Living document version 1.0 , August 23rd, 2020*

Application of the Natural Capital Protocol at Glensaugh Farm

The James Hutton Institute

Author: Paola Ovando

Contact: Paola.OvandoPol@hutton.ac.ac.uk

This is a living document with the version, authors, and publication date above referred. This document is expected to evolve and expand through successive updates, changes, and adjustments. You are invited to provide comments, new evidence, reliable sources, and data to refine Glensaugh 's natural capital assessment study, and in that way contribute, subject to revision and verification, to the new version of this document.

Please send us your comments and suggestions through the following link: (Glensaugh-NCP)

Executive summary

Aims and approach

1.01 The overall aim of this project is to evaluate the impacts and dependencies of past, actual, and potential changes in Glensaugh farm management strategies through a natural capital lens. More specifically this project analyses the potential and value of applying the Natural Capital Protocol (hereafter "the Protocol") to land-based business. In doing so, it explores how the Protocol can be applied and used to support and evaluate land-based business decision making in Scottish upland farms.

1.02 The application of the Protocol builds upon the Natural Capital Protocol and its sectoral guides for Forest products, Apparel and Food and Beverage developed by the Natural Capital Coalition, and the practical guide for land managers and advisers developed by the trial application of the Protocol to Crown Estates Scotland (CES). This project tests the application of the Protocol in a case study where long-term environmental and economic data sets are available. Our application goes further than the CES Protocol trials by developing a detailed assessment of time series data to estimate a set of quantitative and monetary indicators of changes in the dependencies and impacts of land-based business on natural capital.

1.03 The Protocol is applied to Glensaugh, one of the three Research farms belonging to the James Hutton Institute, which has a long legacy of research and data collection. The farm is located in the Grampian foothills of Aberdeenshire, covering close to thousand hectares. The primary land-based business at Glensaugh is commercial livestock (beef-cattle, sheep, and deer) farming, which is supported by an extensive grazing resource. Glensaugh is considered representative of Scottish upland sheep and beef-cattle farms.

1.04 The application of the Protocol uses data gathered at the farm level over the last 20 years. Those include data collected by the Environmental Change Network (ECN), farm accounts and reports that allow tracing back a group of site-specific indicators on land management and environmental performance. The analysis is complemented with a literature review and consultations with stakeholders and experts.

1.05 The natural capital assessment includes a retrospective analysis of management decisions on the farm covering the period 2002-2018. Over this period, Glensaugh has experienced changes in its land use and management, involving a shift in objectives from maximizing agricultural production to agriculture with increased environmental benefits. These changes include (in line with the industry trend) a reduction in livestock numbers and the use inputs, such as chemical fertilisers, but also a diversification of farm enterprises through investment in woodland expansion, renewable energy sources (mainly wind and solar energy), and rural tourism activities.

1.06 In addition, our assessment includes a prospective analysis of natural capital investment decisions aimed at enabling a transition to low carbon farming. More specifically, this report applies the Protocol to measure and value natural capital impacts of woodland expansion investment in Glensaugh. Our analysis considers alternative native and non-native trees species, and analyzes their economic and environmental performance, while assessing the main trade-offs of carbon sequestration, timber, biodiversity conservation, and other ecosystem services.

Summary of results and key findings

Main natural capital dependencies: Traditional and diversified farm enterprises are dependent on natural capital and the range of ecosystem services that flow from them:

2.01 Livestock farming mainly depends on biomass from cultivated terrestrial plants in the form of swards and own-produced conserved winter feed (haylage and silage), which today cover about 89 percent of the farm's total livestock metabolic energy requirements. The hill sheep flock basically depends on extensive grazing resources, while between 30 to 50 percent of the low-ground sheep flock, beef-cattle, and deer energy requirements are covered by haylage and silage.

2.02 The farm's livestock, crop and forestry enterprises all depend on regulating services. In particular, the regulation of soil quality through decomposition and fixing processes that affect soil nutrient availability and biota, local climate regulation through the provision of shelter and shade by trees and woodlands to cattle, sheep and deer, pest and disease control to maintain cultivated plants and livestock production, and the maintenance of wild species and habitats that (as well as their biodiversity value) provide recreational opportunities for tourism, fishing and game shooting.

2.03 The land-based businesses of Glensaugh also depend on ecosystems that provide the basis for scientific research and for ecological knowledge and understanding to be built up over many generations, contributing to knowledge advancement, upland management culture and heritage.

Changes in natural capital state and condition: Table S1 shows a summary of main natural capital of Glensaugh farm, and trends in natural capital extent and condition over the period 2002-2018.

