SOIL CARBON MATTERS

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Kite

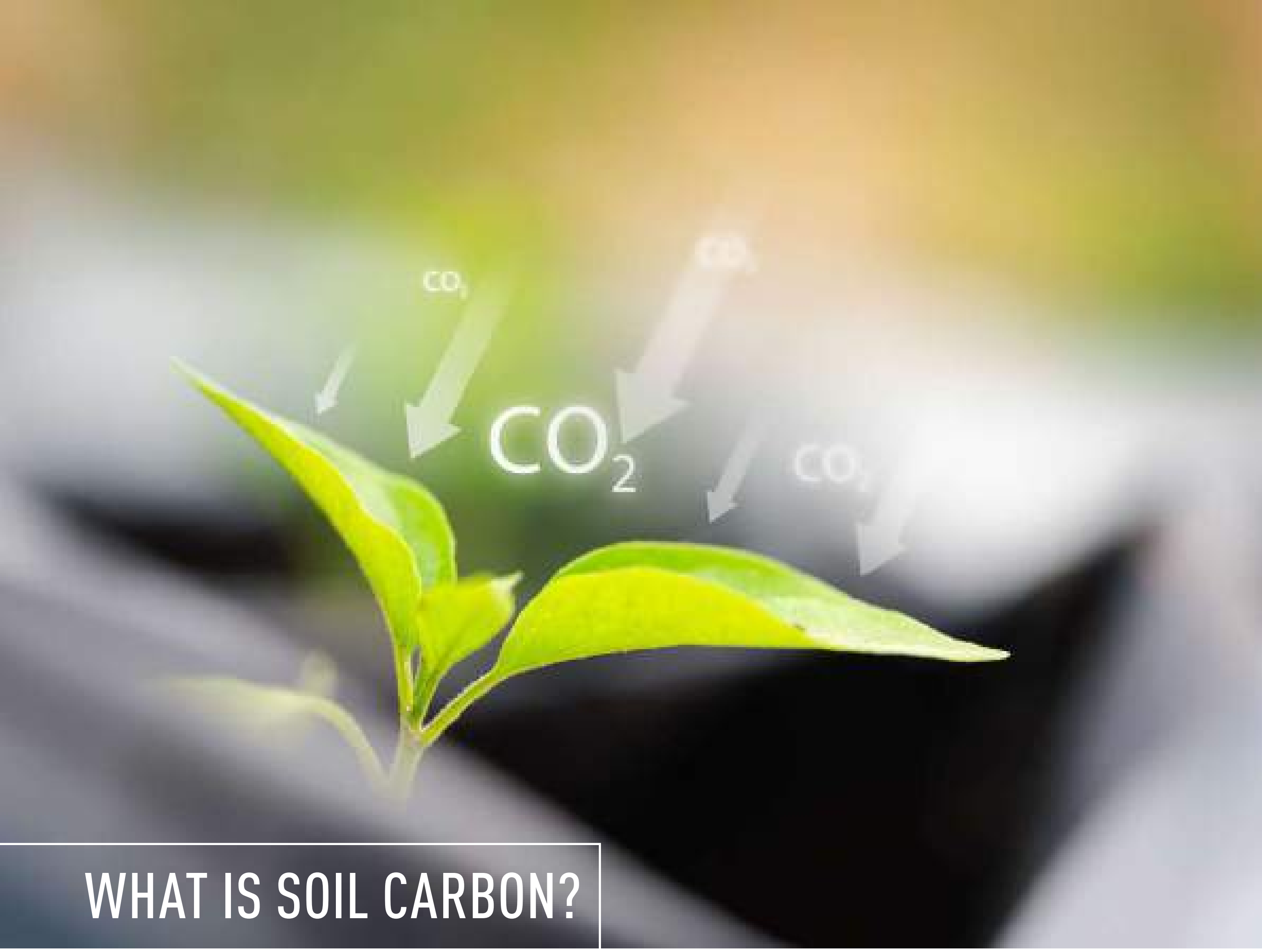
INTRODUCTION

The agriculture sector, whilst being an emitter of greenhouse gas emissions, has the potential to offer a solution to climate change through carbon sequestration – the process of carbon capture and storage.

