*Stapledon Memorial Trust Report*

# A GIS assessment, using grid-based sampling, of pasture species and their relationships with soil physical, chemical and management factors on the North Wyke Farm Platform.

***Visit to Rothamsted Research, North Wyke 17 July – 9 August 2013***

***Hosted by Robert Orr, robert.orr@rothamsted.ac.uk***

***Rothamsted Research, North Wyke; Okehampton; Devon***

***EX20 2S B; UK***


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***Stapledon Memorial Trust and the Trimble Foundation***



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# Part A –Summary

## Purpose of travel

Identify the key reasons why travel was undertaken, e.g. carrying out specific research, updating certain technical skills, maintaining or extending international contacts, presenting particular information at conference.

- The aim of my visit to Rothamsted Research (North Wyke, Devon) was to work with scientists to complete baseline botanical composition assessments of the pastures in the Farm Platform project and to gain an understanding of how the botanical composition was related to soil factors. The Farm Platform Project is a large scale farmlet study which is comparing sward improvement through: 1) increased intensification of existing pastures through sustainable fertiliser application, 2) increased use of legumes through pasture renewal, or 3) reseeding with novel perennial grass germplasm. The Farm Platform is addressing issues facing future sustainability of pastoral agriculture in UK, many of which are relevant to New Zealand. Issues include: (i) replacement of N fertiliser with N-fixation by legumes to achieve a reduction in energy and GHG emissions; (ii) using plants to manage soils and hydrology; (iii) efficient phosphorus cycling in grassland systems; (iv) resilience of soil biota and their functions to land-use change; (v) C sequestration; (vi) water resource use efficiency and (vii) systems modelling to design optimal grassland production systems.
- A visit was made to Moorepark Research Institute in Ireland and meetings with scientists held on dairy pasture persistence and productivity. Much of their research is directly relevant to New Zealand.
- A meeting was held with Phil Grime, from Sheffield University, to observe and discuss results from his long-term grassland climate change experiment and relate findings to current research in New Zealand.
- Funding for this work was provided by the Stapledon Memorial Trust and the Trimble Foundation.

## Key outcomes

Briefly identify key outcomes in terms of main findings/impressions/observations/recommended actions.

- New research approaches and methods were learnt during the time spent on the North Wyke Farm Platform. In particular, a method to assess botanical composition in pastures and an approach to assessing long-term changes in pasture botanical composition and other factors, using a GIS grid-based sampling. Baseline data were collected and initial analyses of these baseline data have been completed. These will provide a valuable resource for future years when determining how the different systems influence botanical composition on the Farm Platform. Results will contribute towards scientific knowledge on soil physical and chemical factors which are critical for ryegrass persistence. Future collaboration on this work is envisaged.
- Discussions with scientists at Moorepark and with Phil Grime were useful for better understanding the impact of multiple stresses on perennial ryegrass growth and issues relating to the productivity and persistence of perennial ryegrass-based dairy pastures. These issues are currently under investigation in New Zealand.

## Itinerary

Please see the table below.

## Conferences attended and companies or institutes visited

| Date(s) visited | Conference / Company / Institute | Location (Town/City, State, Country) | Key contacts | Topics covered |
|---|---|---|---|---|
| 17 July – 15 August | Based at North Wyke, Rothamsted Research, UK | Near Okehampton, Devon | Robert Orr | Farm Systems, pasture ecology |
| 30 -31 July | Moorepark Research Institute, Ireland | Fermoy, County Cork, Ireland | Mary McEvoy | Perennial ryegrass-based pasture persistence and production |
| 16 August | Sheffield University | Buxton Climate Change Laboratory, Sheffield, UK | Phil Grime | Impacts of stress / competition on grassland species productivity |

## Summary of budget

| Source of cost | Budgeted | Actual | % variance |
|---|---|---|---|
| Air travel (international) | 3000 | 2920 | <10% |
| Travel within UK & Ireland, including hire car, fuel, plane flight from Bristol to Irelant return | 2400 | 2168 | <10% |
| Accommodation & meals (bed and breakfast + other meals) | 2300 | 2384 | <10% |
| Accommodation (8 nights) including 8 dinners, 8 breakfasts + 8 lunches | 1000 | 1080 | <10% |
| Other (stationary, gifts in lieu, phone, postage) | 300 | 309 | <10% |
| Total costs | 9000 | 8861 | <10% |

*£2000 was provided by the Stapledon Memorial Trust, which covered the costs of international travel, and accommodation, internal travel and meals in part. The Trimble Foundation provided for the remaining costs.