2.04 The most significant change in the extent of natural capital in Glensaugh is woodland expansion, which has reduced the area of both improved grasslands and semi-natural plant communities (i.e. acid grassland and dwarf shrub heath). More than 50 ha (accounting for 5.1 percent of the farm area) of new woodlands have been planted in the farm since 2002, using mainly a mix of native woodlands, with Scots pine as dominant species, and Larch, Ash, Hazel, Aspen, Holly and Juniper, as part of the species mix.

2.05 While most of the ecosystem assets have a moderate to good status, changes in crop and livestock management strategies and woodland expansion have improved the condition of overall natural capital in terms of their capacity to deliver ecosystem services.

2.06 There is evidence of a slight improvement in the water quality, substantiated by a reduction in the concentration of nitrates and phosphates in water and soils. There is also a traceable improvement in 'climate change regulation service', with net greenhouse gas emissions (GHG) having experienced a reduction greater than 20 percent since 2008. This reduction is mainly due to a decrease in livestock numbers, a decrease in fertiliser-induced emissions, and a partial substitution of fossil fuels and grid power by on-farm production of renewable energy.

Table S1 Glensaugh natural capital status and trends 2002-2018

Ecosystem asset (broad habitat)	Trends (2002-2018)		Current status
	Extent	Condition	
Enclosed farm: Temporary pasture (45.0 ha)	↘	→ ↗	
Enclosed farm: Permanent pasture (67.4 ha)	↗	→ ↗	
Agroforestry plot (10.2 ha)	→	→	
Seminatural grassland and dwarf shrub heath (640.2 ha)	↘	↗	
Blanket bog (grass and heather dominated) (131.7 ha)	→	↗	
Woodland (66.0 ha)			
Coniferous woodland (20.6 ha)	↗	↗	
Broadleaf woodland (11.6 ha)	↗	↗	
Mixed and other woodland areas (33.8 ha)	↗	↗	
Freshwaters (7.3 ha)	→	↗	

Where the following arrows indicate: "↗" improving/growing, "→" stable ; "↘" decreasing/shrinking. The Status colours indicate: Good; Moderate; Poor , which is defined according to the relative composite wildness index, ecological water conditions, and literature review (see sub-section 2.3.1).

Natural capital impacts: Table S2 summarizes the estimated impacts on natural capital of the main land use and management decisions in Glensaugh since 2002. Those impacts are framed in terms of the ecosystem services delivery.

2.07 Ecosystems assets (broad habitats) simultaneously generate multiple services, although it is generally not possible to manage those habitats to simultaneously maximize all services, and as a result, trade-offs can occur. In Glensaugh the consequence of woodland expansion on the maintenance of wild species associated with semi-natural plant communities where those plantations took place, and the protection of soil carbon stocks need to be carefully addressed.

2.08 The evidence of changes in biodiversity is inconclusive at the farm scale. Glensaugh is one of the terrestrial monitoring sites of the ECN which includes biodiversity surveys of the presence and abundance of butterflies, carabids, spittle bugs, bats, birds, and frogs. ECN data show variations in biodiversity over time, but no clear trends either in the number of individuals of specific invertebrate or vertebrate species counted or in the number of species identified.

2.09 The effect of woodland expansion on wild species diversity needs some further examination, as it would depend on the type of woodland planted and their management. The literature suggests that commercial tree plantations (i.e., oriented to timber production) established on semi-natural plant communities will affect the diversity of wild species associated with these habitats. But there are biodiversity trade-offs. For example, woodland expansion if properly done can provide new habitat and enhance habitat connectivity for species

such as woodland birds. Existing woodlands in Glensaugh involve mainly native species that form relatively continuous and connected forest strips, which in principle is expected to enhance biodiversity conservation, while increasing timber and biomass production in the future. Currently three-quarter parts of woodlands in Glensaugh comprise trees with an age lower 10 years.

Table S2 Estimated changes in delivery of ecosystem services due to changes in land use and management

	Provisioning				Regulating & mantainance										Cultural			
	Cultivated plants & reared	Wild plants and animals (biomass)	Water supply (quantity)	Energy supply	Biological pest and disease	Global climate regulation	Local climate regulation	Control of erosion rates	Habitats and wild species	Pollination	Freshwater quality	Regulation of soil quality	Water flow /flood control	Wate water treatment	Aesthetic	Cultural and heritage	Knowledge systems Social	Recreation and ecotourism
Woodland expansion																		
Commercial plantation (timber)	↗	↘	→	↗	↘	↗	↗	↗	↘	↘	↗	↗	↗	↗	→	↘		↗
Seminatural woodland (amenity/conservation)	↗	→	→	↗	→	↗	↗	↗	↗	↘	↗	↗	↗	↗	↗	↗	↗	↗
Agroforestry	↗	→	→	↗	→	↗	↗	↗	↗	→	↗	↗	↗	↗	↘		↗	↗
Grazing management																		
Rotational heather burning	↗	→	→			→		↘	↘		↘	↘			↘	↗		↘
Reduction in fertilizers & increased liming	↗	↗	→			↘		→		→	↗	↗	→		→		↗	→
Livestock management																		
Reduction on livestock numbers	↘	↗			↗	↗		↗	↗		↗	↗						
Production of winter feed	↗	↘	↘	↘	↘	↘		↘	↘		↗	↘		↘	↘		↗	
Renewable energy production (solar, wind)				↗		↗			→						↘		↗	↘
New recreational services			↘	↘							↘			↘		↗	↗	↗

