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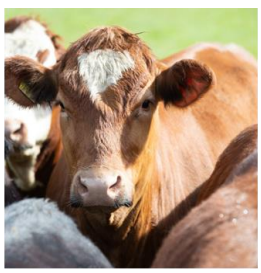
Biotechnology and Biological Sciences Research Council

North Wyke Farm Platform

Forage Quantity and Quality Data



User Guide

Version 1.0

The North Wyke Farm Platform: Forage Quantity and Quality Data

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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 forage (pasture, silage) quantity and quality data.

This document is associated with other dedicated user guides that detail the design, establishment and development of the NWFP, field events, and the quality control process of datasets.

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

Funding: Rothamsted Research receives strategic funding from the UK Biotechnology and Biological Sciences Research Council (BBSRC). The NWFP has been supported by grants BB/J004308/1, BBS/E/C/000J0100 and is currently supported by grant BBS/E/RH/23NB0008 (2023-28).

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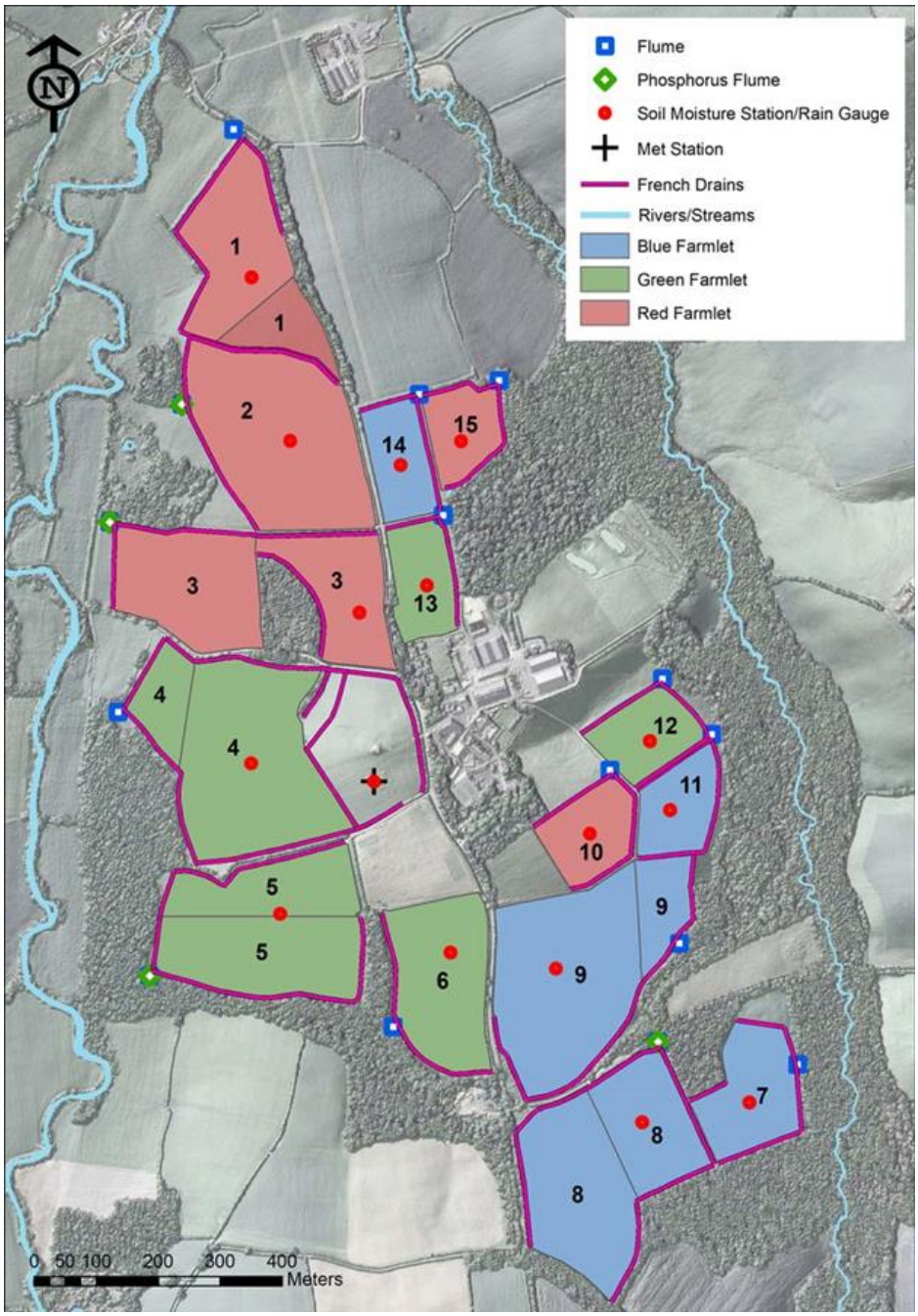
1 Introduction

