An Analysis of Woodmeadow Soils 2016 - 2018[1]

Past status of the site soils and initial woodmeadow creation

Prior to 2012, the 10-hectare site had been in continuous agricultural use. The last crop was barley and the rotation was generally spring barley / winter barley / beans, the fertility of the field being too poor for wheat. The field may have contained sugar beet many years ago. The soil was high in potash and magnesium, and low in phosphorus and it was 'limed' at some point. It would have had 120 units of Nitrogen applied each year (Nick Leaf, pers. comm).

The underlying solid geology consists of the Sherwood Sandstone Group comprising red, brown and yellow occasionally pebbly sandstone interbedded with mudstone and siltstone, deposited during the Period of Earth's history known as the Triassic. pH 7.4, P index 3 (27 ppm).

A block of about 3 hectares at the southern end of the site had the topsoil removed for use in the Hollicarrs Holiday Park 5 years previously. This area is more diverse floristically (possibly due to reduced fertility) and was planted in 2012. The rest of the site was planted in 2013. After the last barley harvest (2012) the land was ploughed and a 'stale seedbed' approach employed: weed species were allowed to germinate then spayed with glyphosate. In May 2013, a shallow rolling-in of seed directly into the site was carried out to minimise soil disturbance using seed mixes based on MG4 (wet grassland) and MG5 (dry grassland) species composition along with a nurse crop of cornfield annuals at sufficiently high density to prevent ingress of undesirable weed species[2]. Pits had been dug throughout the area prior to sowing to assess soil moisture conditions and the southern end, from which topsoil had been removed (see above) was frequently inundated in winter. Selection of areas for MG4 and MG5 mixtures was based on this survey.

Soil nutrient management consists of regular biomass removal. The first hay cut was in late July 2013 (89 bales weighing 400kg) and a second crop was taken that October. By December 2013, 10,000 saplings had been planted into the now-meadow comprising 29 species of native broadleaf trees and shrubs (40% by volunteers) in a lazy-S pattern (marked out with a white line marker) to facilitate grass cutting and reserving 40% of open space as meadow (Figure 4). Trees were planted in rows 2.5 m apart with trees spaced between 1.5 – 5 m within the rows.

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[1] This report was written by Dave Raffaelli in May 2020, with input from Ros Forbes Adam and Kelly Redeker. All the data were collected by University of York Biology Department masters students and some has been re-analysed and re-presented by Dave Raffaelli. Anyone requiring access to those data should contact the report author.

[2] Hawthorn, L. (2015a). The creation of a wood-meadow ecosystem. *Woodland Heritage* 2015: 88-90; Hawthorn, L. (2015b). Three Hagges Wood-Meadow: a model for the potential of wood-meadows for sustaining biodiversity. *Conservation Land Management Winter* 2015: 9-13

The soil sampling campaigns

No formal soil survey was carried out prior to planting the woodmeadow. The data presented here therefore approximate the 'baseline' for site. The first detailed survey and all subsequent surveys, have been made by a University of York Biology students under the supervision of Dr Kelly Redeker to whom the Trust awarded a grant. The material provided to the Trust includes Powerpoint presentations, rough drafts of dissertations, outline methodologies and approaches and various maps showing sampling points on which this report is based. The original material and other intellectual property are not included here.

The Biology student material contains data and information on the following:

Sampled/analysed	**File/Folder**						**Comments**
August 2015	Sam Witham	Trace gases					
October 2016	Yousef Samari	Trace gases	%C,N	Soil nutrients	Soil physical		
Spring 2017	MBiol group	Trace gases					
August 2017	Hannah Botterill				Soil physical		Same as below
2017	Teodora Manea				Soil physical		Same as above?
November 2017	MBiol group		%C,N	Soil nutrients	Soil physical	Trace metals	
January/February 2018	MBiol group		%C,N				

Inspection of the data reveals two distinct time periods for soil nutrients and physical properties: the material dated autumn 2016 and the winter period 2017/18 (trace gas data from cores from the site and included in the student's write-ups do not form part of this report). Both time periods are from the woodmeadow itself (mown and unmown areas[3] are distinguished), Nick's Field (an adjacent area immediately south of the woodmeadow and cut for hay) and "Agricultural Field", an area in conventional agricultural use to the west of the old York Road. The 2017/18 data distinguish between MG4 ('wet') meadow) and the MG5 ('dry') meadow plantings, but the 2016 data do not.