Soils are the largest terrestrial carbon store on earth. With the right management, its capacity to sequester and store carbon can be increased. Yet, while the potential is there, uncertainty remains as to how carbon sequestration can be credibly measured and accounted for in the supply chain.

Questions remain around how long carbon is stored in the soil, how much additional carbon can be sequestered, how to accurately monitor and understand soil carbon levels and who 'owns' any carbon credits. Yet, despite these uncertainties, there is no doubt that healthy soils are vital to farming's productivity, resilience and climate impact.

In this paper, Kite Sustainability Lead, Helen Dent explores some of the key considerations for dairy farmers and milk processors on this complex topic.



WHAT IS SOIL CARBON?

Carbon is found in two forms within the soil:

Inorganic soil carbon is derived from mineral composition of soils, for example, chalk (calcium carbonate) and limestone. Inorganic carbon is impacted more by weathering and geology than management.

Organic soil carbon is organically derived from the breakdown of plant or animal material and is impacted more by biological systems and management approaches.

- **Soil organic matter** (SOM) is a different term, but one that is often used interchangeably with soil carbon (SOC). This is due to the direct relationship between SOM and SOC, with soil organic carbon comprising approximately 58% of soil organic matter. SOM constitutes a living fraction (microfauna, mesofauna, macrofauna and plant roots) and a non-living fraction of detritus and humus.
- **Soil Carbon Storage** is the **total** amount of carbon contained within the soil. The soil carbon stored in agricultural soils has built up over time and must be protected. Disturbances to soil, or land management changes can release stored soil carbon which releases carbon dioxide to the atmosphere.
- **Soil Carbon Sequestration** is the **increase** of carbon contained within the soil over time, where the rate of soil carbon addition is greater than the rate of decomposition or loss. Soil carbon sequestration is often confused with the carbon held short-term within plant biomass, such as grass. Although plants do take-up atmospheric carbon dioxide for photosynthesis, this is only held short-term in plant material, and will be released when the grass is digested or decomposed.

NOT ALL SOILS ARE EQUAL

The UK is geographically diverse, with a variety of soil types, all presenting differing soil carbon levels and sequestration potentials.

That said, there are three main pools of organic matter present within soils, which contribute to soil carbon levels:

Fresh plant residues such as decaying roots, which fuel biological soil processes	Decomposing (active) organic matter	Stable organic matter (humus)

Although the stable pools of organic matter are beneficial for long-term carbon storage, the active pools of carbon have an important role within biological processes, nutrient cycling and soil structure.

As well as mitigating climate change through soil carbon, soil organic matter has many benefits to the farming system, including:

- Improved soil structure, friability and workability
- Greater window for mechanical operations
- Improved water holding capacity, drainage and infiltration
- Reduced risk of erosion, compaction and capping
- Improved drought resistance
- Improved waterlogging resistance and flood management
- Increases cation exchange capacity
- Buffers pH, reducing lime requirements
- Contains and supplies nutrients such as N, P, S
- Provides a food source for soil organisms, improving soil biological activity

HOW TO IMPROVE SOIL ORGANIC CARBON?

Soil carbon is part of a biological system with inputs and outputs that are influenced by many interacting factors.

Environmental factors include moisture, temperature, pH and soil texture. Human factors include type and quantity of plant residues, carbon to nitrogen ratios of organic additions, cover crops, tillage and cropping.

The input phase is where soil sequestration is occurring; in other words, the state where soil carbon inputs are exceeding soil carbon outputs, leading to increased soil organic carbon stocks. Outputs include oxidation, erosion, leaching and removals off-site.

It is the balance between carbon inputs into soil and the processes that release carbon back into the atmosphere (outputs) that determine soil carbon stocks, which can vary greatly across a single field, depending on differences in soil properties.

