RASE

NUFFIELD Farming Scholarships

ELIZABETH CREAK CHARITABLE TRUST

NUTRIENTS & WATER

Turning potential pollution into resource efficiencies; **A Bitesize Guide**

INTRODUCTION

Each year, 20 people under 45 are selected as scholars and sponsored by the Nuffield Farming Scholarships Trust to travel, research and report on subjects they are passionate about and which contribute to advancing agriculture, horticulture, forestry and ancillary industries.

These studies bring new thinking, technology or management approaches from across the globe to the UK. While many know of Nuffield Scholarships, few farmers are aware of the huge knowledge base of global reports, dating back to 2006, that can be accessed via the online Nuffield library.

This Bitesize Guide, supported by the Elizabeth Creak Charitable Trust and the Royal Agricultural Society of England, highlights a selection of reports which discuss practical action which can be adopted on farm. They give an insight into the farming experiences and research freely available at:

https://www.nuffieldscholar.org/reports

WHAT IS THIS GUIDE, AND HOW SHOULD I USE IT?

'Nutrients & water – turning pollution into resource efficiencies' is a topic confronting every farmer, regardless of their sector, geography or individual circumstances. This Bitesize Guide provides some recommendations to help turn a potential problem into positives. It highlights recommended actions from relevant Nuffield Scholarship reports, grouped into three sections:

- Action that can be taken immediately (Do now);
- Actions that require some planning (Start planning), and;
- Long-term options to consider (Think ahead).

Each of the report sections has a short description followed by a QR code to access the relevant Nuffield Farming Scholarship report for more information, case studies and discussions. This first Bitesize Guide is produced in memory of Richard Tudor, 2017 Nuffield Scholar.

DO NOW

Work out your farm's N and P surplus

The total nutrient surplus generated by fertiliser and manure use on managed agricultural land in the UK remains high at 79kg/ha for nitrogen and 2.8kg/ha for phosphorus (Defra, 2022). There is scope for every farm business to be more efficient; the nitrogen (N) and phosphorus (P) surplus of each farm enterprise should be known. This can then be benchmarked against similar farms and measures implemented to reduce losses.

In the UK we have some of the tools and scientific evidence to quantify nutrient loss from farms e.g. free to access software like FarmScoper, but countries like New Zealand and the Netherlands have given it greater priority.

KEY RECOMMENDATIONS:

- In some nutrient loss hotspots, overall stocking rates and crop inputs may need to reduce, at least on the less productive parts of the farm. This may involve growing different crops, modifying livestock enterprises and entering the 5-10% of least productive land into an agri-environment scheme.
- Adopt Lean Management principles for minimising all types of wastage (see below). Set clear policies, procedures and targets for protecting water quality on the farm.
- Choose agricultural contractors who have invested in more accurate fertiliser and manure application equipment and can supply digital application records.

Defects	Over production	Waiting	Non-utilised talent
Extra work caused by rework, scrap and incorrect / inadequate information	*Production that is more than needed, or before it is needed*	*Wasted time waiting for the next step in a process*	*Under-utilising people's talents, skills and knowledge*
Transportation	**Inventory**	**Motion**	**Extra processing**
Unnecessary movement of products and materials	*Excess products and materials not being processed*	*Unnecessary movements by people (e.g. walking)*	*More work or higher quality than is required by the customer*

Source: Tim Stephens, adapted from Lean Six Sigma

The eight wastes, which lean management seeks to minimise, much of which is applicable to nutrient management on-farm.

Tim Stephens, NSch 2017: https://tinyurl.com/5dhzbdhw

Adopt catch and cover cropping

Why plant cover crops? The answer is simply to keep the soil alive. There are more living organisms in a spade of soil than humans on Earth. Biologically, living roots feed fungi and bacteria in exchange for nutrients; dying plant residues are a feast for the soil microbes, themselves turning into organic matter. Structurally, plant roots shrink and swell, creating aggregation while penetrating compacted layers with up to 300psi of pressure alongside worm burrows, helping the soil to breathe.

Soil chemical elements such as nitrogen, potassium and phosphorous can be accessed and cycled through plant roots, making them less prone to leaching and more available to the subsequent crop.

Cover crops are the keystone to the biological, chemical, and physical function of the soil.

KEY RECOMMENDATIONS:

- Understand carbon and nitrogen cycles in the soil. Avoid nutrient immobilisation while better managing artificial inputs. Feed the soils and they will feed the plants.
- When growing cover crops, think FDD - Functionality, Diversity, and Density. Set out with clear objectives and a management plan. Treat the cover crop with the same care and attention as any cash crop.
- Build resilience into a farm business by farming layered, not naked. If cover crops are part of a broader system change, then the opportunities that come through changing the system are only limited by our imaginations.
- Always consider individual context as it varies between farms and fields.

