMagic) & white clover (AberHerald)
July – August 2015	Reseeding of Red farmlet catchments: 1 (Little Pecketsford & Pecketsford) with perennial ryegrass (AberMagic); 10 (Lower Wheaty) with perennial ryegrass (AberMagic)
	Reseeding of Blue farmlet catchments: 7 (Lower Wyke Moor) with perennial ryegrass (AberMagic) & white clover (AberHerald); 11 (Dairy East) with perennial ryegrass (AberMagic) & white clover (AberHerald)
09 May 2018	Catchment 14 (Longlands North) over sown with white clover mixture: Aberpearl (40.0%); Aberherald (40.0%); Aberace (wild white clover, 20.0%)
August – October 2019	Conversion of all Red farmlet catchments from grassland to arable. Sprayed with herbicide, ploughed, and sown with winter wheat (variety = Crusoe). Pecketsford and Little Pecketsford now known as Pecketsford (whole).
October 2020	Red farmlets sown with winter wheat (variety= RGT Skyfall).
October 2021	Red farmlets sown with winter oats (variety = Mascani)
Late September-October 2022	Red farmlets sown with winter wheat (variety = Crusoe). Minimum tillage used (no ploughing) – shallow disk/tine cultivator, herbicide spray and min-till drill.
2023	No drilling as too wet
April 2024	Red Farmlets sown with spring oats (variety = Merlin)
November 2024	Red farmlets sown with winter field beans (variety = Vespa)

11.2 Catchment Details

11.2.1 Names, ID numbers and areas of fields

Appendix B. Name of field, field number and area contributing to each catchment flume on the three NWFP farmlets as of 2015.

Red Farmlet	Field Names	Field Numbers	Fenced area (ha)	Total Fenced area (ha)	Total Hydrological area (ha)
Catchment 1 Pre-autumn 2019[1]	Pecketsford	NW001	3.50	4.81	5.00
	Little Pecketsford	NW038	1.31		
Catchment 1 Post-autumn 2019[2]	Pecketsford (whole)	NW047	4.81	4.81	5.00
Catchment 2	Great Field	NW002	6.65	6.65	6.79
Catchment 3	Poor Field	NW003	3.92	6.63	6.84
	Ware Park	NW004	2.71		
Catchment 10	Lower Wheaty	NW015	1.82	1.82	1.94
Catchment 15	Longlands East	NW019	1.54	1.54	1.62
Total				**21.4**	**22.2**
Green Farmlet	**Field Names**	**Field Numbers**	**Fenced area (ha)**	**Total Fenced area (ha)**	**Total Hydrological area (ha)**
Catchment 4 Pre-Aug 2013[2]	Burrows	NW006	6.39	11.12	11.55
	Bottom Burrows	NW005	1.26		
	Top Burrows	NW007	3.47		
Catchment 4 Post-Aug 2013[3]	Burrows	NW006	6.49	7.75	8.08
	Bottom Burrows	NW005	1.26		
Catchment 5 Pre / Post Aug 2015	Orchard Dean North	NW008 / NW045	2.55	6.47	6.73
	Orchard Dean South	NW008 / NW046	3.92		
Catchment 6	Golden Rove	NW009	3.86	3.86	3.95
Catchment 12	Dairy North	NW016	1.78	1.78	1.87
Catchment 13	Longlands South	NW017	1.75	1.75	1.81
Total pre-Aug 2013				**25.0**	**25.9**
Total post-Aug 2013				**21.6**	**22.4**
Blue Farmlet	**Field Names**	**Field Numbers**	**Fenced area (ha)**	**Total Fenced area (ha)**	**Total Hydrological area (ha)**
Catchment 7	Lower Wyke Moor	NW012	2.60	2.60	2.71
Catchment 8	Middle Wyke Moor	NW011	4.32	7.02	7.33
	Higher Wyke Moor	NW10	2.70		
Catchment 9	Dairy South	NW013	6.45	7.75	7.91
	Dairy Corner	NW039	1.30		
Catchment 11	Dairy East	NW014	1.76	1.76	1.85
Catchment 14	Longlands North	NW018	1.72	1.72	1.78
Total				**20.8**	**21.6**
Total NWFP Area pre-Aug 2013				**67.2**	**69.7**
Total NWFP Area post-Aug 2013				**63.8**	**66.2**

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[1] At the start of the NWFP, Catchment 1 consisted of 2 fields, Pecketsford and Little Pecketsford, but following conversion of the Red farmlet to arable, the fields were combined and renamed Pecketsford (whole).