Increasing soil carbon is a slow process, as it is limited by the amount of carbon fixed by photosynthesis or applied through organic additions. In contrast, the processes that cause carbon to be released back into the atmosphere—microbial, plant respiration, human factors—are relatively unconstrained, so soil carbon levels can decline very quickly when not managed correctly.

As such, a soil's carbon sequestration potential only really changes if a farmer changes what they are doing to the soil – either through stopping a practice that might degrade soils, or by introducing a practice that enhances it (commonly this is what 'regenerative agriculture' refers to).

Soil carbon not only takes a long time to accumulate, it can plateau. Soil organic inputs must continue to exceed outputs to achieve continual sequestration. The job then is to maintain it.

A useful analogy perhaps is going to the gym. Over time, with the right inputs and management, you will build muscle. Once optimum muscle mass has been achieved, it then must be maintained. If you stop going to the gym, those muscles will decline.

Land on dairy farms has, generally speaking, been well managed. Farmers have introduced longer term leys into their rotations, with regular additions of organic material. Yet, while there will doubtless be potential to increase soil carbon, some dairy farms are likely to have reached, or be close to reaching, the plateau stage. Maintaining soil carbon is equally important in these situations.

In practice, where farms are looking to improve soil carbon/organic matter, they may look to incorporate the following practices:

Improved grassland rooting

Rotational grazing

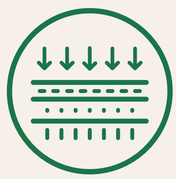
Herbal leys where appropriate

Reduced tillage

Cover crops – always having green leaf area

Organic amendments

Grassland integration to arable systems



Reducing soil compaction

SOIL CARBON MATTERS

Although soil carbon sequestration has many benefits for farming and the environment, there are several matters that should be considered regarding the transference of soil carbon into 'carbon credits' for emissions offsetting.

One issue is the 'permanence' of soil carbon. Soil carbon stored can easily be released with land-use and management changes and therefore requires continual monitoring to be guaranteed. Typically, 100 years is considered a benchmark for soil carbon to be considered permanent.

For example, one tonne of additional CO_2 stored as organic carbon today cannot be considered as one tonne of CO_2 emissions 'offset', unless there is an assurance that the same one tonne of carbon will still be in the ground in 100 years' time - otherwise known as 'long-term storage'.

Saturation is another debated topic. It is widely accepted that there is an 'upper-limit' to the amount of carbon a specific soil can absorb, which is related to the surface area of the soil particles. Once the upper-limit is reached, a soil is said to have reached carbon saturation.

The saturation level will vary based on soil type and management, as well as other factors. There is research to suggest that, on permanent pasture, soil carbon can continue to build and have not yet reached their theoretical carbon saturation point, but the science is unclear. The New Zealand Agricultural Greenhouse Gas Research Centre1 (NZAGRC) is currently funding a long-term national-scale benchmarking and monitoring study to look at whether New Zealand's soil carbon stocks under agricultural land are increasing or decreasing.

Finally, accurate and consistent testing for soil carbon presents one of the biggest difficulties. There are several methods used across the UK and throughout the world. High natural soil carbon variation makes it difficult to prove that any small percentage change gained through sequestration is statistically significant. A rigorous, and scientific method should be followed which can be repeated in following years.

[1] Funded by the NZ Government to invest in and coordinate research aimed at helping reduce New Zealand's agricultural greenhouse gas emissions.

HOW DO GREENHOUSE GAS CALCULATORS ACCOUNT FOR CARBON?