Cover cropping in action: Bean and oat roots intertwined.

Toby Simpson NSch 2022 https://tinyurl.com/3va8n6aw

DO NOW

START PLANNING

THINK AHEAD

Soil health and fertility in the uplands

For building soil fertility, the ultimate soil food that balances the whole nutrient cycle is livestock manure or compost. The key words are 'feeding the soil' as opposed to 'feeding the plant'. If soil tests indicate sufficiently high levels of potassium (K) and phosphates (P) then large additions of extra manure can have a detrimental effect on the uptake of other nutrients (copper and zinc under high phosphate and boron and magnesium with potassium).

When applying manure in ideal conditions it feeds the soil on a slow release basis with release of nutrients better matching plant needs over the season. This results in less pollution risk from nutrients and a constant food source for soil biology.

KEY RECOMMENDATIONS:

- A minimum requirement should entail carrying out a comprehensive assessment of your soils every five years to allow better monitoring of trends in deficiencies and excesses, and this should become a Key Performance Indicator (KPI). A Soil Health Plan should be formulated from the assessment to set out necessary amendments and actions.
- There is an urgent need for a renewed focus on lime on hill and upland grasslands, and a better appreciation of the calcium requirement of soils.
- Grass breeding should reconsider the metrics used for evaluating grasses, with the current focus on yield under nitrogen fertilisation and cutting of questionable relevance to many upland and hill situations. The over-reliance on ryegrass breeding at the expense of other species should also be rebalanced.

Discussing paddock management on a Spanish organic dairy farm.

Richard Tudor NSch 2017: https://tinyurl.com/46ymm4a2

DO NOW

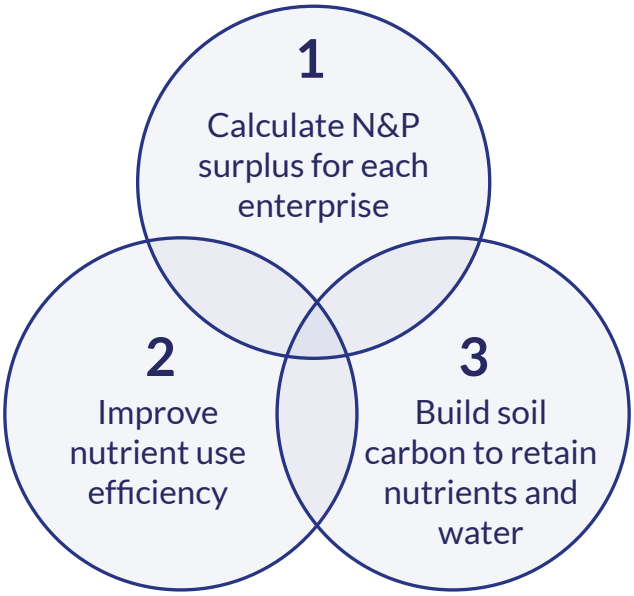
START PLANNING

THINK AHEAD

START PLANNING

Keeping nutrients out of water

- Source high-quality management training on topics like resource management and environmental compliance. Provide farm staff with formal training in manure and fertiliser application best practice.
- Do your own research, development and on-farm trials. Make use of the help available through initiatives like the UK's Innovative Farmers network.
- Become FACTS qualified and challenge your advisors more.
- Fine-tune arable and grassland crop nutrition by making the most of whatever precision farming technology the business can afford.
- Review farm infrastructure and have a maintenance and investment plan: buildings, yards, drains, tracks, fences, livestock water supplies etc. Repair broken guttering and unblock drains. Slow the flow of water through the landscape to prevent erosion.
- Build more manure storage capacity with the aim of applying all manure in spring and early summer.
- Grow more. Increasing yields to produce more dry matter per hectare from the same inputs will utilise more nitrogen and phosphorus. Double cropping is another way of doing this, as is companion and relay cropping.



Source: Tim Stephens

Three key actions to reduce nutrient loss to water

Tim Stephens NSch 2017: https://tinyurl.com/5dhzbdhw

Catch and cover cropping - agroforestry

While cover crops protect soil from some environmental risks, layering fields with multiple enterprises, such as fruit trees as well as grazing or other crops, could add a level of financial protection.

Agroforestry can make the farm bigger and more productive if you choose to crop the extra dimension - above and below ground. It makes better temporal and spatial use of natural resources: sun, air, soil, water, than monoculture.

Modern agroforestry systems are compatible with present-day agricultural techniques and tree densities c. 100 trees/ha allow alley crop productivity to be maintained. Successful systems are being used on farms in Canada, the USA, China and in more than 18 EU member states.