[2] At the start of the NWFP, Catchment 4 consisted of 3 fields, Bottom Burrows, Burrows and Top Burrows, which made up a total area of around 11 ha. As the Green farmlet (25 ha) was considerably larger than the Red farmlet (21.4 ha) and the Blue farmlet (20.8 ha), it was decided to remove the Top Burrows field, which has an area of 3.47 ha, from the platform, for all farmlets to be of a similar size. To isolate the Top Burrows field, additional French Drains were constructed to intercept and divert water draining from Top Burrows away from Flume 4. completed 13 August 2013.

11.2.2 Names, ID numbers and areas of Red Farmlet cropped catchments (from 2019)

Appendix C. Name of field and cropping area contributing to each catchment flume on the Red farmlet as of autumn 2019.

Red Farmlet	Field Names	Field Number	Total Cropped Area (ha)
Catchment 1	Pecketsford (whole)[3]	NW047	4.45
Catchment 2	Great Field	NW002	6.34
Catchment 3	Poor Field	NW003	3.65
	Ware Park	NW004	2.49
Catchment 10	Lower Wheaty	NW015	1.59
Catchment 15	Longlands East	NW019	1.37
Total			**19.89**

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[3] *formerly Pecketsford & Little Pecketsford*

11.2.3 Field strip demarcations and areas

Appendix D. Map of NWFP showing temporary field strip demarcations and areas.

Farm Platform Field Strips
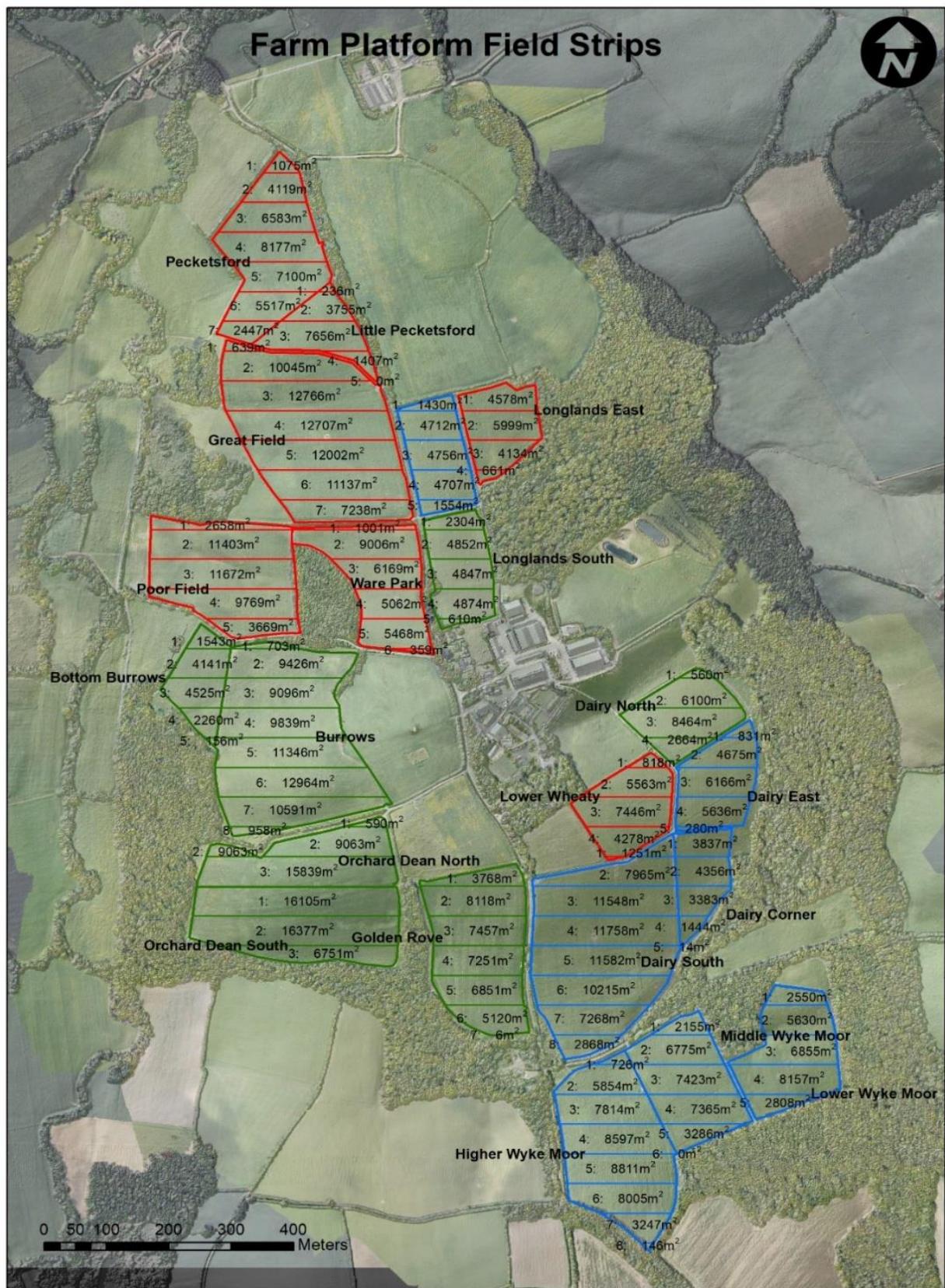
11.2.4 Field strip areas

Appendix E. Field strip areas.