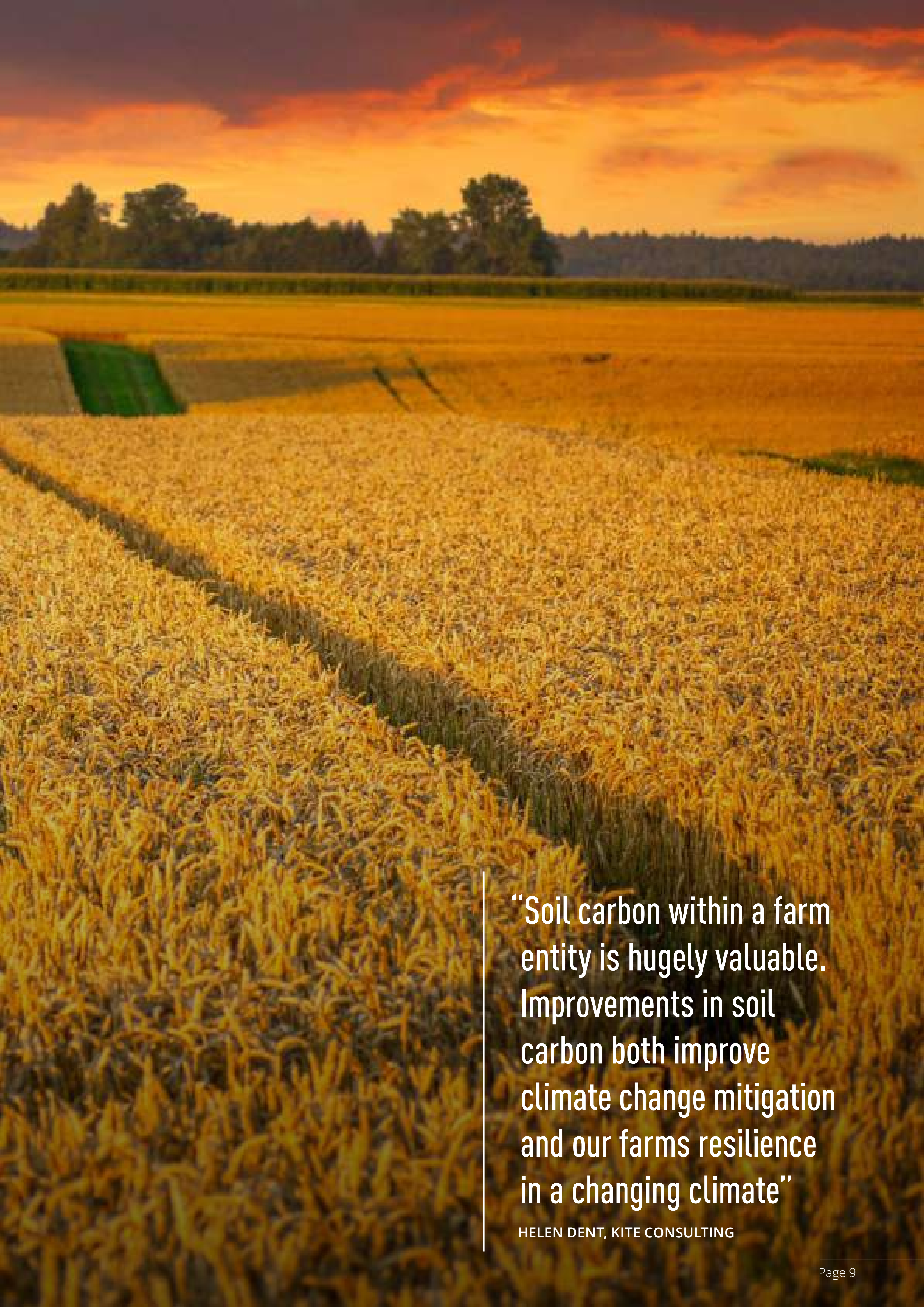
Some greenhouse gas calculators include soil carbon within their calculations, for example: Cool Farm Tool and Agrecalc use IPCC tier 1 methodology, (with slightly different data entry methods), while Farm Carbon Toolkit asks users to enter in soil carbon data (from sampling).

Such models consider factors such as grass growth, land use changes, management and nutrient inputs to determine whether soil carbon levels are changing, and these changes are assumed to occur over a 20-year period.

