NUFFIELD
Farming Scholarships

Sustainable Forage Cropping for Dairy Cattle in the Face of Climate Change Challenges

Written by:

Ian Baggs NSch

November 2025

A NUFFIELD FARMING SCHOLARSHIPS REPORT

KINDLY SPONSORED BY:

The Trehane Trust

NUFFIELD FARMING SCHOLARSHIPS TRUST (UK)

Awarding life changing Scholarships that unlock individual potential and broaden horizons through study and travel overseas, with a view to developing farming and agricultural industries.

"Leading positive change in agriculture"

"Nuffield Farming" study awards give a unique opportunity to stand back from your day-to-day occupation and to research a subject of interest to you. Academic qualifications are not essential, but you will need to persuade the Selection Committee that you have the qualities to make the best use of an opportunity that is given to only a few – approximately 20 each year.

Scholarships are open to those who work in farming, food, horticulture, rural and associated industries or are in a position to influence these industries. You must be a resident in the UK. Applicants must be aged between 25 and 45 years (the upper age limit is 45 on 31st July in the year of application).

There is no requirement for academic qualifications, but applicants will already be well established in their career and demonstrate a passion for the industry they work in and be three years post tertiary education. Scholarships are not awarded to anyone in full-time education or to further research projects.

Full details of the Nuffield Farming Scholarships can be seen on the Trust's website: www.nuffieldscholar.org. Application forms can be downloaded and only online submission is accepted.

Closing date for completed applications is the 31st July each year.

ISBN: 978-1-916850-65-1

Published by The Nuffield Farming Scholarships Trust
Bullbrook, West Charlton, Charlton Mackrell, Somerset, TA11 7AL
Email: office@nuffieldscholar.org
www.nuffieldscholar.org

A NUFFIELD FARMING SCHOLARSHIPS REPORT (UK)

NUFFIELD Farming Scholarships

"Leading positive change in agriculture. Inspiring passion and potential in people."

Date of report: February 2025

Title	Sustainable Forage Cropping for Dairy Cattle in the Face of Climate Change Challenges
Scholar	Ian Baggs
Sponsor	The Trehane Trust
Objectives of Study Tour	To identify crops, methods of establishment and harvest, and dairy farming systems that will enable UK farmers to have sustainable and resilient businesses in the future, in spite of changing weather patterns.
Countries Visited	UK; France; Australia; New Zealand
Messages	- For profit, choose the system that best suits your farm; then breed the right cow for the system. - Get your stocking rate correct. - Include diverse herbs and legumes in your grazing and silage leys. - Make some space for nature on your farm, for example by planting trees and hedges, which also bring benefits to livestock.

EXECUTIVE SUMMARY

Forage production (whether grazed or conserved) is an essential cornerstone of any dairy business. Climate change is inevitable, and for many UK farms this will mean more extreme weather, with warmer, wetter winters and hotter, dryer summers. This challenges the de-facto methods of forage production in the UK dairy industry; namely perennial ryegrass leys supplemented with maize/whole crop cereals.

To understand how UK farmers can adapt, I visited dairying regions slightly closer to the equator; France, Australia and New Zealand. The following observations were made:

In many dryer regions (Victoria, Tasmania, Loire, Canterbury Plains) irrigation is deemed necessary for dairy businesses to thrive. Where practical, the economic case for irrigation of forage crops may become justified in the UK, as is commonplace in France, Australia and New Zealand.

Alternative crops, better able to cope with dry conditions, will be part of the solution. Most are already well known, and include deeper rooting grasses (cocksfoot, fescues), herbs (chicory, plantain) and legumes (lucerne, red clover). Grazing management of these is different to perennial ryegrass, for example longer rotations and higher residuals.

Warmer, wetter winters present an opportunity to grow valuable cover crops, for example between maize crops, which can offer additional tonnes of dry matter, alongside other benefits such as reducing nutrient leaching, improving soil structure, outwintering and increasing organic matter.

However, solutions will require more than a change to the seeds we sow, and how we grow them. Dairy systems will evolve to mitigate risks, as seen in other nations with more extreme climates, and dairy farms are likely to diverge into the following two specialisms:

- All-year-round confinement systems, where cows are fully housed and fed a total mixed ration. Feed can be grown and ensiled in the “good times”, or substituted with imported feedstuffs. Capital spend is higher, so milk yields are higher (10,000+ litres) to compensate for higher depreciation, finance and fixed costs.
- Block calving, grazing-based systems, with a calving pattern to best-match the grass growth potential of the area; i.e. spring calving for wetter areas, autumn calving for drier farms. Yield is lower, but so are overall costs, leaving similar potential for profit. These systems “let the cow do the work”.

Given that I run a grass-based system, this study has gravitated towards grazing systems. I deem these to be more sustainable, as they have a lower embodied

carbon cost, are better able to cope with volatile milk price and as ruminants evolved to graze, they are potentially better able to provide eco-system benefits if managed sympathetically.

