CASE STUDY – Improving soil

This case study applies the Natural Capital Protocol to a practical example.

FRAME STAGE: Why?

Step 01: Get started

When farmer Richard Pettit took over Den Farm in 2016, he realised the soil of this 129ha farm was degraded and suffering from compaction, due to:

- Drainage in disrepair
- Mono-cropping during previous tenancy
- Lack of soil organic matter
- Low soil pH (acid soil) preventing the uptake of soil nutrients

Richard undertook a variety of measures to improve soil condition, in order to improve crop yield, breed/produce healthy livestock, and increase the resilience of his business.

SCOPE STAGE: What?

Step 02: Define the objective

The objective of this case study is to understand what impact Richard's activities to improve soil health have had on natural capital, as well as providing a high level cost/benefit analysis (incorporating financial costs and natural capital costs/benefits).

Step 03: Scope the assessment

This case study assesses the impacts of improving soil condition to increase productivity, including:

- drainage repairs
- adding lime to reduce acidity
- applying farm yard manure to increase organic matter
- applying other fertilisers and trace elements based on soil analysis

Step 04: Determine the impacts

The material impacts of arable and livestock enterprises are on crop production, livestock production, climate regulation (greenhouse gas emissions), soil quality, disease and pest regulation, and wild species diversity.

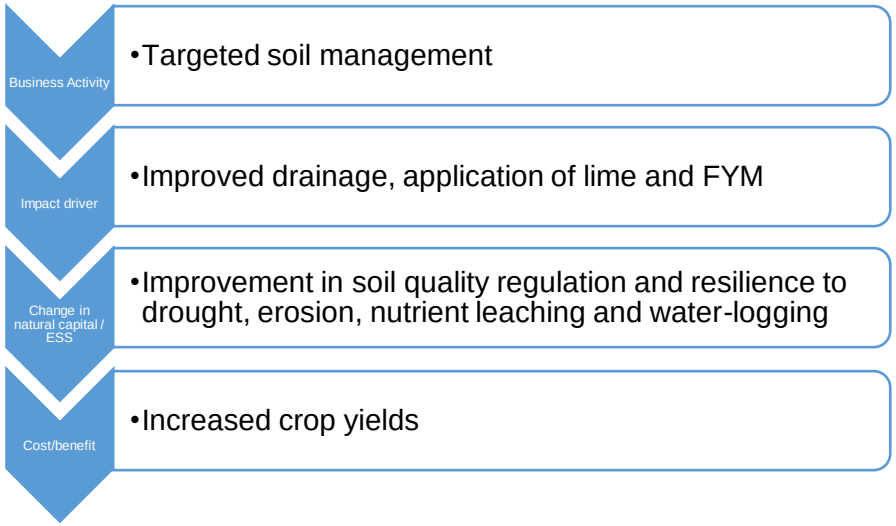
MEASURE AND VALUE STAGE: How?

Step 05: Measure impact drivers

Climate regulation; the main impact drivers for changes in greenhouse gas emissions (GHGs) are habitat cover and land use change, the number of livestock and the energy required for operating crop and livestock enterprises. For example, practices such as conservation tillage (e.g. no/min-till), retaining crop residues, including cover crops in crop rotations, and adding organic nutrient sources such as manure, all reduce carbon dioxide emissions and help to sequester atmospheric carbon in soil organic matter. No measures of GHGs are currently available for Den Farm, but it is anticipated that a carbon footprint analysis will be carried out in due course, as part of the QMS (Quality Meat Scotland) scheme.

Soil quality regulation; the main impact drivers here are changes in drainage and the application of lime and farm yard manure. Improving drainage reduces water-logging and restores soil microbe populations. Applying lime helps to reduce soil acidity, which improves microbial activity and the availability of nutrients. Applying farm yard manure adds humus and structure to the soil and encourages earth worms. All of these changes have the effect of improving soil quality, increasing soil fertility, and aiding water and nutrient retention.

The impact pathway showing the 'logic chain' from business activity to impacts on natural capital and the costs and benefits associated with these impacts is shown below.



Wild species diversity; the nature of crop and livestock production is not beneficial to wild species diversity (e.g. pollinators and birds), as these enterprises are based on growing a restricted number of cultivated species. However, soil rotation and adding organic matter does improve earthworms and micro-organisms. There was no data on biodiversity and soil biota available for Den Farm.

Step 06: Measure changes in the state of natural capital

Table A below sets out the asset register for this case study, detailing the interventions taken to improve soil quality on Den Farm and the resulting changes in the state of natural capital on-farm. There are also off-farm impacts to consider, such as the impact of sourcing lime and minerals from elsewhere, but these are outside the scope of this study. Adding lime to soil improves pH and uptake of other soil nutrients, such as phosphorus. Phosphorus is a finite (limited) resource. Resource efficiency is key: Richard used soil analysis and advice to understand the right amount of inputs required, reducing waste. Field margins on the farm prevent leaching of nutrients to water courses. Crop rotation, livestock manures and min-till farming, may help reduce the amount of fertilisers required in the future.