Generally, where it is estimated, soil carbon is considered at an enterprise level and is not deducted from, or allocated in any way to, the carbon footprint of the agricultural product being assessed (e.g. CO_2e per litre of milk). This is because the emissions associated with producing a litre of milk measure combine all the inputs against the final output, in isolation of the wider farm, as per the Greenhouse Gas Protocol for a product footprint boundary.

Soil carbon may be offered as a stand-alone calculation from the carbon footprint of the product (e.g. milk). Even then, greenhouse gas calculators can only provide an indication of soil carbon changes. Soil carbon is a variable biological system. Therefore, the only true way to measure and assess soil carbon levels and trends is to correctly sample soils over time.

All facts regarding calculations are correct at time of publishing.



"Soil carbon within a farm entity is hugely valuable. Improvements in soil carbon both improve climate change mitigation and our farms resilience in a changing climate"

HELEN DENT, KITE CONSULTING

THE CARBON MARKET: OPPORTUNITY OR 'WILD WEST'?

The role of soil carbon credits in the quest for reaching net zero, at a company, sector or national level, may be widely discussed, but is not particularly well defined or understood. We won't pretend to solve that debate here, but we can reflect on some of the considerations for farmers and processors at this time.

One of the first considerations is how soil carbon credits may be used and to appreciate the difference between 'offsetting' and 'insetting'. Put simply, offsetting occurs outside a supply chain, and insetting occurs within a supply chain. As an example, a dairy supplier may (in time) provide credits to his milk processor, who may in turn credit these against the volume of milk sold to a retail customer. Emissions 'ownership' goes up the supply chain as the product is sold. Hence why the drive to reduce emissions generally comes from the top of the supply chain and works its way down.

INSETTING	OFFSETTING
Directly addressing internal carbon emissions and reducing them	Reducing emissions elsewhere, not addressing internal emissions

Reducing CO_2 emissions internally	**Continually emiting CO_2 Buying carbon credits**

As of 2021, the Woodland Carbon Code and the Peatland Code are the only two offsets schemes accredited by the UK Environmental Agency. More offset schemes may be added in the future; however, there isn't yet a soil carbon code. There are many international carbon offset schemes available that have been verified by Verra, Plan Vivo, or Gold Standard. These standardisation bodies offer certification and validation for companies seeking to purchase offsets.

Whilst the long-term benefits of a regulated and transparent carbon market include financial reward for the owner of the credits, improved soil health and lower emissions; currently there is more uncertainty than clarity. At this time, farmers and landowners wanting to understand more about the potential role of carbon markets in their business might consider the following:

- Are you currently, and accurately, testing and monitoring soil carbon levels?
- How might any soil carbon sequestered be calculated and verified? Consider the verification process of the carbon credit carefully. It needs to be highly rigorous and trusted, there are minimal acknowledged international standards at present.
- Are any 'carbon credits' you might have best reserved for use within your own supply chain, or sold outside of your supply chain? Have any conversations taken place with your customers about the role of carbon credits in reaching net zero targets?
- If selling credits, consider the contract and seek legal advice before signing to understand all clauses relating to the credits, values and land management/ownership implications.