In addition, benefits of the following (non-crop-related) approaches have been observed:

- Planting more trees/hedges
- Breeding smaller/more efficient cows
- Enhancement of soil health and organic matter through a range of measures, including reduced tillage and mob-grazing

Fundamentally, farming systems become more resilient when they work in harmony with nature, and we would be wise to evolve our businesses to suit this.

TABLE OF CONTENTS

DISCLAIMER

CONTACT DETAILS

Ian Baggs

West Mill Farm, Wareham, Dorset, UK

Ian.baggs@gmail.com

Nuffield Farming Scholars are available to speak to NFU Branches, agricultural discussion groups and similar organisations.

Published by The Nuffield Farming Scholarships Trust
Bullbrook, West Charlton, Charlton Mackrell, Somerset, TA11 7AL
email : office@nuffieldscholar.org
www.nuffieldscholar.org

CHAPTER 1: INTRODUCTION

My name is Ian Baggs, and I am a dairy farmer. I care about our farm, our herd of cows, and the environment.

When I returned to the family farm in 2016, change to our farming methods was necessary, for both economic and climate resilience reasons.

This report shares the lessons that I have learned through my Nuffield travels and experimentation within my own business. I hope readers will find it useful.

CHAPTER 2: BACKGROUND TO MY STUDY SUBJECT

Our family dairy farm is on the south coast of Dorset, UK, and covers a strip of sandy soils between two rivers, which feed into Poole Harbour.

Climate change feels inevitable and, in my lifetime, I believe this will mean warmer, wetter winters, and hotter, dryer summers.

In summer our better soils struggle with a moisture deficit, typically from May to August, while in winter our meadows are flooded which can kill the pasture.

- How will we feed our cows and earn a living?
- What do we need to change?
- Are we fighting a losing battle?

These were the questions I had when I submitted my application to Nuffield.

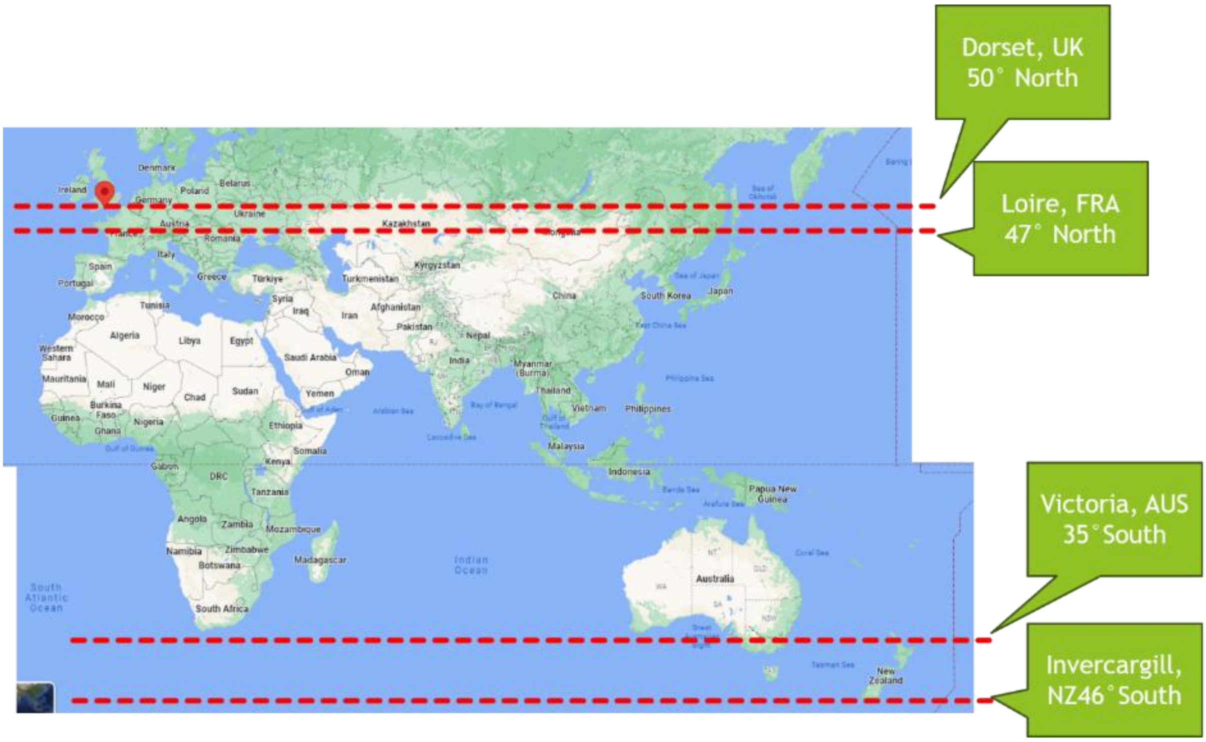
CHAPTER 3: MY STUDY TOUR

Forage production is a cornerstone of any dairy business. For UK farms, climate change may mean more extreme weather events, with warmer, wetter winters and hotter, dryer summers.