This document provides a guide to the forage (pasture, silage) quantity and quality data produced on the NWFP (Figure 1). Information on the site characteristics and design and development of the NWFP can be found in the User Guide entitled 'NWFP_UG_Design_Develop.pdf' available on the NWFP website or here: https://repository.rothamsted.ac.uk/item/98y1x/the-north-wyke-farm-platform-design-establishment-and-development.

Figure 1. Map of NWFP showing systems as of 2015-2019 (first system change period [1]).



[1] *Green farmlet = permanent pasture, Blue farmlet = high sugar grass/clover; Red farmlet = high sugar grass, and later converted to arable in autumn 2019 (start of second system change period). In November 2017, phosphorus was measured at catchment or flume 3 in addition to flumes 2,5, & 8. From autumn 2023 onwards phosphorus will be measured on all catchments. Numbers represent catchment number. Note some catchments consist of multiple fields.*

2 Pasture

2.1 Pasture Quantity

The height and density of the pasture are currently measured using a Jenquip EC20 Bluetooth Electronic Rising Plate Meter (RPM) that is connected via Bluetooth with the Pastureprobe app installed on a smartphone (Figure 2).

The meter estimates the available forage for livestock grazing and helps determine when to move livestock to fresh grazing areas, thus optimising forage utilisation and ensuring sustainable pasture management. The meter is placed or 'plonked' on the ground, and at each 'plonk' the circular plate rises creating a slight compression of the herbage material that is supporting it underneath, and thus a measure of usable forage height. Metal divots spaced at 0.5 cm intervals up the stem of the meter provide a 'click' at each point that register the changes in height of the plate above the ground. The height readings are automatically converted to forage dry matter (DM) values within the Pastureprobe app using the calibration equation:

Figure 2. Jenquip EC20 Rising Plate Meter

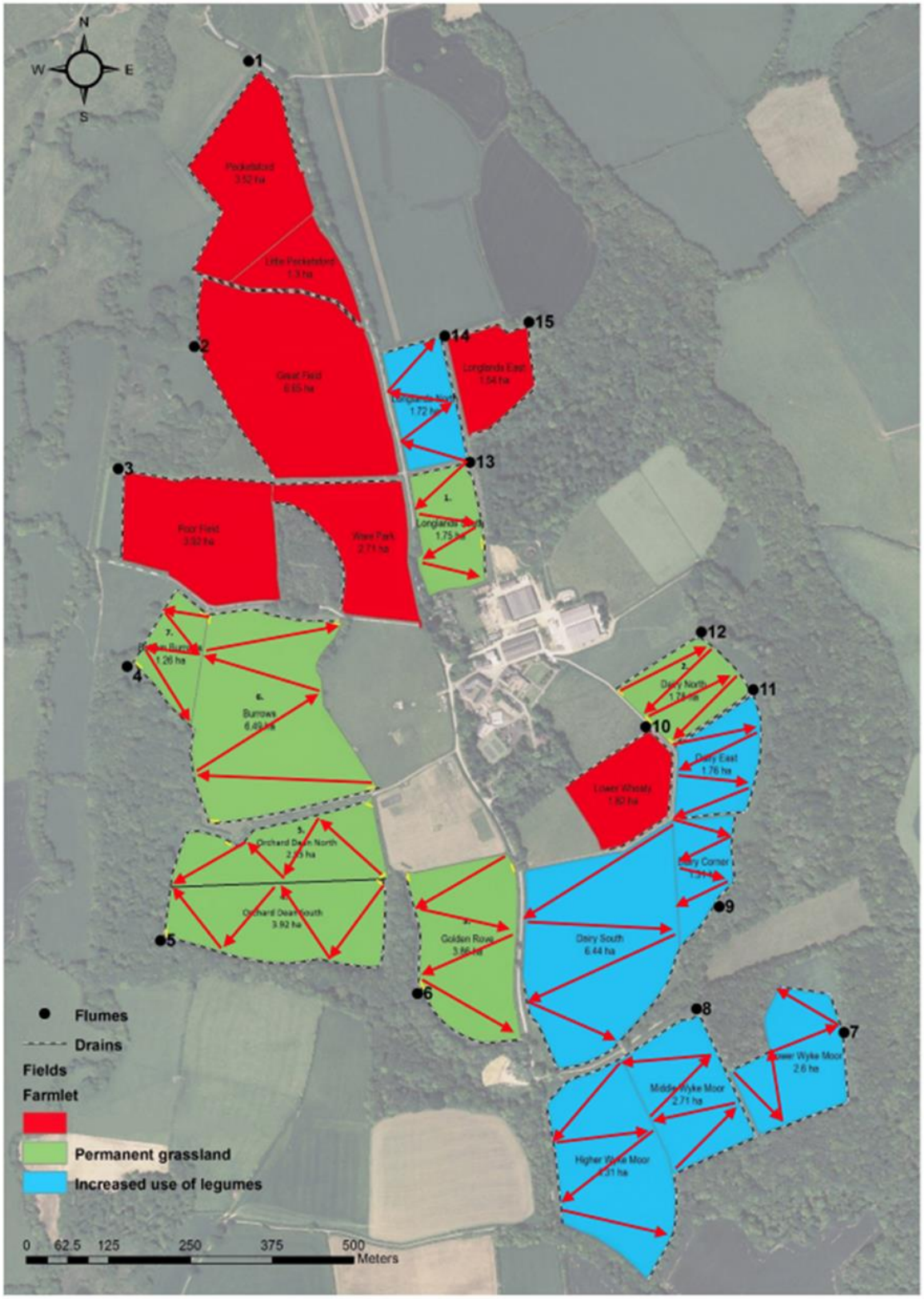
Dry Matter (kg ha^{-1}) = ((Raw Reading * 2) / 10) x EquationMultiplier + 500