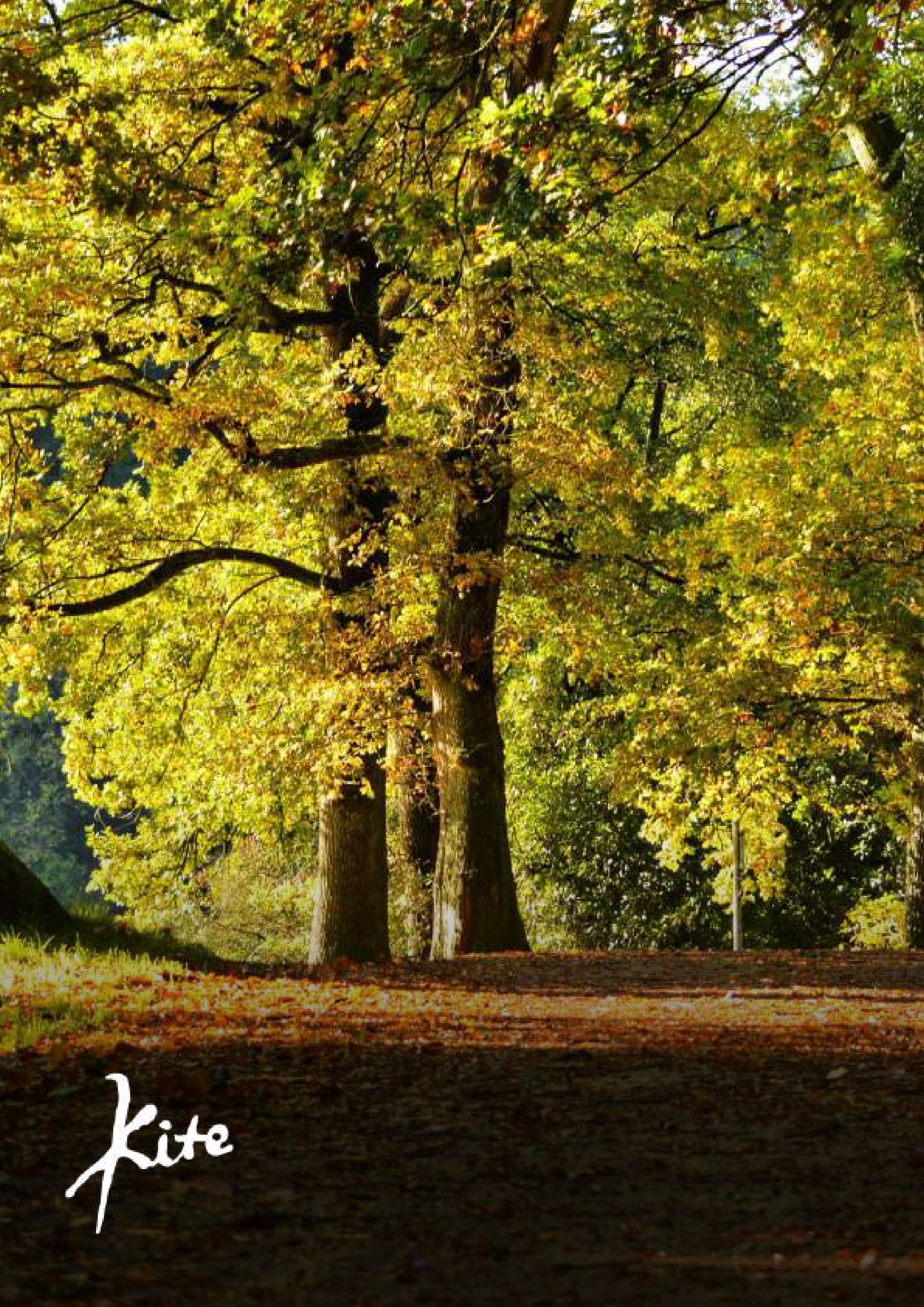
Many companies in the UK food supply chain, including supermarket retailers and dairy processors, have adopted Science-based Targets (SBTs), committing them to reduce emissions from food production and distribution. For companies that have significant volumes of agricultural products in their supply chains, the standard recognises the potential to balance emissions produced with the sector's ability to remove emissions also.

The SBT Initiative recognises the ability of plants to sequester carbon and store it in biomass and soils; describing this potential for carbon removal as the sector's 'secret weapon'. It is estimated that these carbon removals could make up half of the mitigation potential in the food, land and agriculture sector. As such, companies in this sector will soon start accounting for carbon removals in their targets, alongside making deep emissions cuts.

That means the conversation and clarity needed to consistently account for carbon removals in the agri-food supply chain is firmly on the agenda for all big food businesses.

"Right now, dairy farmers should stay focused on cutting emissions from milk production, and building and testing soil carbon on their farms. But watch this space, because exciting developments on the role of soil carbon credits in UK supply chains are most definitely on the horizon."

HELEN DENT, KITE CONSULTING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