There are also differences between the autumn 2016 and winter 2017/18 sampling campaigns with respect to the section of the core analysed for bulk density, water retention and carbon. The data from 2016 are for 5-10cm and 10-15cm sections, but the 2017 data are for middle 3cm section from a 30cm deep core (13.5-16.5 cm). Because soil properties change with depth, only the 2016 10-15cm data are analysed, to allow better comparisons with the 2017 data. However, detailed comparisons between the 2016 and 2017 should be

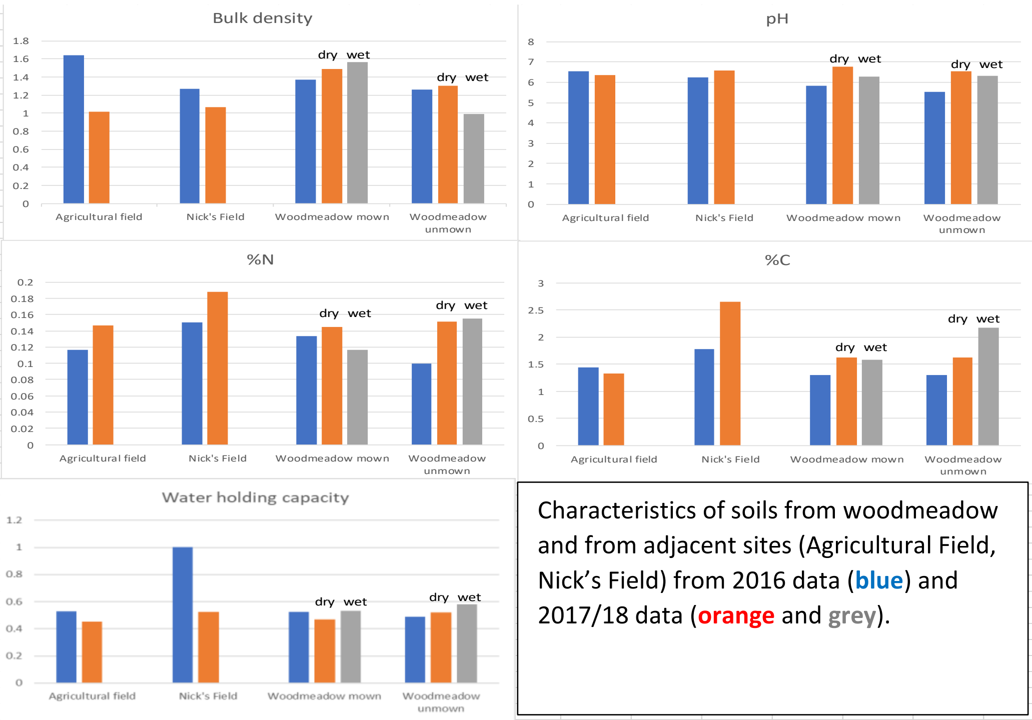
[3] Most of the student reports reports distinguish between' mown' and 'unmown' areas. Mown = open ground mown for hay; unmown = in the copses, which are usually brushcut/flailed, rather than cut and collected.

made with caution given the different investigators and protocols as well as the time of year the samples were collected.

All the graphs and analyses presented here are made from the raw, unprocessed data from individual sample replicates from the Excel files provided to the author. Standard errors were calculated for each of the means shown in the graphs, but these were generally too small to allow presentation.

Results and discussion

Bulk density reflects the degree to which the soil is compacted, which in turn affects other soil properties, including water retention and the ability of plants to put down roots. The use of heavy machinery will increase soil bulk density, whilst tillage will reduce it, explaining the large differences seen for the agricultural field between 2016 and 2017/18 and perhaps the lower bulk density for the unmown areas compared to mown areas in 2017/18 (found to be just statistically significant by the 2017/18 students, p=.02). It should be noted that a bulk density of 1.6 g/cm^3 has been identified in some literature as a threshold above which there are adverse effects on plant growth[4]. The 'wet' mown meadow approaches that value, but it is likely that bulk density will reduce over time, especially in the upper layers due to plant root movement and soil fauna activity. Intriguingly, a more recent analysis by the University of York team initially suggests that in the unmown sections the bulk density for some areas was low, so that rehabilitation may be proceeding more rapidly (Kelly Redeker, pers. comm.).