It can be as or more productive and profitable than monoculture systems; nutrient cycling and utilisation is more efficient in agroforestry systems and nitrogen losses can be reduced by 50% in agroforestry, with improved phosphate availability compared to monoculture.


© Stephen Briggs

Agroforestry is well established at France's INRA research organisation.

Toby Simpson NSch 2022: https://tinyurl.com/3va8n6aw

Stephen Briggs NSch 2011: https://tinyurl.com/324jbdfb

DO NOW

START PLANNING

THINK AHEAD

The circular farm – reduce, reuse, recycle

The circular economy is shaped by three principals:

1. **Design out waste and pollution:** Most waste is created at the design stage of products and systems: change your mindset to view waste as a design flaw, or as a raw ingredient for another process.
2. **Keep products and materials in use:** Millions of tonnes of materials, from plastic to potash, are disposed of or lost every year into ecosystems, the atmosphere or water, so consider remanufacturing, reusing, and repurposing.
3. **Regenerate natural systems:** Nature does not heed the concept of waste; the classic example is a tree falling in the forest, decomposing to become nutrients for further growth.

These principles are used in the development of the circular farm. They focus on good yields, the sparing use of resources and energy, while putting as little pressure on the environment, nature, and climate as possible. Minimising inputs, be that in manufactured or mined fertilisers, pesticides, concentrate feed, energy, or time are key factors in the design of the circular farm. Keeping the residuals of farming, such as manure, other biomass and food processing within the farm as a renewable resource is also a crucial part of the closed cycle. The more local the loop, the more effect the systems in place.

KEY RECOMMENDATIONS:

- Design out waste across the farm, from lean management to reduce wasted time, designing manure handling to reduce ammonia loss, measuring soil carbon, examining overland flows to reduce diffuse pollution, or collaboration with producers of biofertilser.
- Embrace complexity - it has a critical mass, and a minimum level is required to benefit from the synergies available.
- Knowledge is essential, but you do not have to know everything. Collaboration with experts will build and support your knowledge.
- Develop a system thinking toolbox. Those tools are the ability to see interconnection, synthesis, and the whole rather than parts. Think in circles not lines, and remove silos that funnel thinking into the boxes.
- Embrace diversity - the more diversity the more components to the farming system. Diversity mitigates risk and is strength.
- Identify functions that each component can fulfil, for example is it food, fuel, building material, soil amendment or energy production?
- Put the right component in the right place at the right time in the right amount, be it complimentary crops on a field scale or precision management of a landscape.

Canadian company Lystek, featured in the report, embraces the circular approach.

Charlie Steer NSch 2019: https://tinyurl.com/2ahvxsxe

Anaerobic digestion

In order for a biogas project to be a likely profitable venture there has to multiple elements involved. These recommendations give a good starting point for a profitable AD process and one for which minimal subsidies would be required.

KEY RECOMMENDATIONS:

- Feedstock supply: the days of 100% energy crops are likely behind us. The future will likely lie in the by-products, residues and wastes.
- Co-location with a secondary business which will profit from the heat, electricity, gas or CO_2 production, such as large corporations looking to offset CO_2 emissions, or wanting to secure a carbon free or even carbon negative supply. Large corporations' green credentials will act like the once-government subsidies were. They will help monetise the public good aspect.
- Solve a waste problem. Identify existing waste streams that are not cost efficiently dealt with. This market will be more competitive, however, as long as there is organic matter there will likely be a pre-treatment method in order to access its full biogas potential. Identifying the market that will give a long term source of cost reliant and secure feed will be the key. Any subsidies that are available will likely only be around waste or residue material.
- Digestate: Quality is key. A poor quality digestate may save money in the short term through reduced investment. However, any investment in digestate treatment and nutrient recovery will be a worthwhile investment that will reduce the risk of pollution incidents and competition with others in a saturated market place.
- Work to the strengths of biogas and fill the gap that other renewables cannot. This includes peak load demand feeding schemes and gas storage and renewable gas for HGV transport.
- Engineering design, right first time. Rather than look to what has been done already in the commercial biogas sector, look to lessons learnt by AD plants in other sectors, in particular the water treatment sector. Decades of experience here provide multiple design lessons.
- Biology robustness: AD is a biological process, if the bacteria are not happy the biogas will not be created. Biological management protocols and KPIs have a key part to play.
- Modify, adapt, evolve with engineering challenges. The best AD plants have in-house operations and maintenance teams that take responsibility, can react quick and do not rely on third parties. Not the cheapest but will likely pay dividends.
- AD plants must be designed in order to maximise the full energy flows. All heat flows need to be valorised to the maximum. Third party heat supply arrangements in an ideal world but in feedstock pre-treatment at the very least.
- Co-digestion with sewage sludge. Sewage sludge is a feedstock that will only increase with increasing population. It is one of the few readily accessible 'wastes' that can be secured at a competitive price due to the diverse geographical distribution of treatment works.