To understand how UK farmers can adapt, I visited dairying regions closer to the equator; France, Australia and New Zealand. I visited grazing systems, as this is personally relevant.

Locations travelled:

- UK (Cornwall, Devon, Dorset, Hampshire, Sussex, Dumfries, Leicestershire)
- France (Britanny, Normandy, Loire)
- Australia (Victoria, Tasmania, New South Wales);
- New Zealand (Southland, Otago, Canterbury, Bay of Plenty, Waikato)



Above: Map showing latitude of locations visited and latitude

CHAPTER 4: WHY DAIRY COWS?

Before the industrialisation of agriculture, it was difficult to grow crops without livestock. Cattle were used to build fertility; recall Charles 'Turnip' Townsend, and the Norfolk four-course system, incorporating wheat, turnips, barley, and clover or ryegrass.

Here, the cow was part of a sustainable system.

Fast-forward 200 years: mechanisation has created power for tillage and harvesting; cheap and accessible macro-nutrients (N-P-K-S) have removed the need for livestock to build fertility; economic specialisation has splintered many farms into exclusively arable or livestock.

But, fundamentally, the most sustainable form of dairy farming remains; using the cow to convert home-grown crops into saleable milk in a cost-effective and efficient way.

This report aims to examine, in a changing climate, the most sustainable options for feeding the cow.

CHAPTER 5: DAIRY FARMING SYSTEMS

Types of 'dairy farming system'

I define the dairy farming system as:

The combination of cows, land, crops, infrastructure and people, which are managed by the farmer to produce milk.

Through international travel, I observed distinct systems in geographical areas.

I visited circa 20 dairy farms in Australia and New Zealand and was **shocked** to find that the only buildings were usually a milking parlour and a small calf house. No cubicles, no scraper tractor and often no concrete silage clamps, feed pads, or slurry storage.

The table below generalises the systems:

System	Forage type	Popular Regions	Yield potential
Spring block	Significant focus on grazed grass	Ireland New Zealand Tasmania (AUS) Gippsland (AUS)	3000 to 6000 litres Or 300 to 550kg milk solids
Autumn block	Focus on grazed forages in spring/summer/autumn. In UK, typically winter housed	Northern Victoria (AUS)	6,000 to 8,000 litres Or 500 to 600kg milk solids
All year round "composite"	Winter housed, summer grazing	Some UK and French farms	6,000 to 10,000 litres
All year round "housed"	Cows permanently housed, milked 3+ times/day, all forage is conserved, significant proportions of straights (cereals, proteins) fed to increase yield and off-set costs	Holland Denmark California (USA)	10,000 litres +

In each country, I observed consistency in the dairy system used, while even in the tiny Isle of Purbeck (where I farm), there are a mix of all systems, breeds and calving patterns, with herd sizes from 50 to 5000 cows, and yields from 5,000 to 12,000 litres/cow.

My hunch is that those who pick a system and dedicate themselves to it are more resilient and focused than those who do not.

Extreme climate events may require strategic selection of the farming system to suit the farm's environmental context and to survive.

Influence of farming system on forage cropping

The farming system influences the types of forage grown.

In a grazing system, it is possible to feed cattle only with grass. By contrast, in a housed system, feeding only grass would lead to economic ruin, as the high levels of capital employed require higher yields to offset costs.

System choice dictates whether the forage is grazed or mechanically harvested and ensiled.

In a housed system, as forage is preserved, time of growth is not important.

In a grazing system, the objective is to balance herd demand with forage growth. By choosing the most appropriate block (spring or autumn), the herd's forage demand can be shifted to suit the growing potential of the farm.

- If the farm reliably grows forage through summer, spring block calving is an option.
- If a farm struggles to grow forage in summer, autumn block calving may be preferable. With hotter, dryer summers, this may be a more climate resilient model.

To maximise profit, the system selected must **fit the growth pattern and layout of the farm**.

CHAPTER 6: CATTLE BREEDING – THE RIGHT TOOL FOR THE JOB

Dairy farmers often think of themselves as cattle farmers, when in fact they should consider themselves forage farmers. The cow is simply a tool to convert crops into saleable milk (and meat).

Choosing the animals best adapted for the system is fundamental to this.

In housed systems, Holsteins are generally chosen to produce high volumes of milk, while fed silage and concentrates.

In grazing systems, Jerseys, Friesians and Kiwi Cross cows are among those preferred to produce more modest volumes of milk, predominantly from grazed forages, and to be fertile enough to produce a calf per year.