Characteristics of soils from woodmeadow and from adjacent sites (Agricultural Field, Nick's Field) from 2016 data (**blue**) and 2017/18 data (**orange** and **grey**).

[4] Amacher, M. C., O'Neill, K. P. and Perry, C. H. (2007) Soil Vital Signs : A New Soil Quality Index (SQI) for Assessing Forest Soil Health, USDA Forest Research, 3(May), p. 12. Available at: http://www.fs.fed.us/rm/pubs/rmrs_rp065.pdf)

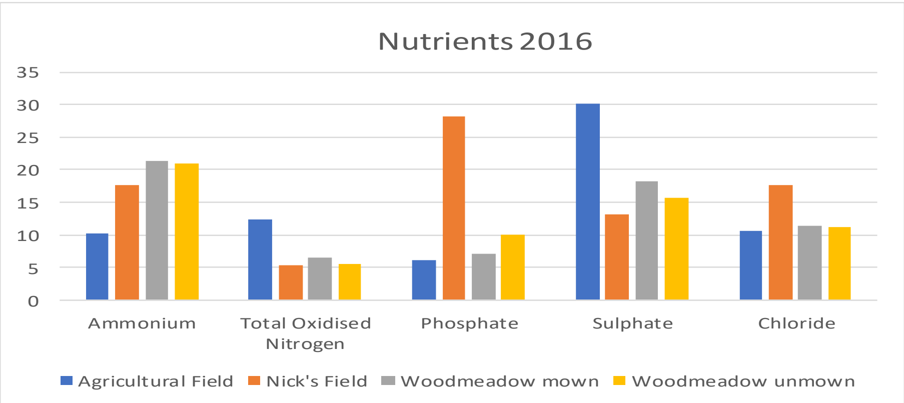
Water holding capacity was much higher for Nick's Field in 2016 compared to other sites and periods. This anomalous finding is hard to explain, but all replicates had similarly high values. Of more interest is the consistent difference between 'dry' and 'wet' parts of the woodmeadow, irrespective of mowing regime; 'wet' areas seem to retain more moisture than 'dry' areas. Again, this difference was found to be marginally statistically significant by the 2017/18 students.

Soils had a slightly acid **pH**, with 'wet' areas having a slightly lower pH than 'dry' areas, although this was not statistically significant and within the range for typical MG4/MG5 mesotrophic British grassland[5]. Other studies have found little response of pH following arable field restoration after many years[6].

For both **nitrogen** and **carbon**, the differences between periods and different areas are large and difficult to interpret: Nick's Field had the highest %carbon and %nitrogen, and unmown 'wet' had a higher %carbon and %nitrogen than mown 'wet'. It should be noted that many soil properties are interrelated and these differences in %nitrogen and %carbon may simply reflect differences in bulk density and soil moisture. Nevertheless, it is clear that %carbon of the woodmeadow soils is generally in the range 1-1.5%, 'wet' unmown areas slightly higher.

In 2016, samples were analysed for a range of soil **nutrients** (but not in 2017/18), whilst in 2017/18 samples were analysed for **trace metals**.

For **nutrients**, Ammonium and Chloride show little variation between areas. As expected, total oxidised nitrogen (TON), mostly nitrate, was higher in the Agricultural Field, as was sulphate. Phosphate ranged between 7ug/g and 10ug/g for the woodmeadow, but was much higher for Nick's Field (28 ug/g). The values for woodmeadow are not dissimilar to those found in MG4 (5-15) meadows[7].