# Part B – Detailed Report

## Success of travel

| Assess the success of the travel in terms of purposes and objectives, by considering whether these were met and what, if any, modifications to these became necessary. |
|---|
| All objectives were met. The visit to Moorepark Research Institute, Ireland, had been discussed with the Trimble Foundation but was not confirmed at the time of submitting this application. However, the weather was favourable at North Wyke; this facilitated field work so that that the project was completed in a timely manner and enabled me to visit Moorepark Research Institute. |

## Commentary

| Describe outcomes of the travel, including identification of any significant and enduring contacts that were established, information obtained, research methods used, facilities available, suggestions for future liaisons, main findings and impressions or observations. |
|---|

***Overview of the Farm Platform***

The Farm Platform is designed to promote new ideas and tackle old problems in new ways. It comprises three farming systems consisting of five component fields of approximately 20 ha per farmlet. The three systems are based on: 1) increasing fertiliser application on existing pastures, 2) increasing use of legumes, or 3) reseeding with modern perennial grasses. Since establishment in 2011, within each farmlet, fields have been grazed predominantly by either 30 yearling beef cattle, or by ewes or lambs (50 ewes and twin lambs). Some fields within each farmlet are used for silage cuts.

Within the Farm Platform, all the water leaving individual fields is channelled through a flume (15 in total). Each of these farmlets is managed differently and the impact on the water, air, soil, pasture and livestock recorded to determine which farmlet provides the most productive and sustainable system. Parameters monitored include:

- Water chemistry: nitrate, ammonium, phosphate, dissolved organic carbon, turbidity, water flow, temperature, conductivity, pH, dissolved oxygen, chloride
- Soil characteristics: soil moisture, temperature, pH, bulk density, soil biology, decomposition, Soil C, P and N, plant diversity
- Atmospheric parameters: rainfall, temperature, $CO_2$ and $N_2O$
- Farm management variables: live-weight gain, field inputs and outputs, farm activity, labour hours machine hours.

***The applicant's contribution***

While assessments have been undertaken for many variables since the establishment of the farm platform, botanical composition data to provide a baseline for future monitoring was lacking. Knowledge of the botanical composition and how it changes over time is fundamental for understanding the contribution of the different species to system productivity. It was necessary to obtain these data before pastures were renewed and novel legume and ryegrass germplasm introduced in autumn (September, October) 2013.

Botanical assessments were made using a 25 m GIS-sampling grid and GPS to locate the sampling points. The 25 m sampling grid has been created by Bruce Griffith and Robert Orr from North Wyke using GIS, based on the British ordnance survey national grid (OSGB36). Co-ordinates were obtained for each of the gridline intersections which could then be located using GPS. The GPS unit is a Real Time Kinematic (RTK) system comprising a trimble R8 *base* and a trimble R6 *rover*. The base (fixed on a known position) and the rover, (which is used out in the field) both observe satellite signals. The

base re-broadcasts these signals (via UHF radio) and these signals are used to correct the rover estimates of the sampling location so that it can find the position of the intersections to within a few millimetres. This enables accurate data to be collected over the duration of the Farm Platform programme and is an extremely valuable tool that can be used monitor changes in different parameters over time.

The botanical composition was assessed in 0.25 $m^2$ quadrats at each of the 293 sampling locations and species 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:

Table 1. Domin Scale used to classify grassland vegetation. These are converted to a linear scale using the Bannister conversation (Journal of Ecology, 1996).

| *Cover* | *Domin Score* | *Bannister value* |
|---|---|---|
| 91–100% | 10 | 195 |
| 76–90% | 9 | 172 |
| 51–75% | 8 | 137 |
| 34–50% | 7 | 108 |
| 26–33% | 6 | 91 |
| 11–25% | 5 | 70 |
| 4–10% | 4 | 60 |
| <4% (many individuals) | 3 | 22 |
| <4% (several individuals) | 2 | 10 |
| <4% (few individuals) | 1 | 5 |

The Handbook explains that "Even when vegetation does not appeared 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."

With experienced observers, a high degree of consistency can be obtained. The Domin method is widely used in the UK. Ensuring that one operator does all the observations at one site, increases consistency of the assessments. One disadvantage of this method is that the results are not linear; therefore statistical analyses are limited to non-parametric tests, which are less powerful. However, conversion of the values to a linear scale using a Bannister transformation can be undertaken (Journal of Ecology 1996). The Domin method is not used widely in New Zealand pasture research. It would be a valuable tool that we could use to monitor changes in botanical composition over time, when the dry matter contribution of each vegetation component is not required. It is also easily repeated. Estimating classes, rather than estimating exact percentages, will reduce the variation in estimates made by different operators.

The dominant species in all pastures were *Lolium perenne* (perennial ryegrass) and *Agrostis stolonifera* (creeping bent grass, Table 2). Other species present in at least 50% of the quadrats included *Holcus lanatus* (Yorkshire fog grass), *Alopecurus geniculatus* (meadow foxtail), *Ranunculus repens* (creeping buttercup), *Rumex obtusifolius* (broadleaved dock) and *Taraxacum officinale* (dandelion). Analyses showed that there was significantly less meadow foxtail under ewe than cattle grazing but that there were no significant differences between grazing management in the other species present.