These pointers emerged as being important when selecting the most efficient breed to best suit the environment and system:

- Pick the best breed for the system; be led by data, seek advice from other farmers on a similar system, and be prepared to change.
- Use your own data, including milk recording. If you are on a solids/manufacturing contract, compare cattle on a milk solids production basis rather than on litres produced.
- Weigh cattle and relate production to size to identify efficient cattle.
- For breeding replacements, use sexed semen on the best performers to accelerate genetic improvement.
- Consider genomic testing for accurately identifying the best heifers to breed replacements from.
- Strive for longevity. A heifer typically produces 70% to 80% of output of a mature cow, so there is a yield penalty for every heifer in the herd. And the lower stress the system, the longer the cattle will last.

Left: Olivier and Jean Francois Glinec's organic herd, Brttany, France.

They pride themselves on a low stress system, where cows average eight lactations, helping to keep costs low.

CHAPTER 7: WHY FORAGE MATTERS

Imported vs homegrown feeds

Most farms feed supplements (cereals, pulses/beans, etc.), which are usually imported feedstuffs, often from across the globe. These supplements are therefore "exporting production" outside of the farm gate.

Economically, the oft cited 1-2-4 rule of £1's worth of dry matter as grazed grass would cost £2 in silage form, or £4 in concentrate form. So, there is a profit advantage in producing quality forage and converting this into milk efficiently over purchasing concentrates.

Stocking rate

In a grazing system, if a farm is over-stocked, grass growth will require permanent supplementation, which increases costs. The business will also be less resilient to challenging growing seasons.

If the farm is under-stocked, pasture growth will exceed demand, and quality will be wasted. Milk output per hectare will be reduced.

Here are some tips to consider when planning stocking rates:

- Understand how much forage is grown by using records and data. Use plate metering for grazed grass, and weighing or volumetric calculations for silage.
- Calculate cost supplementation vs. removing cows from the system. Consider not only the cost per tonne of dry matter, but also additional overhead costs e.g. manure handling, milking, cooling, etc.
- Consider the long-term output of your farm, e.g. the five-year rolling average.
- Consider cow size as well as herd size; breeding a smaller, more efficient cow will reduce forage demand.
- Have a contingency plan if/when demand exceeds supply; e.g. drying cows off early, outsourcing youngstock grazing, contingency forage stocks.

CHAPTER 8: GRAZING TECHNIQUES

Pros and cons of grazing

Grazing is the cow's natural state. She evolved with a rumen to digest cellulose in pasture, and other vegetation (fruits, leaves, etc.). She is her own forage harvester, muck spreader and bedding machine.

However, not every farm nor every region can graze grass, such as in extreme hot or cold environments, or where there is insufficient grazing ground accessible from the dairy.

Many farmers successfully house cows permanently. But this introduces a lot of work, moving forage and slurry around. It requires investment and embodied carbon, in concrete, steel and depreciating equipment.

It also upsets natural processes; slurry cannot be utilised by invertebrates in the same way as they can a cow pat; mechanically harvested crops are predominantly monocultures, which offers limited support to natural ecosystems.

Grazed forages are therefore generally more sustainable than ensiled forages.

Grazing techniques

Lactating cattle require forages with high metabolizable energy and palatability. Overstood swards become stemmy and fibrous, reducing intakes, energy density and milk production.

Therefore, grazing needs careful management to maintain quality. Below are some common techniques:

- **Rotational Grazing**

The herd is moved around the farm sequentially, grazing a different area each day. This helps grass to grow, as the plant is grazed, then afforded several days (say 20 to 40) to rest and regrow before it is grazed again.

In cooler climates (such as the UK), farmers predominantly rely upon ryegrass and graze at the three-leaf stage (typically 2800 to 3200kgDM/ha).

This works well when moisture and nitrogen are plentiful, but in drought conditions, this system is vulnerable and prone to slow regrowth.

- **Rotational grazing with higher covers**

Higher covers can help grow more grass, as there is larger "solar panel" (leaf) to absorb the sun's energy. However, as grass gets taller, quality and feed value can reduce. Utilisation is also more difficult to manage, leading to wastage.

In herbal leys, swards tend to require higher covers and longer recovery time to enable herbs to persist; perhaps 3400kgDM/ha, or an extra three to five days on round length.

Above: A taller cover of herbal ley about to be offered to Gavin & Sheryn Fisher's herd of organic dairy cows, Waikato, New Zealand

- **Mob grazing**

High covers of grass are grazed with a tightly packed herd of cattle; moved multiple times per day. The pasture is then rested for longer periods (several months) to allow the grass to regenerate.

Stocking density typically exceeds 100,000 kilos of liveweight per hectare at any time, to ensure non-selective grazing and high amounts of 'hoof impact'.

It is an excellent tool for conditioning soil as the taller plants exude surplus carbon into the soil. As pasture is more fibrous, it is predominantly used for beef cattle.

Above: Mob grazed beef cattle at Peter Blair's farm in Owaka, New Zealand. Cattle are moved three times/day and pasture rested for three+ months.