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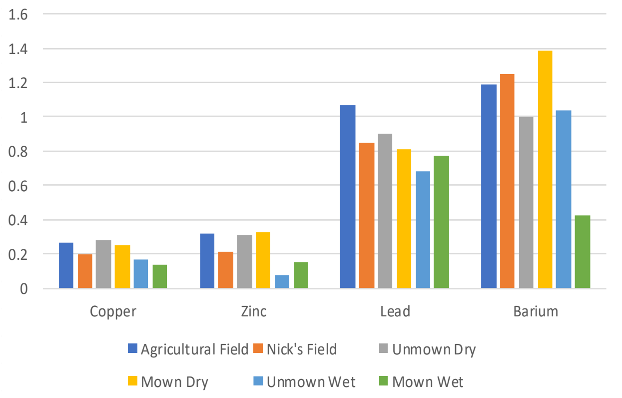
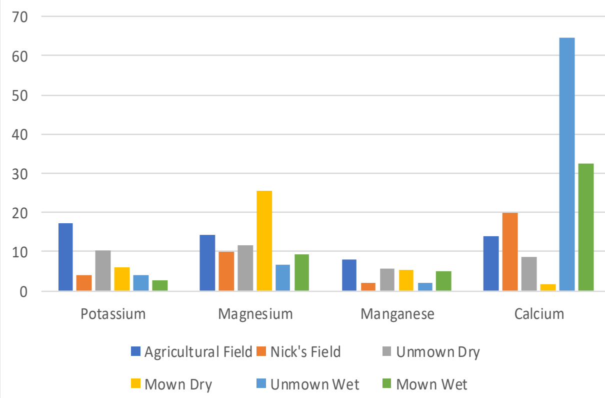
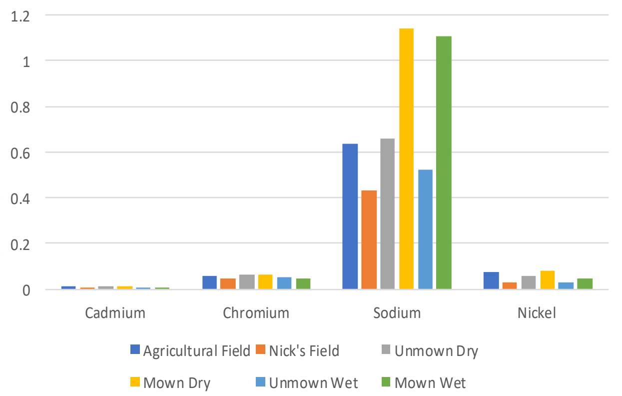
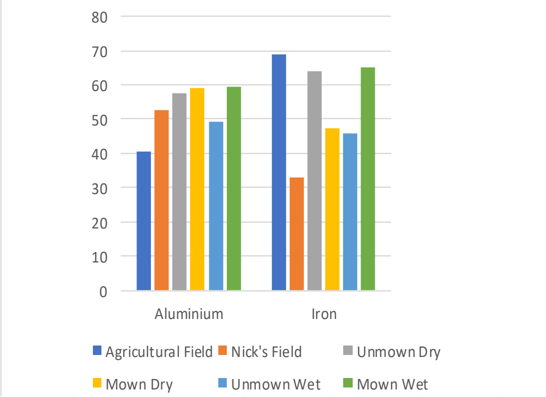
[5] Critchley, C. N. R. et al. (2002) Association between lowland grassland plant communities and soil properties, *Biological Conservation*, 105, pp. 199–215.
[6] Falkengren-Grerup, U., Brink, D.-J. ten and Brunet, J. (2006) Land use effects on soil N, P, C and pH persist over 40–80 years of forest growth on agricultural soils, *Forest Ecology and Management*, 225), pp. 74–81.
[7]www.floodplainmeadows.org/

The 2017/18 **trace metal** data (all ppm) reveal great variation between woodmeadow areas, with no clear, easily interpretable pattern.









Conclusions

The 2016 and 2017/18 data sets were reported by a range of investigators in different seasons and it would be unwise to make detailed comparisons between the two campaigns. Instead, and in the absence of a pre-intervention baseline for soils data, it is recommended that these data be seen as a baseline range against which future soil surveys can be compared.

Nevertheless, there are suggestions of recovery of soil compaction in the unmown areas and possibly of a reduction in soil phosphorus since the original meadow creation, as the values recorded are towards the lower parts of the range for such meadows.