A regression analyses was also undertaken to determine if there were significant linear relationships between:

Perennial ryegrass and soil bulk density, pH, There was also no significant relationship between the presence of ryegrass or any other species and bulk density, pH, total N in vegetation (expressed as a percentage of total DM), total C in vegetation (expressed as a percentage of total DM), N in the soil and the percentage of organic matter in the soil. The same analysis was undertaken for creeping bent grass – the most dominant unsown grass.

The only significant effect was for the positive regression between perennial ryegrass and soil N ($P<0.01$), no other significant effects were detected.

A subsequent assessment will be made in several years and results compared against this baseline data to investigate the impact of the three systems on botanical composition and how this relates to soil factors.

Table 2. Dominance in the sward of a range of species under cattle grazing, cutting for silage, ewe grazing or lamb grazing. Data were obtained using the Domin scale and converted to a linear scale using the Banister conversion (Journal of Ecology 1996). Data are based on 293 sampling locations and only include species or categories that were present in 50% or more of the quadrats. Banister scale data are reported. This scale has no units.

| Species | Cattle | Cut | Ewes | Lambs | LSD | P value |
|---|---|---|---|---|---|---|
| *Lolium perenne* | 122 | 161 | 175 | 160 | 44.4 | 0.108 |
| *Agrostis stoloniferous* | 121 | 85 | 54 | 74 | 50.5 | 0.064 |
| *Holcus lanatus* | 12 | 10 | 14 | 3 | 16.2 | 0.693 |
| *Alopecurus geniculatus* | 10 | 2 | <1 | 4 | 8.5 | 0.025 |
| *Ranunculus repens* | 3 | 1 | 1 | 1 | 6.0 | 0.789 |
| *Rumex obtusifolius* | 1 | 2 | <1 | <1 | 5.9 | 0.896 |
| *Taraxacum officinale* | <1 | 1 | 1 | 2 | 2.5 | 0.680 |
| Bare | 6 | 5 | 3 | <1 | 11.9 | 0.663 |
| Dung | 5 | 8 | 14 | 18 | 13.0 | 0.264 |

***Other activities while in the UK and Ireland***

A day was spent meeting 5 scientists at Moorepark Research Institute in Killarney, Ireland and a presentation given on New Zealand dairy pasture persistence research. Moorepark is the centre of government-funded dairy research in Ireland. Their goals are to: increase production efficiency; increase the value of milk; meet environmental, animal welfare and food quality targets; and improve labour efficiency. These goals are similar to those of the New Zealand dairy industry. Scientists whom I met included: Michael O'Donovan (overview of persistency work and issues in Ireland); Deirdre Hennessy (improving clover content of swards in relation to N application); Vincent Griffith (impact of ploidy on perennial ryegrass persistence); Mary McEvoy (persistence of a range of perennial ryegrass cultivars and morphological characteristics associated with their persistence); Patrick Cashman (involved in the perennial ryegrass persistence work with Mary McEvoy). Key discussion points are highlighted below:

- Moorepark has a strong link with the farming industry. There are 18,000 dairy farmers in Ireland. Recently, thousands of farmers attended an industry field day at Moorepark Research Institute. This demonstrates the impact that research can have on the farming community and provides an example for us in New Zealand of how well attended industry field days can be.

The dairy industry is extremely important for the Irish economy; it exports 90% of its milk and meat, and produces 25% of world infant milk formulae.