- **Strip grazing**

An effective method of grazing a block and rationing feed, for example standing hay, brassicas and fodder beet.

Managing droughts

Droughts are typically managed by extending the rest period of pasture and waiting for rain to arrive. This is typically done by allocating a smaller area each day, and providing supplementary feed.

Autumn calving herds are well placed to manage droughts by drying off cows early in summer and therefore reducing feed demand.

Standing hay (grass that is allowed to grow tall through summer) is an economical method of storing feed for summer. It removes the cost of baling silage in the spring surplus, to feed back to cows later. Benefits include:

- Drought resilience; the standing hay is effectively a grazeable forage store.
- Sward improvement; plants can set seed, reproduce and persist in the sward.

Above: Milking cattle grazing standing hay on Matthew & Pip Gunningham's farm, Tasmania. In summer, cattle are given 1/3 of the daily diet as standing hay, which helps maintain pasture quality for milk production in 2/3 of the diet.

CHAPTER 9: FORAGE CROPS

I have reviewed some of the popular forage types I saw on my travels.

- **Grasses**

Perennial Ryegrass; grows well at low soil temperatures (from 6˚C to 8˚C), providing an early bite and, high yields. It responds well to plentiful nitrogen and moisture. Highly palatable. However, shallow rooting depth results in low drought tolerance, and growth falters above 25˚C.

Timothy; highly palatable, well suited to damp conditions, heavier soils and plentiful moisture. Lower yielding than ryegrass.

Tall Fescue and **Cocksfoot**; deep rooting; drought tolerant; can become tough and unpalatable if allowed to grow too tall. Lower energy than ryegrass with less milk output potential per unit of dry matter. These grasses can dominate a sward if soil conditions allow.

Hybrid grasses such as **Festuloliums** are a cross between say a fescue and a ryegrass; however, their seeds may not offer viable progeny so may be better suited to short-term cutting leys.

Annual Ryegrass is useful for double cropping (e.g. between maize crops) as they grow at low soil temperatures. Commonly used on irrigated farms in Northern Victoria as they grow through winter. Does not tolerate high temperatures or moisture deficit well.

Warm season grasses are popular overseas, (e.g. **Kikuyu grass** grown in North Island, New Zealand) but unlikely to grow effectively in the UK for the foreseeable future.

- **Herbs**

Herbal leys have multiple species, with different rooting depths, which makes them more drought tolerant, and hold feed value better at taller covers.

Chicory – deep tap-rooted perennial. Drought tolerant. Sometimes grown as a monoculture and used as an effective summer feed.

Plantain – fibrous root system, drought tolerant. Popular in New Zealand as favoured for their ability to reduce nitrogen leaching. Proliferates easily, can be applied in a fertiliser spreader.

Various other herbs are available, including **sheep's burnet** and **yarrow**. These may not add significantly to forage quantity, but provide additional minerals.

Above: Herbal grazing ley with six+ species

Above: Drought tolerance of herbal ley (right) vs ryegrass and clover (left) on my farm, Dorset, UK

- **Legumes**

These plants play an important role in providing organic nitrogen for themselves and other plants in the sward.

White clover; excellent companion to shorter grazing grasses; easy to grow, high protein; highly palatable. White clover grows close to the ground so good grazing residuals are required to prevent grasses outcompeting the clover.

Red clover is typically used in silage. It can be grazed, but it is less persistent than white clover, and upright in growth making it less suitable. Good drought tolerance, thanks to its deeper root structure.

Lucerne is a persistent perennial with deep tap root structure. Typically grown as a pure stand. High in protein and yields well, but slow to establish in the first year. Stands can last five or more years. Prefers alkaline free-draining soils, so ideal for chalk farms.

Above: Lucerne at Brendan Hehir's farm, Northern Victoria, Australia.

Left is a sward of Lucerne. Right are dairy cows eating Lucerne hay, fed as a supplement in paddock.

Other perennial legumes such as **Alsike Clover, Sainfoin** and **Birdsfoot Trefoil** tend to be less productive and therefore less popular additions to commercial grazing leys in the UK.

Annual legumes e.g. **Vetch, Peas** and **Crimson Clover** can provide additional protein and nitrogen fixing properties, in cover cropping or undersowing applications.

Particular caution should be exercised regarding **bloat**; this can kill cows if they are allowed to gorge and consume too much clover without sufficient time for their rumen to adapt.

Above: Herbal silage ley including chicory and red clover, on my farm, Dorset UK.

- **Maize**

Common in the south of the UK, maize is high energy and yields well but is low protein.

It is very moisture efficient, due to its C4 ("warm season") photosynthesis mechanism.

Australian dairy farmer Brendan Hehir relied on irrigating crops and stated that to grow one tonne of dry matter of permanent pasture required three megalitres ($3000m^3$) of water per hectare; two megalitres for lucerne but only one megalitre for maize, making it three times more efficient to grow than permanent pasture.