Table A: Case study asset register

		Start of tenancy 2016		Management interventions	Current status 2017	
	Natural capital asset	**Hectares**	**Data source**	**Activities undertaken**	**Hectares**	**Data source**
Extent	Cropland	121	Savills	Laid 42 ha to grass	86	Farm map
	Temporary pasture	5	Savills	Increased grassland to 42ha	42	Farm map
Condition	**Quality Indicators**	**Status / Score**	**Data source**	**Activities undertaken**	**Status / Score**	**Data source**
	Organic matter	completely lacking	Observation farmer	Added farm yard manure	Some organic matter in soil, but expected to be still low	Farmer
	Drainage	in state of disrepair due to deep ploughing by previous tenant	Observation farmer	Repaired most drainage	Majority of drainage repaired	Farmer
	Soil structure	high levels of compaction	Observation farmer	Cultivating practices; plough, press and one pass harrow/drill/roll	The soil is still quite compacted.	Farmer
	pH	low from 5.0 - 5.9	soil tests	Liming the soil to increase pH to improve uptake of nutrients and crop yield	pH increased, but still low. Can only be built up in stages	Farmer
	Extractable P	Lowerhalf of moderate	soil tests	Nutrients added according to advice based on soil analysis	Not known until future soil test	not available
	Extractable K	Upperhalf of moderate	soil tests			
	Extractable Mg	Low to moderate	soil tests			
	Trace elements	copper and zinc deficiencies	leaf analysis	Give nutrient bolus to cattle to improve cow and calve health		

Step 07: Value impacts

Soil improvement costs and crop yield increases are set out in Table B.

Table B: Costs and yield increases

T0 = start of tenancy 2016; T1 = 2017; T2 = 2022

Soil improvement cost	T0	T1	T2	Notes
- materials	£1,380	£4,054	£1,536	33% is cost of nutrients
- labour	£160	£942	£342	
- other costs	£0	£1,848	£856	
Total cost of soil improvement	**£1,540**	**£6,845**	**£2,734**	
Crop yield increase	**T0**	**T1**	**T2**	**Notes**
spring barley - t/ha	5.8	6.2	6.8	based on 63 ha
winter wheat - t/ha	8.4	8.9	9.4	based on 10 ha
spring barley - additional yield £		£4,032	£10,080	T2 compared to T0
winter wheat - additional yield £		£680	£1,350	
Total crop yield increase		**£4,712**	**£11,430**	

Costs to improve soil quality include bought-in lime (for 46ha in T1 and 32ha in T2) and fertilisers (yearly, for 128ha), adding farm yard manure (free, apart from application costs) and repairing drainage.

Crop yield gain:

- Reducing nutrient deficiencies makes plants stronger/healthier, more resistant to disease and pests, increasing yields.
- Spring barley is increasing from 5.8 t/ha in T0 to 6.8 t/ha by T2, with yields increasing by £4,032 in T1 and £10,080 by T2 (based on 63 ha and 2017 prices)
- Winter wheat is increasing from 8.4 t/ha in T1 to 9.4 t/ha by T2, with yields increasing by £680 in T1 and by £1,350 by T2 (based on 10ha and 2017 prices)
- After T1, the increase in crop yield starts paying back the costs of soil improvements.

A summary of the marginal costs and benefits is set in Table C. This represents an approximate benefit-cost ratio of 4.2:1 by 2022.

Table C: Marginal costs and benefits

Year	2016	2017	2022
Costs	£1,540	£6,845	£2,734
Benefits	-	£4,712	£11,430

In addition, there are animal health and welfare gains:

- Calves reared; 40 calves were reared from 40 suckler cows, higher than the industry average (Nix 2017: average 91 out of 100, equivalent to 36.4 calves reared)
- Reduction in vet & med costs: slight reduction expected.

APPLY STAGE: So what?

Step 08: Interpret and test results

Since Richard has taken over the tenancy of Den Farm, he has made a significant investment in soil quality (part of a five year plan). Harvest results for 2017 show higher yields than at the beginning of the tenancy. Further liming will be required to increase pH to the right level. Given the high cost of adding nutrients, there is a balance to be struck between increasing yields and adding costs.

Step 09: Take action

Adding farm yard manure will further improve soil organic matter and soil structure at little cost. Rotational crops may help keep up fertility of the land. Cover crops and min-till farming could also help improve the soil. In future, precision farming using GPS-technology may help pinpoint specific areas that need additional nutrients, enhancing resource efficiency of the farm.