(Note: For more details see sub-sections 2.4.2 and A.2.3 at the Supplementary material)

Potential changes in ES delivery

Not relevant		Un-known		Stable/neutral	→		
Improvement	High	↗	Moderate	↗	Low	↗	
Decline	Low	↘	Moderate	↘	High	↘	

2.10 Woodland expansion has improved the GHG emissions balance in Glensaugh over the last decade. The existing and newly planted woodlands were estimated to remove about 128 metric tonnes (t) of carbon dioxide (CO_2) from the atmosphere by 2018. This figure is expected to rise in the future considering that the early-years carbon sequestration balance includes initial soil carbon release due to assumed ground preparation practices (included in the models used).

2.11 GHG emissions from land-based business are still relatively large in Glensaugh, mainly due to livestock enteric fermentation and feed related GHG emissions, but also due to the consumption of fossil fuels, biomass burning and grid power consumption. There is some uncertainty regarding livestock farming GHG emissions in Glensaugh, as the two carbon auditing tools tested provide different results.

2.12 Changes in the management of crop, grassland, and livestock enterprises towards a reduction in inputs, and an increased dependency on grazing resources, has been translated into cost saving and increased efficiency. For instance, the ratio between net profits and GHG emissions by standard livestock unit has increased for all livestock enterprises (i.e., low-ground sheep, hill sheep, beef-cattle, and deer) in Glensaugh over the last 3 years, which suggests a combined increase in environmental and economic efficiency. Likewise, current grassland management fertilization costs represent (in real terms) less than a half of the costs recorded in 2006.

2.13 The adoption of new enterprises, mainly the production and use of renewable energy, has created new income and cost saving opportunities, while contributing to climate change mitigation through, amongst other things, the use of wind, solar and biomass renewable energy sources to contribute towards the farm heating and electricity demands.

Potential natural capital impacts due to woodland expansion

2.14 Further woodland expansion is planned on the farm involving up to 113 hectares in the short-term. Those woodland expansion plans have potential for increasing carbon dioxide sequestration by 700 to 1,500 t CO_2 per year over the next 20 years, depending on the species planted, and the point in time that planting takes place.

2.15 Special attention needs to be given to tree species and site selection, as well as to the temporal nature of the potential CO_2 sequestration due to the initial carbon release associated with soil disturbance, which in turn depends on ground preparation method and soil type.

2.17 Woodland expansion can create further opportunities for GHG emissions off-setting. There is a trade-off between carbon sequestration and potential biodiversity gains when non-native commercial species are planted instead of native woodlands. There is also an economic trade-off between commercial species and native woodland, as the minimum carbon payments required to make native woodland expansion profitable can be at least double the payments required when non-native fast-growing species are involved.

2.17 Woodland expansion seems also a more cost-effective alternative to improve the farm GHG balance than reducing livestock numbers, when the livestock revenues forgone are accounted for.

Risk and opportunities

3.01 Key natural capital related risks to the farm include:

- Climate change leading to an increased frequency of poor summers (higher rainfall and low soil temperature) which might reduce quality/quantity of harvested crops for winter-feed - that would compromise the livestock systems that depend on winter-feed (e.g., low-ground sheep flock and beef-cattle).
- Climate change leading to increased frequency of extreme weather events such as storms and droughts that can affect Glensaugh farm productivity and costs, through both damaging produced assets (e.g., infrastructure, livestock) and natural capital (woodlands, soils, wild species, water courses).
- Nutrients and pesticides leaching to watercourses from fertilizer and pesticide applications, with a potential soil enrichment downstream and proliferation of bracken (*Pteridium aquilinum*), affecting semi-natural plant communities and habitats.
- Loss of wild species diversity and soil biota due to increasing area of commercial non-native woodland plantations, bracken proliferation, and rotational heather burning.

3.02 Other key risk that are not necessarily connected to natural capital, but can have large effects on farm production decisions and farm resource use, include:

- Fluctuations in livestock and production input market prices.
- Uncertain effects of COVID-19 and Brexit on farming systems, agricultural policies, and upstream and downstream distribution chains.