Early varieties can be harvested sufficiently early to enable a grass ley or cover crop to be established afterwards.

Experiments have been undertaken to undersow maize with ryegrass, or companion crop with beans, which can work well but limit herbicide options.

- **Whole crop cereals**

Cereal crops, typically wheat or barley. Chosen for energy, especially where maize cannot be grown (e.g. heavy soils, or insufficient heat units).

Lower yielding that maize, but can be winter sown and harvested in summer rather than autumn. High energy/low protein; can be grown with legumes (peas) to increase protein content

- **Brassicas**

Several types including **radish, rape, swede, turnip, kale**. Cheap to establish so low risk, can be grown for summer or winter use. High protein/low energy, but inclusion at too high a rate causes milk taint so intakes in lactating cattle must be limited. Used in New Zealand as a method of storing green feed "on the plant" for supplementation in summer.

An effective break crop between grass leys, and well suited to outwintering and complimenting with bale grazing.

Above: Summer brassicas on Andre Van Barneveld's Farm, Canterbury, New Zealand; With rainfall less than 500mm/year, Andre used brassicas to grow feed in spring and keep it on the plant, ready for grazing when summer drought occurs.

- **Double cropping and cover crops**

Various mixes of cover crops exist, and are typically planted where soil would otherwise be left fallow between crops (e.g. into maize stubbles).

The cover crops help capture nutrients which could otherwise be lost via infiltration. Establishing a green cover can prevent soil erosion and can provide valuable grazing, which in turn makes the nutrients more available to the next crop.

Above: Diverse cover crop on the grazing platform at Rhys Roberts' farm in Ashburton, New Zealand

- **Fodder beet**

This high energy crop can be grazed in-situ or lifted and fed/clamped for housed cattle. A popular choice for outwintering.

It is high energy/low protein, and highly palatable.

Grown well, fodder beet is the cheapest and highest yielding crop that can be grown in the UK, with yields in excess of 20tDM/ha. However, careful dietary transition is required, or animals can gorge and die.

Agronomy is more complex and good weed control (typically with multiple herbicides) is required.

Some dairy farms successfully graze beet with milking cattle in winter.

Left: Fodder beet fed to dry stock on my farm.

General approaches to forage cropping

Here is some general advice for planning suitable forage cropping.

1. Be realistic about how much forage can be grown on. Determine the optimum stocking rate and build a resilient system around an appropriate number of cows.
2. Choose the most suitable crops for the farm. Accept factors that are beyond your control (soil type, subsoil alkalinity, altitude, latitude, aspect, rainfall); choose crops which stand the best chance of thriving.
3. Incorporate diversity into grazed pastures.
4. Use legumes to reduce artificial nitrogen requirement.

CHAPTER 10: SOIL HEALTH

Healthy soil is a pre-requisite of sustainable forage cropping. Soils are complex; apparently there are more living bacteria in one teaspoon of soil than there are people on the planet.

However, to simplify healthy soils, here are some characteristics:

- High organic matter; soil is blacker and smells earthy. Sandy soils will typically only have an organic matter of 5% to 10% compared to clay soils which may reach 20% organic matter.
- Plenty of worms
- Structure/compaction – soils is crumbly, aerated and friable, there are no hard “pans” in the soil strata.
- Chemical composition (pH, P and K indices) is suitable for the crops being grown.

Below are some practical approaches to maintain soil health and ecosystems.

Organic Matter

Organic matter is the building block of soil health. Increasing it improves infiltration rates, reduces water logging and increases moisture retention, and therefore drought tolerance.

Long term grass leys are an effective tool for increasing organic matter.

Tillage

Tillage can have major agronomic benefits; controlling of weeds, removing compaction, and releasing available nutrients, especially nitrogen. But the most debated tillage form is the plough and the practice can be destructive to soil health, because it breaks mycorrhizal fungi relationships and releases carbon from the soil. In arable-only systems, without livestock and pasture integration, continual use of tillage degrades soils.

In a rotation which includes grass, the grazed ley will rebuild organic matter. This allows soil to “recover” from occasional cultivations.

Where this is not possible, for example in purely arable rotations such as forage blocks, explore alternatives to heavy cultivations such as minimum tillage or direct drilling.

Compaction

Compaction compresses soils, reducing porosity and water infiltration, and inhibiting root development. A penetrometer can be used to identify layers of compaction. Mechanical means may be necessary to resolve compaction quickly.

Above: A sward lifter can be used to alleviate compaction at depths of up to 450mm.

Anthelmintics

These products, while beneficial where necessary, are sometimes overused and have significant negative impact on soil flora and invertebrates.

There is consensus of veterinary option that farmers should be more discretionary with their use, for example by using health indicators to determine need for treatment, including faecal egg counts, dung consistency, body condition, cleanliness of coats and tails, growth rates and presence/absence of cough, rather than using by protocol.