- One of the biggest pasture issues facing farmers in Ireland is the lack of consistency of dry matter production and knowing at what point it is worth reseeding. In Ireland, loss of pasture plants is not an issue, but rather a loss of the yielding ability of the sown plants. The relative importance of the loss of yielding ability versus plant mortality is also being researched in New Zealand.
- There is a large focus on increasing the amount of grass grown and the proportion of grazed grass in the dairy cow diet, which is similar to our focus in New Zealand on increasing forage production and utilisation of home grown feed.
- At Moorepark, a range of New Zealand cultivars have been sown and monitored and it was found that the New Zealand varieties were less dense, generally had much lower ground cover scores and were less able to withstand wear than Irish cultivars. Generally, ground cover scores had declined in most perennial ryegrass over the last 40 years, which may be linked to a reduction in perennial ryegrass persistence. This raises the question of whether achieving dry matter targets in plant breeding has led to a reduction in persistence.
- In Ireland, farmers have faced difficulties in managing clover. Traditionally, clover would dominate swards in autumn, and reduce grass growth in the following spring. Farmers were concerned about the impact of this on production. Recent work shows that if fine-leaved cultivars are selected, clover will be more evenly distributed throughout the sward in spring, which does not impede grass growth. Rather, adding clover increased the forage production, which could be harvested to provide additional forage for the following winter. High amounts of N could still be added without huge detriment to the clover, depending on the soil N status. This work is of huge relevance to New Zealand, where clover is often overlooked.
- Pasture Base is an online support tool, through which farmers can enter paddock production and management data (cultivars sown, soil nutrients, pasture DM production, stocking policies etc.). It helps the farmers to plan rotations and prepare feed budgets and is widely used throughout Ireland. It is also being used in a national cultivar evaluation scheme.
- Comparisons are being made between tetraploids, diploids and high sugar ryegrasses. High sugar varieties were actually least grazed by the cattle while tetraploid varieties had less pseudostem and were grazed more. As in New Zealand, there is great interest in the relative performance and persistence of the different ryegrass functional types, and discussions on the relevant merits of tetraploids and diploids were most useful to help understand results from current research projects in New Zealand.
- A surprising fact was the extremely high sowing rates used in Ireland, up to 40 kg/ha seed/ha, which is almost double that used in New Zealand. This deserves further investigation – why such a high sowing rate given the increased probability of density-dependent mortality at these high rates?
- An Irish persistence study is very similar to one being done in New Zealand. A key difference is that the Irish spaced plant experiment was not fertilised or grazed to allow full expression of morphological characteristics based on their genetic potential. The aim was to detect if there were a genetic drift in seedlines that has been sown previously and gone through ten cycles of conservation for silage management or for grazing. Analyses of results are underway.
- Finally, results from a study comparing grazing to mowing of plots raises concerns. In the first year there was no correlation between cutting and grazing in how the ryegrass cultivars ranked with respect to their DM production. In the second and third years there was a correlation of 0.5, which is relatively low. This highlights how important it is to test ryegrasses under grazed conditions if we want to know how they perform on dairy farms.
- There was opportunity to visit Phil Grime, at the Buxton Climate Change Laboratory, through assistance of the Stapledon Fellowship, to discuss his long-term experiments. This discussion with Phil Grime demonstrated to me how important it is for scientists working in agriculture to maintain links with ecologists in extensively managed grasslands. Underlying ecological

principles can be applied in either intensive or low input biodiverse systems, and help to explain some of the phenomena we are seeing in grazed pastures.

- Of particular interest was relating some of Phil's long-term experimental results to current research on the impact of multiple stresses on perennial ryegrass growth and persistence. Key factors in the study include ploidy (tetraploid vs. diploid varieties), drought (with vs without), insect pest pressure (with vs without) and defoliation intensity (2.5 cm vs 6 cm). Firstly, Phil suggested that tetraploid plants have greater genome size and greater water use earlier in their life-cycle – possibly due to greater leaf expansion earlier of young plants. This may increase the extent to which they are susceptible to drought stress. Secondly, with respect to insect and drought stress, to maintain root growth, a big reduction in shoot growth is likely. The reduction in shoot growth was particularly evident under drought in the New Zealand study. Phil's discussion on the humpback model with respect to the relationship between productivity and diversity were also enlightening. At high levels of fertility, a response to increased pasture diversity is unlikely, which was useful in explaining observations of field surveys of beef, sheep and dairy pastures in five regions in the North and South Islands of New Zealand.

## Benefits

State the benefits arising from the visits undertaken. Where possible, estimate the financial/time gains/savings.

- North Wyke: The approach in using of GIS and GPS to enable repeated sampling at the same location was novel and is an approach that can be applied in New Zealand.
- The Domin method, often used in Europe and UK has the potential to be used in a New Zealand context.
- Moorepark: Information exchange regarding dairy pasture production and persistence issues was informative and has given scientists at Moorepark and myself new ideas for future research.
- Interactions with Phil Grime demonstrated how important it is for scientists working in agriculture to maintain links with ecologists of biodiverse low input ecosystems. The underlying principles can be applied in either system and help to explain some of the phenomena we are seeing in grazed pastures.
- Discussions with Phil Grime cast light on interpretation of current persistence-related research projects where we have been struggling to understand mechanisms leading to the results we observed.

## Acknowledgements

This work was made possible by the generous support of the Trimble Foundation and Stapledon Memorial Trust to whom I am extremely grateful. The Stapledon Memorial Trust provided funding for international travel and subsistence costs which enabled the GIS assessment, using grid-based sampling, of pasture species and their relationships with soil physical, chemical and management factors on the North Wyke Farm Platform. In addition, the Stapledon Memorial Trust enabled the visit to the Buxton Climate Change Laboratory, Sheffield, for discussions with Phil Grime.

The Trimble Foundation also provided funding for subsistence costs for the GIS assessment while at North Wyke Research and enabled the visit to Moorepark Research Institute.

Thanks also to the staff at North Wyke Research for hosting me and assisting in the research.