where Raw Reading is the number of clicks the plate is above the ground when settled on top of the vegetation, converted firstly by 2 to cm, and then by 10 to mm. The EquationMultiplier and +500 are from an industry standard formula to produce an average DM value.

From April 2018 to 19th July 2023 inclusive the EquationMultiplier value was 125 but is currently set at 140.

Measurements are carried out on a fortnightly basis during the summer grazing period, and monthly during winter, on all pasture based farmlet fields (currently Blue and Green farmlet systems as Red converted to Arable in 2019) at a minimum of 30 points in a 'W' shaped pattern across each field (Figure 3). The change from winter to summer sampling frequencies, and vice-versa, is determined by the growth rate of the pasture. Where possible, RPM readings are taken by the same individual to reduce the risk of operator bias.

Figure 3. The 'W' walking pattern implemented in each of the Farm Platform pasture fields. The Red farmlet is currently an arable system.



2.2 Pasture Quality

Alongside the RPM readings described above, snip samples of herbage are taken on a fortnightly basis throughout the summer grazing period, and monthly during the winter whilst the sheep are grazing, from all grazed fields on each pasture-based farmlet (currently Blue and Green). As with the RPM readings, the change from winter to summer sampling frequencies, and vice-versa, is determined by the growth rate of the pasture.

Herbage sub-samples are taken at 9-points along the 'W' pattern shown in Figure 3, which are combined to produce a single bulked sample (~200 g) for each field. The undisturbed sward height is measured at each sampling point and the top 2/3 of the herbage is cut using scissors.

2.3 Pasture Sample Processing

- Each bulked herbage sample is weighed and frozen immediately prior to freeze drying.
- Samples are coarse ground through a 0.5 mm sieve.
- A representative sub-sample (~5 g) of the coarse ground sample is further fine ground for analysis of total N to determine crude protein (CP %), and water-soluble carbohydrate (WSC %).

2.4 Analysis of Herbage Samples

Sample analysis is performed in-house and a list of determinands and analytical methodologies is given in Appendix A.

3 Silage

3.1 Silage Sample Collection

3.1.1 Cattle Silage

Samples are collected during the livestock housing period (typically Nov-April). One sample (~100g fresh weight) is collected weekly from each of the three farmlet silage clamps (Green, Blue, and Brown (formerly Red prior to 2019) and combined across two weeks to form a composite sample for each. A sample is comprised of sub-samples taken from a minimum of 4 areas of the clamp in the area where the silage is being extracted that day for feeding (thus prior to the addition of any supplementary minerals or concentrates) and is bagged and frozen on the day of collection. The following week's sample is added to the bag of the previous week and the fresh weight of the fortnightly composite sample recorded alongside the first and second sample collection dates.