Less toxic variants could also be used preferentially, and this requires the farmer to appreciate the relative soil health impact of different products.

Pesticides, herbicides and fungicides

Use these only when necessary; note that due to their inherently toxic nature, such products are likely to have a detrimental impact on soil health.

In the UK, there are currently no clover safe sprays, so use of legumes or broadleaved species (e.g. herbal leys) will prohibit their use.

Good grazing management, and occasional topping, are often sufficient to control weeds in pasture-based systems.

Living Crops

Keep living crops in the soil. In long term pasture, living roots are always present, but in annual cropping, cover crops and under sowing can be used to prevent bare soils. This helps protect organic matter, and reduce soil erosion.

CHAPTER 11: FEEDING THE CROP

Most conventional farmers use artificial nitrogen and mined phosphate and potash to enhance plant growth.

Fertilisers have a significant carbon emission associated with them; the CO_2 emissions associated with applying 1 tonne of 46% urea is equivalent to driving a small petrol car approximately 15,000 kilometres.

Conventional farmers can take some simple steps to significantly reduce their nitrogen use, for example increasing legumes in grass leys. These require warmer temperatures to fix nitrogen, so application should be targeted earlier in the season, and reduced when temperatures climb.

Do we need artificial nitrogen?

Sound use of legumes and organic manures can provide plentiful forage, with some organic farmers producing 13 tonnes of dry matter a hectare from clover-grass and herbal leys.

I visited Rhys Roberts at Align Dairy Farms, Canterbury, New Zealand where, in response to the eutrophication of Canterbury Bay caused by excess nitrogen leaching from dairy pastures, Rhys has set up an experiment to compare "regenerative dairy" (zero-artificial N use) with conventional practice.

On one farm, the cows are split into two herds of around. 300 cows each, with two separate grazing platforms and bulk tanks. One herd grazes conventionally on ryegrass and artificial nitrogen, and one is a regenerative herd grazing herbal leys with no artificial N. Other variables are controlled and measured.

He stated that the systems are roughly comparable in profitability. In the 2023/24 year, the regenerative system was marginally less profitable with an EBITDA (earnings before interest, tax, depreciation, amortisation) of $2.60 NZ compared with $2.74 NZ per kilo milk solids for the conventionally grazed herd. However, this may be an acceptable sacrifice to ensure a sustainable and socially accepted dairy sector.

By getting the basics right, Rhys is proving that we can kick the artificial nitrogen habit and still remain profitable.

The latest findings on this comparison can be found on:
https://alignfarms.co.nz/regenerative-study/study-findings/financial-findings/

CHAPTER 12: IRRIGATION

Irrigation is seldom used in the UK for forage cropping.

However, in certain parts of the world, the dairy industry is reliant on irrigation, including Australia (Northern Victoria, Tasmania); United States (California); France (Loire) and New Zealand (Canterbury Plains).

With the high land prices in the UK, there may be scope to invest in irrigation infrastructures to water forage crops.

Above: Centre Pivot irrigation in New Zealand

CHAPTER 13: TREES, HEDGES AND BIODIVERSITY

Trees and hedges have multiple benefits on a dairy farm:

- Shelter and shade
- Expression of natural behaviours (e.g. browsing)
- Fly repellent (Walnut)
- Anti-inflammatory properties (Willow)
- Beneficial for wildlife include birds and pollinators
- Carbon sequestration
- Human factors (mental well-being, social license to farm)

I saw several farmers investment in trees and hedges, for some or all of the reasons above. External funding often means the capital cost is fully financed.

Grazing fields are often subdivided using electric wire, presenting an opportunity to introduce trees and hedges across multiple kilometres even on a modest farm, while sacrificing little land.

Some planting advice:

- Plant trees in north-south lines, rather than east-west, so that the pasture in adjacent paddocks gets more sun to grow pasture
- Select varieties suited to the soil type and moisture availability
- Select a diverse mix, so that you get a variety of benefits
- Off-set electric wires sufficiently from the hedge to enable a hedge cutter to be used "inside the wire".

Above & Left: Paddocks on Gavin & Sheryn Fisher's farm in Waikato, New Zealand. Note the mature trees surrounding each paddock, and the browse lines where the cattle have been foraging.

CHAPTER 14: SUSTAINABLE INFRASTRUCTURE & COST CONTROL

Infrastructure is intrinsically related to forage utilisation. Below are some noteworthy examples:

- **Grazing infrastructure**

Good tracks with multiple gateways help prolong the grazing into the shoulders of the season, increasing pasture utilised, and reducing other demand on other infrastructure requirements (e.g. silage pit, slurry store).

- **Silage storage**

Effective and well managed silage pits reduce losses in both energy density and tonnes dry matter.

Self-feed silage pits are an effective method of feeding cattle in the winter while controlling overhead costs.