Field Strip Name	Cutting Area (ha)	Fenced Area (ha)	Inorganic Spreading Area (ha)	Organic Spreading Area (ha)	Hydrological Area (ha)
NW002_03	1.266318	1.276554	1.264961	1.205449	1.290915
NW002_02	0.983281	1.004502	0.982765	0.788262	1.058084
NW002_01	0.05265	0.063917	0.056906	0.010889	0.08608
NW002_07	0.697816	0.723802	0.696142	0.640298	0.73374
NW002_06	1.103569	1.113676	1.102033	1.053154	1.127758
NW002_05	1.190472	1.200184	1.188325	1.143034	1.21256
NW002_04	1.261061	1.270715	1.25909	1.2145	1.283033
NW006_04	0.974615	0.983924	0.983924	0.942879	0.99873
NW006_03	0.899858	0.909571	0.909064	0.875968	0.924396
NW006_02	0.919387	0.942617	0.933112	0.79938	0.978357
NW006_01	0.059127	0.070271	0.058651	0.002605	0.098416
NW006_08	0.083541	0.095758	0.082007	0.015205	0.120938
NW006_07	1.034022	1.059069	1.034793	0.843197	1.111207
NW006_06	1.286498	1.296368	1.291984	1.209287	1.335022
NW006_05	1.1238	1.13462	1.131526	1.052185	1.167409
NW008_02	0.878718	0.90629	0.882057	0.655195	0.978814
NW008_01	0.048929	0.059019	0.052006	0.008653	0.079283
NW008_03	1.538362	1.583876	1.576615	1.477178	1.619234
NW008_06	0.645892	0.675084	0.642227	0.406734	0.752193
NW008_05	1.623181	1.637667	1.622402	1.506975	1.667441
NW008_04	1.569013	1.610537	1.600309	1.520801	1.633565
NW009_03	0.736625	0.745722	0.735715	0.69492	0.757568
NW009_02	0.802485	0.811839	0.801626	0.760249	0.823723
NW009_01	0.352415	0.376767	0.366811	0.239494	0.378326
NW009_07	0	0.00057	0	0	0.007924
NW009_06	0.490494	0.51205	0.48645	0.342567	0.539404
NW009_05	0.675527	0.685059	0.673608	0.589709	0.70083
NW009_04	0.716121	0.725133	0.714714	0.649892	0.738756
NW012_02	0.553671	0.562971	0.55295	0.470207	0.57593
NW012_01	0.240137	0.254998	0.240507	0.143025	0.278694
NW012_05	0.263274	0.280789	0.268018	0.165469	0.307093
NW012_04	0.802454	0.815678	0.808707	0.725264	0.830415
NW012_03	0.66992	0.685477	0.673601	0.563231	0.713811
NW013_04	1.166786	1.1758	1.170803	1.168375	1.1758
NW013_03	1.14575	1.154765	1.149743	1.149743	1.154765
NW013_02	0.773156	0.796519	0.795394	0.727143	0.796519
NW013_01	0.109754	0.12513	0.12513	0.108705	0.12513
NW013_08	0.272196	0.286815	0.273889	0.169332	0.323842
NW013_07	0.71543	0.726787	0.716051	0.616633	0.757243
NW013_06	1.011459	1.021477	1.011645	0.922251	1.047488
NW013_05	1.148701	1.158165	1.147624	1.100747	1.168464
NW010_08	0.007731	0.014577	0.013918	0.000519	0.0297
NW010_07	0.31216	0.324661	0.319058	0.233177	0.380221
NW010_06	0.787519	0.800539	0.79159	0.700112	0.841134
NW010_05	0.871319	0.881105	0.871721	0.79036	0.905689
NW010_04	0.849113	0.85971	0.852933	0.806758	0.870017
NW010_03	0.771874	0.781424	0.775813	0.735199	0.792969
NW010_02	0.572248	0.585362	0.57656	0.504037	0.604252
NW010_01	0.061831	0.07263	0.066569	0.031252	0.086565
NW011_02	0.662708	0.67746	0.66665	0.576782	0.7019
NW011_01	0.199513	0.215527	0.201818	0.112042	0.247903
NW011_06	0	1.7E-05	0	0	0.000864
NW011_05	0.309275	0.328609	0.317717	0.230346	0.358166
NW011_04	0.722193	0.736458	0.729939	0.676961	0.751147
NW011_03	0.732362	0.742313	0.736264	0.692172	0.755288

11.3 Methods and instrumentation specifications

11.3.5   Flow and water quality variables; methods and instrumentation specifications

Appendix F. Flow and water quality variables; methods and specifications.