This French AD plant uses food waste collected from commercial premises.

Chris Rose NSch 2018: https://tinyurl.com/5ffus9xk

THINK AHEAD

The circular farm

Wageningen University's 'circular farming lighthouse farm' project provides an insight into what is possible for circular farming. One lighthouse farm is run by the Maj family in Belvadia, Latvia.

The farm ignores the concept of 'by-' and main products, with the family milking 1,000 cows on 4,000ha. Milk is the offshoot of manure production, manure enters the farm's AD plant, producing enough electricity for 2,000 homes, the offshoot of the electricity is heat. The heat is used to warm water in which sturgeon and eels are raised. In two years, the sturgeon grows to 10kg and is then processed and sold. The fish is not the end of the story; caviar from the mature sturgeon is the farm's final product.

The farm has carefully examined its flows and mass balances of biomass and energy and created a model that makes every asset, be it land, stock, the anaerobic digester, or the fish farm, work to best use all mass and energy from each interlinked enterprise to maximise the flow of money.

GLOBAL NETWORK OF LIGHTHOUSE FARMS

Lighthouse Farms are an insight into what is possible for circular farming.

Charlie Steer NSch 2019: https://tinyurl.com/2ahvxsxe

The soil carbon market (SCM)

The soil carbon market (SCM) may not be the transformative panacea envisioned. It is uncertain whether the offset SCM will be a suitable instrument for driving genuine climate change mitigation, or agricultural transformation. It could have a role to play in future if the carbon price increases, even then its impact may be limited to small changes.

Carbon farming benefits farmers and the environment, disseminating new knowledge and understanding into the farming sector. However, the potential of carbon farming to mitigate climate change is uncertain and strongly debated.

KEY RECOMMENDATIONS:

- Farmers should focus on climate change 'adaptation', as opposed to 'mitigation'.
- Proceed with caution and consider the risks of SCMs. The risks of the offset SCM may currently outweigh the benefits. A major risk is farmers getting embroiled in 'greenwash' and damaging their own credibility.
- Mitigate risks by pursuing other private markets for non-offset based carbon outcomes, e.g. insetting within the supply chain, and other business models.
- Policy, entrepreneur-led innovation (Regenpreneurship), new markets and social cooperatives could also be vital drivers of change in agriculture.
- Farmers should spearhead internal transformation of the sector. Otherwise, external forces will likely impose unwanted changes instead.
- Keep an eye on SCMs but keep expectations realistic, don't allow it to delay decision making. The challenges are clear enough to proceed in a direction. The risks of delaying action are bigger than the benefits.

Proceed with caution and consider the risks of SCMs, says Ben Hunt.

Ben Hunt NSch 2022: https://tinyurl.com/4pb5tt6f

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Farming carbon-neutral insects for food and feed

As population levels rise, it is expected that livestock consumption will increase, generating a greater demand for nutritious protein sources for humans and animals. Edible insects offer an alternative protein source to soya, suitable for both humans and animals.

At present, producing insects for food and feed is constrained by limitations in scale, high costs, and inconsistent quality. Improvements like automation, enhanced insect genetics, and optimised diets are crucial for advancing insect farming, as is understanding insect diseases and pests.

Carbon-neutral insect farming is possible when waste unsuitable for animal consumption becomes insect food, instead of soya-based materials. Using livestock manure as insect food could be a strategic alternative, subject to careful risk assessment. Blending waste as a substrate for insects and integrating renewable energy can establish carbon-neutral insect farming as a viable option.

In the UK, supermarkets and feed producers alike are exploring soy alternatives in livestock diets. However, insect meal is about ten times the cost of soya (at a comparable 50% protein level) – a key barrier.

While the demand for costly and unfamiliar insect-based foods and feeds might be limited at present, overcoming challenges through ongoing research and innovation could position insect farming as a pivotal player.

Crickets packaged and available for human consumption in Canada.

Olivia Champion NSch 2022: https://tinyurl.com/ys75en3u

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IN SUMMARY

This Bitesize Guide, from the Nuffield Farming Scholarship Trust and RASE, provides a snapshot of the breadth and depth of reports available at

https://www.nuffieldscholar.org/reports

The website also features reports from global Nuffield Scholars, including Australia, New Zealand, USA and Brazil. The reports are a rich source of inspiration, case studies and thought-provoking recommendations for agriculture.

Please get in touch at info@rase.org.uk if you have questions, comments or feedback.

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