Bales, meanwhile, have a far higher plastic usage, but allow bale grazing and feeding in-field (e.g. bale unroller), which reduces overhead costs.

- **Slurry separators**

Many British farms grow forage crops on off-lying ground, and bring it to silage pits for feeding at the main farm. Slurry separators can help better use manures:

- Solid fraction is higher dry matter, and more cost-effective to export to cropped ground.
- Liquid fraction can be more easily spread to the grazing platform (e.g. light-weight umbilical implement), and is readily absorbed into the soil when thicker slurry would sit on the surface and cause grass rejection.

- **Mobile milking infrastructure**

Mobile milking units are rare, but they offer a tangible way for milking herds to integrate with large arable estates. The pasture provides a sound rotation, and builds soil fertility which can subsequently be used to grow better cash crops.

It also enables new farming business models, where a third party (tenant or contract farmer) can invest in assets without them being tied to the land; think "wheels and legs" rather than concrete.

Land must be free-draining land to enable winter grazing; and a climate which permits sufficient summer grass growth for a spring block.

Above: Mobile parlour at Oli Chedgey and Tim May's 'Open Air Dairy'

- **Cost control**

It is fundamental to any milking system to have appropriate cost control. I met several farmers who made a good living by keeping overheads low, controlling costs, and operating a simple pasture-based farming system.

Gerard Grandin in France is a strong advocate for profitable spring block calving. He feeds no supplements, never tops or mows his grazing paddocks and never reseeds. He makes a profit through good cost control.

CHAPTER 15: TECHNOLOGICAL INNOVATIONS

While on my travels, I observed some pasture allocation innovations which may help farmers manage grazing in a more sustainable way.

Above: Pensagro Timed Wire Lifter on David Tregarth's farm, Normandy, France. These wires lift to open up fresh sections of pasture.

Above: Halter "no fence" collars on Pete Templeton's cows in Southland, New Zealand. The solar panel tops up the battery, and the GPS tracker and audio+ electric shock technology can be used to control grass allocations to cattle.

CHAPTER 16: CONCLUSIONS

Sustainable forage cropping is one part of a sustainable dairy farming; most elements of farming are interlinked. Therefore a "systems" approach is required to connect profitability, productivity and a thriving environment.

I have distilled this report into 10 simple tips, to make them as practical as possible:

1. Choose the right system for your farm, personal interests and context; be that high-input/output housed, or block-calving grazed system. If block calving, choose block that best suits your farm.
2. Get your stocking rate right.
3. Breed the right cow for your system.
4. Invest in suitable infrastructure, to make the most of all the forage and manure you produce, and control costs.
5. Manage grazed grass proactively. Build grass covers in anticipation of a drought; use supplementation, standing hay or annual crops to increase round length; change forage demand (e.g. early dry off), to maintain fresh grass availability.
6. Incorporate diverse species of herbs and legumes into grazing swards. Clovers, plantain and chicory are popular choices to start.
7. Include legumes in your silage leys such as red clover, vetch, lucerne.
8. Consider grazable annual crops to fill forage deficit, such as chicory and brassicas in summer () or forage rye, fodder beet, brassicas and kale in winter.
9. Value your organic manures, and distribute them according to need.
10. Make positive steps to enhance and make space for nature; for example, planting trees and hedges, bird and bat boxes, allowing existing hedges to grow taller, or hosting bee hives. These changes will provide long term benefits for you, your cows and society at large.

CHAPTER 17: AFTER MY STUDY TOUR

Since my Nuffield travels, I have continued to implement changes to our family business.

These include:

Reducing herd size and cow liveweight to the optimum level. The target is 200 cows averaging 600kg liveweight, run as an autumn block calving herd.

All grass reseeds are now herbal leys, generally with three grasses, three legumes and three herbs.

Standing hay is used for summer grazing and outdoor calving, and to rejuvenate tired swards.

Fodder beet is grazed during the winter to reduce outwintering costs and increase home-grown forage production.

More than 10,000 trees have been planted in 2024/25 along paddock fences and boundaries on the grazing platform.

None of the above actions are ground-breaking. Sustainable farming systems do not have to be. The objective is to keep getting a little better every year, stay in profit and make some space for nature.

CHAPTER 18: ACKNOWLEDGEMENT AND THANKS

Thank you to Nuffield for choosing me as a scholar, and to my sponsor, the Trehane Trust, for providing funding and support without which this scholarship would not have happened.

Thank you to my partner and my family for allowing me the opportunity to travel away from the farm for several weeks.

Thank you to all those farmers who were so kind to host me, show me their businesses, introduce me to their families and eat at their tables; I hope someday to be able to repay that kindness.

978-1-916850-65-1

ISBN: 978-1-916850-65-1

Published by The Nuffield Farming Scholarships Trust
Bullbrook, West Charlton, Charlton Mackrell, Somerset, TA11 7AL
Email: office@nuffieldscholar.org
www.nuffieldscholar.org