Variable	Method	Units	Range	Resolution	Accuracy
Discharge	Equation	L s^{-1}			
Pump	Peristaltic Pump	On/Off	n/a	n/a	n/a
Nitrate and Nitrite-N	UV absorption sensor (Nitratax)	mg L^{-1}	0.1 - 100	0.1	±3% of the measured value ±1.0 mg L-1
Fluorescent Dissolved Organic Matter	UV fluorescence	QSU	0 - 300	0.01	Linearity: R2 > 0.999 for serial dilution of 300 µg L^{-1} QS solution
Ammonia-N & Ammonium-N	Ion selective electrode (YSI 6600V2)	mg L^{-1}	0 - 200	0.001 - 1	±10% or 2mg N L^{-1}, whichever is greater
	Ion selective electrode (YSI EXO 2)	mg L^{-1}	0 - 200	0.01	±10% or 2mg N L^{-1}, whichever is greater
Specific Conductivity	Ion selective electrode (YSI 6600V2)	mS cm^{-1}	0 - 100	0.0001 – 0.1	±0.5% + 0.0001
	Ion selective electrode (YSI EXO 2)	mS cm^{-1}	0 - 200	0.001, 0.01, 0.1	±0.5% of reading or 0.001 mS cm^{-1}, whichever is greater
pH	Ion selective electrode (YSI 6600V2)	n/a	1 - 14	0.01	±0.2
	Ion selective electrode (YSI EXO 2)	n/a	1 - 14	0.01	±0.1 pH units within ±10˚C of calibration temp or ±0.2 pH units for entire temp range
Dissolved Oxygen	Optical Sensor (YSI 6600V2)	%	0 - 500	0.1	0-200: ±2%; 200-500: ±6%
	Optical Sensor (YSI EXO 2)	%	0 - 500	0.1	0 to 200%: ±1% of reading or 1% saturation, whichever is greater.\n200 to 500%: ±5% of reading
Turbidity	Optical Sensor (YSI 6600V2)	FNU	0 - 1000	0.1	±2% or 0.3 FNU, whichever is greater
	Optical Sensor (YSI EXO 2)	FNU	0 - 4000	0 - 999: 0.01 FNU\n1000 - 4000: 0.1 FNU	0-999: 0.3 FNU or +/- 2% of reading, whichever is greater\n1000-4000 FNU: +/- 5% of reading
Temperature	Thermistor (YSI 6600V2)	°C	-5 - 50	0.01	±0.15
	Thermistor (YSI EXO 2)	°C	-5 - 50	0.001	-5 to 35: ±0.01°C\n35 to 50: ±0.05°C
Total Phosphorus & Ortho-Phosphate	Reduction method, IR-LED photometer	mg L^{-1}	0-5	0.1	±2.0%+0.05mg L-1

11.3.6   Soil moisture variables; methods and instrumentation specifications

Appendix G. Soil moisture variables; methods and instrumentation specifications.

Variables	Method	Units	Range	Resolution	Accuracy
Precipitation	Tipping Bucket	mm	0 – 100 per hour	0.2	0-50: ±1%
Soil Temperature @ 15 cm Depth	Thermistor	°C	-55 - 70	0.125	±0.5
Soil Moisture @ 10 cm Depth	Capacitance sensor	%	0 - 100	0.1	±2.0

11.3.7   Site-wide meteorological variables; methods and instrument specifications

Appendix H. Site-wide meteorological variables; methods and instrument specifications.

Meteorological properties	Method		Units	Range	Resolution	Accuracy
Precipitation (2013-2015)	Tipping Bucket		mm	0 – 100 per hour	0.2	0-50: ±1%
Precipitation (since 2015)	Weighing		mm/15-min	0.1 – 500 per hour	±0.01	±0.05
Air Temperature	Thermistor		°C	-40 - 60	0.01	±0.1
Relative Humidity	Capacitance Humidity element		% RH	0 - 100	0.1	0-90: ±1.0; 90-100: ±2.0
Wind Speed @ 3 m height	Anemometer		km h^{-1}	1.44 - 270	0.01	±0.8
Wind Direction @ 3 m height	Magnetic Hall Element		Degrees	0 - 360	0.1	±2.5
Solar Radiation	Pyranometer		W/m^2	0 - 1600	0.1	±1.8%