3.1.2 Sheep silage

Samples are collected during the livestock housing period (typically Jan-April). One sample is collected per feed from each pasture based farmlet silage bale (currently Green and Blue farmlets; Red farmlet prior to 2019) and is pooled across two weeks to give a fortnightly composite sample of ~350g fresh weight (depending upon feeding frequency) for each farmlet. Samples, consisting of a minimum of 4 sub-samples (~50g fresh weight), are taken from the bales which have been spread out, and prior to the addition of any supplementary minerals or concentrates. If there is no baled silage or the bales have been used up, the sheep are fed clamp silage and samples are taken as described above. The samples are bagged, frozen, and the fresh weight of the fortnightly composite sample recorded alongside the first and last sample collection dates.

3.2 Silage Sample Processing

- Samples are freeze dried and their dry weight recorded to give % dry matter (DM %).
- Samples are coarse ground through a 0.5mm sieve.
- A representative proportion of the coarse ground sample is further fine ground for analysis of total nitrogen to determine crude protein (CP %), and water-soluble carbohydrate (WSC %).

3.3 Analysis of Silage Samples

Silage analysis is performed in-house and a list of determinands and analytical methodologies is given in Appendix A.

4 Data Portal

The NWFP Data Portal (https://nwfp.rothamsted.ac.uk/) allows accessibility to the core NWFP datasets to not only Rothamsted Research but also the wider research community. The data are open access and free to download but users are required to register their interest.

The NWFP website offers a wealth of online, and regularly updated information to complement the data: http://resources.rothamsted.ac.uk/farmplatform

5 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.

Data used	Main title of User Guide PDF document	DOI
All datasets	NWFP_UG_Design_Develop.pdf	https://doi.org/10.23637/rothamsted.98y1x
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	Awaiting

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

"The North Wyke Farm Platform is a UK National Capability supported by the Biotechnology and Biological Sciences Research Council (BBS/E/RH/23NB0008)."

"We acknowledge the interests of the Ecological Continuity Trust (ECT), whose national network of LTEs includes the experiment on which this research was conducted."

6 Appendices

Appendix A. Details of herbage and silage analysis

Determinand	Unit	Method	Calculations
Crude Protein (CP)	%	Dried & finely ground samples weighed into tin capsules. Total N analysed using a Carlo Erba NA 2000 elemental analyser linked with a Sercon 20:22 isotope ratio mass spectrometer. Wheat flour, IA R001 (Iso-Analytical, Crewe, UK) used as reference standard; another wheat flour, calibrated by Iso-Analytical used as a quality control standard.	% CP% = % Total N * 6.25
Water Soluble Carbohydrate (WSC)	%	20mls ultra-pure water at 90ºC added to sample (0.2g). Heated in hot block at 90ºC for 15 minutes, cooled in a cold bath, shaken for 15 minutes at ambient temperature, & filtered (Whatman No. 1). Samples filtered through a 0.2µm syringe filter into a HPLC vial or frozen if not analysed within 24 hours. Sample analysed on an Agilent 1260 Infinity II HPLC (Agilent Technologies LDA UK Limited, Stockport, UK) with evaporative light scattering detector (ELSD). Settings: evaporator = 90°C, nebuliser= 50°C, flowrate= 1.1 standard litre per minute (SLM) **Grass analysis:** Agilent Hi-PLEX H column 300 x 7.7mm, H2O eluent, 0.6ml/min 40°C. ELSD. Standard mix: Fructan (inulin), sucrose, glucose & fructose **Silage Analysis:** Analysis 1 - Agilent Hi-PLEX H column 300 x 7.7mm, H2O eluent, 0.6ml/min 40°C ELSD for fructan, sucrose & glucose. Analysis 2 - Agilent Hi-PLEX Ca (duo) column 300 x 6.5mm, H2O eluent, 0.6ml/min 80°C ELSD for fructose & mannitol. Standard mix; fructan (inulin), sucrose, glucose, fructose & mannitol.	
Neutral Detergent Fibre (NDF)	% dry organic matter	Samples freeze dried, ground (2mm), & stored in a freezer until analysis. NDF of samples (0.45 to 0.5g in F58 filter bags) determined by an automated extraction system (Ankom 2000, Ankom Technologies, Macedon, NY, USA) in using a neutral detergent solution (NDS) at boiling temperatures combined with a heat-stable alpha amylase to dissolve the most digestible cell components, sodium sulphite for removal of some nitrogenous matter. NDS, sodium sulphite, & sodium lauryl sulphate used to solubilize nitrogenous matter. EDTA used to chelate calcium & enhance the removal of pectins at boiling temperatures. Disodium phosphate & sodium borate used as buffers to maintain a neutral pH. Heat-stable amylase used to hydrolyse starch to saccharides. Samples rinsed with acetone before & after the extraction process, dried & weighed.	*% NDF = (100 x (W3-W1 - BK)) / (W2 x (OM/100))* Where: W1 = bag weight (g) W2 = sample weight (g) W3 = dried weight (g) of bag with fibre after NDF extraction BK = blank bag correction [difference between the bag weight (g) after fibre analysis & oven-dried process & the original bag weight (g)] OM = organic matter content (%)
Modified Acid Detergent fibre (MADF)	% dry organic matter	Samples freeze dried, ground (2mm), & stored in a freezer until analysis.	*% MADF = (100 x (W3-W1 - BK)) / (W2 x (OM/100))* Where:

		MADF, ADF & ADL of samples (0.45 to 0.5g in F57 filter bags) determined sequentially by an automated extraction system (Ankom 2000, Ankom Technologies, Macedon, NY, USA.) Acid detergent solution (ADS: 20g cetyl trimethylammonium bromide in 1L 0.5M sulphuric acid) used for MADF & ADF determination, (where the ADS for MADF determination is 50% ADS & 50% 0.5M sulphuric acid) to dissolve the acid-labile carbohydrates, proteins that are not complexed in Maillard products (heat-damaged) & fats, leaving a fibrous residue that is primarily cellulose & lignin (plant products) or insoluble protein complexes (animal products & heat damaged feeds). ADL is determined after MADF & ADF extractions by soaking the sample & filter bags in 72% sulphuric acid for 3 hours then rinsing with boiling water. Samples rinsed with acetone, dried & weighed after each extraction step.	W1 = bag weight (g) W2 = sample weight (g) W3 = post MADF extraction sample weight (g) BK = blank bag correction [difference between post MADF extraction bag weight (g) & the initial bag weight (g)] OM: organic matter content (%)
Acid Detergent Fibre (ADF)	% dry organic matter		*%ADF = (100 x (W4-W1 - BK)) / (W2 x (OM/100))* Where: W1 = bag weight (g) W2 = sample weight (g) W4 = post ADF extraction sample weight (g) BK = blank bag correction [difference between post ADF extraction bag weight (g) & the initial bag weight (g)] OM = organic matter content (%)
Acid Detergent Lignin (ADL)	% dry organic matter		%ADL = (100 x (W5-W1 - BK)) / (W2 x (OM/100)) Where: W1 = bag weight (g) W2 = sample weight (g) W5 = post ADF extraction sample weight (g) BK = blank bag correction [difference between post ADL extraction bag weight (g) & the initial bag weight (g)] OM = organic matter content (%)
Ash	%	Organic matter determined by ashing dry samples (dried at 105ºC for 12 to 16 hours) in a muffle furnace (500ºC for 16 ± 4 hours after 2 hours at 300ºC).	*%OM = ((B - C) x 100) / (B-A)* Where: A = Initial weight of dish (g) B = Weight of dish plus 105ºC dried plant (g) C = Weight of dish plus 500-550ºC ashed plant (g)
Metabolisable energy (ME)	MJ Kg^{-1} dry matter	Determined from MADF.	*Fresh grass: (MJ kg-1 DM) = 16.2 - 0.0185 x [MADF]* [2] *Grass silage: (MJ kg-1 DM) = 15.0 - 0.0140 x [MADF]* [3]

[2] Givens, D. I. , Everington, J. M. & Adamson, A. H. 1990. The nutritive value of Spring grown herbage produced on farms throughout England and Wales over 4 years. III. The prediction of energy values from the various laboratory measurements. Anim. Feed Sci. Technol., 27, 185 – 196.
[3] Everington, J. M. & Adamson, A. H. 1989. The digestibility and ME content of grass silage and their prediction from laboratory measurements. Anim. Feed Sci. Technol., 24, 27 - 43.