3.03 Key natural capital related opportunities for Glensaugh include:

- Private funding for investment in GHG emissions mitigation, and other sustainable practices and technologies involving natural capital, aligned with the green recovery and climate change emergency policies.
- A shift in agricultural support towards payments for public goods with additional opportunities for public and private sector funding for farm-based environmental goods and services,
- Further diversification of farm activities with special attention to education/research and demonstration activities encompassing a transition to low carbon farming, recreational services, and renewable energies.
- Developing and demonstrating the value of a set of metrics to monitor the state and condition of natural capital over time.

Main recommendations to Glensaugh and other practitioners

4.01 In the particular case of Glensaugh, this work has demonstrated that natural capital assessment can be used to inform decision-making pertaining to land use and management strategies. For example, the results of the assessment suggest that diversified livestock enterprises can help to balance environmental and economic outcomes and farm financial resilience, while helping the farm enterprise respond better to climatic and price fluctuations. The substitution, for example, of beef-cattle and low-ground sheep enterprises by hill sheep can help GHG emissions reduction towards the transition to low carbon farming, but could have a negative impact on farm revenues, due to reduced livestock diversity and associated resilience to fluctuation of market prices.

4.02 Woodland expansion can create further opportunities for GHG emissions off-setting. More research is needed, however, to inform better site and species selection, by integrating other relevant variables such as access to roads and forest tracks, slope, sunlight and shade exposure, and economies of scale in forest management.

The potential effect of low soil-disturbing ground preparation techniques (e.g. manual turfing) on soil carbon release, and management costs, need to be studied in more detail.

4.03 In more general terms, the application of the Natural Capital Protocol proved to be useful as framework to guide a systematic assessment of natural capital impact and dependencies of Glensaugh farm. However, the application is data demanding (e.g. mapping resources, farm records, modelling), with the reliability and quality of the natural capital assessment being dependent on the availability and quality of information. Other land-based businesses applying natural capital assessment approaches need to evaluate the implications that the quality of the data and the scope of the approach could have in informing their decision-making.

4.04 The proliferation of carbon auditing tools, and standards such as the Woodland Carbon Code could assist the estimation of carbon balances at the whole farm or the land-based activity level. This could inadvertently put the emphasis of the natural capital assessment on carbon stocks and flows and their values, overlooking other important natural capital and ecosystem services impact indicators, for which quantification can be challenging due to information gaps. In this sense, it is critical to keep a larger number of natural capital impact indicators that are material to the farm business, or to wider society, even in qualitative terms, as a way to better balance multiple environmental goals beyond GHG reduction for climate change regulation (e.g. biodiversity conservation, enhancing water quality, reducing flood impacts, etc.).

Actions for consideration

5.01 Improving internal data and reporting:

- Development of natural capital accounts for the farm and integration into the Institute and farm reporting.
- Identification of priority direct or indirect indicators (set of metrics) to track changes in natural capital condition and impacts, such as soil organic matter and nutrients, soil pH, biodiversity index, GHG emissions, carbon stock and sequestration, water quality, and use of inputs (fertilisers, pesticides, fossil fuels).
- Analyse GHG emissions due to livestock farming in more detail, preferably using more sophisticated models (e.g. IPCC Tier 3 approaches), as different carbon auditing tools deliver divergent results, making the GHG livestock emissions more uncertain.

5.02 Funding and investment:

- Identify priorities and opportunities for maintaining and enhancing natural capital in Glensaugh.
- Integrate natural capital impact and dependency assessments in the feasibility analysis of potential investment projects in Glensaugh.

5.03 Working with stakeholders:

- Demonstrate the benefits of incorporating natural capital into land use decisions and research priorities.
- Raise awareness amongst stakeholders of the role of natural capital for maintaining healthy and resilient businesses, economies, and societies.

5.04 Roll-out of the Protocol: The experience gained with the application of the Protocol in Glensaugh suggests that this approach has potential to be beneficial for other farms and estates across Scotland. The Protocol could help them to evaluate and promote land use and management strategies that generate business opportunities, while also enhancing natural capital. To facilitate the Protocol roll-out we suggest:

- Assessment of the changes in the state and condition and impacts on natural capital over time. Creating a natural assets register would help in recording current extent and condition and changes over time of the natural capital base. Defining a set of key indicators (metrics) of impacts of land-based businesses on natural capital, along with the natural assets register, would help create the context for integrating natural capital into land management decisions and future public (government) payments.
- Exploring opportunities to mainstream natural capital assessment and reporting, including alternatives to tie natural capital reporting to other mandatory reporting processes (e.g. for pillar 2 payments, site conditions for Natura 2000, etc.)
- Using qualitative natural capital approaches for those impacts on natural capital and ecosystem services that are not easily measurable and monetarized, along with indicators of financial performance to inform land use and management decision-making. Accounting for wider business and societal cost and benefits can inform about the sustainability of investment alternatives.