Synthesis Report: Screening Enhanced Conditionality Measures

An output of RESAS commissioned project Supporting Scotland's Land Use Transformations

K.B. Matthews[a], K.L. Blackstock[a], D.H. Wardell-Johnson[a], D.G. Miller[a], Mostafa Tavana[a], S. Thomson[b], A. Moxey[c], R. Neilson[a], N. Baggaley[a], M. Giles[a], A. Karley[a], K. Loades[a], E. Paterson[a], R. Pakeman[a], C. Hawes[a], J. Stockan[a], M. Stutter[a], S. Addy[a], M.E. Wilkinson[a], A. Juarez-Bourke[a], K.A. Waylen[a], M. Rivington[a], M.J. Aitkenhead[a], M.C. Coull[a].

[a] The James Hutton Institute, Aberdeen and Dundee, Scotland,
[b] Scotland's Rural College, Edinburgh,
[c] Pareto Consulting, Edinburgh.

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Contents

Acronyms

Acronym	Full Text	Acronym	Full Text
AECS	Agri-Environment Climate Scheme	NECG	New Entrant Capital Grants
BB	Broadband	NESUG	New Entrant Start Up Grant
BES	Beef Efficiency Scheme	P1	Pillar 1
BPS	Basic Payment Scheme	P2	Pillar 2
BRN	Business Reference Number	PGRS	Permanent Grassland
CAGS	Crofting Agricultural Grant Scheme	RPS	Rural Priorities Scheme
EFA	Ecological Focus Area		
FGS	Forestry Grant Scheme	SAF	Single Application Form
FPMC	Food Processing, Marketing and Co-operation	SBCS	Scottish Beef Calf Scheme
FPS	Farmland Premium Scheme	SFGS	Small Farms Grant Scheme
FWPS	Farm Woodland Premium Scheme	SFPS	Single Farm Payment Scheme
FWS	Farm Woodland Scheme	SSBSS	Scottish Suckler Beef Support Scheme
JAC	June Agricultural Census	SUSSS	Scottish Upland Sheep Support Scheme
KTIF	Knowledge Transfer and Innovation Fund	VCS	Voluntary Coupled Support
LFASS	Less Favoured Areas Support Scheme	YFSUG	Young Farmers Start Up Grant
LMO	Land Managers Options		

Summary

This document is an output of the policy-led analysis within the Land Use Transformations (LUT) research project (C3-JHI-1) part of the 2022-27 Scottish Government (SG) Strategic Research Programme. The LUT project has a focus on how to deliver high level policy outcomes – especially achieving "Net Zero and other environmental objectives".

The Vision for the Agriculture Bill signals the potential for a transformation in agricultural support, particularly via the use of Enhanced Conditionality (EC) on at least 50% of direct payments. The research focussed on the proposed EC payments, but in the context of all four Tiers of the Agricultural Support Package. It used the July 2022 list of 93 proposed EC measures covering GHG emissions reduction (36); soil health (12); and biodiversity (45).

The EC measures were considered using a screening matrix with researchers on biodiversity, soil, and water, to consider whether the measures would achieve the objectives of the Agricultural Support Package including potential implementation issues. This screening was supplemented by further consideration of the EC measures by researchers with expertise in multi-level governance, climate change adaptation and natural capital.

Framing – what changes?	**SG Classifications**	**Multi-functionality**	**Measure definitions**	**Uptake**	Reduced financial capital value?
Land?	Cost	Meets Objective?	Compound?	Efficiency	More complex?
Livestock?	Complexity	GHG	**Standards**	Reduced inputs	**Tenure**
Trees?	Capital	Soils	Qualitative,	Margins	Tennant?
Cover?	**Existing?**	Biodiversity	Improve,	Land take?	Seasonal?
Use?	CAP Greening?	Water	Presence	Extra Labour?	**Change Degree**
Management	AECS?	Adaptation	**Scale and Lags**	New Skills?	Transformative?
Reversible?	GAEC2 or SMR?		Action/Detection	Extra Capital?	
			Time Lags	Reduced output?	

The screening criteria covered issues of framing, continuity from prior schemes (AECS, EFA); multi-functionality; measures definitions, and uptake. Key factors included: degree of land cover, use, management, and value change; changes in production efficiency; any associated need for more labour, new skills, or physical infrastructure; and implications for tenure.

The outputs from the screening are:

- A synthesis of the evaluation of the proposed EC measures from multiple perspectives with a focus on their likely effectiveness and the factors affecting their uptake.
- A framing of the wider issues that are likely to shape the implementation and impact of the EC measures. This highlights where there are dependencies, uncertainties or key decision to be made. Where research can contribute then linkages to relevant work is provided or options for further analysis set out.

Key Findings

1. EC measures are a step change in ambition potentially providing more powerful levers to combat the climate and biodiversity emergencies but will initially have increased transaction costs and have uncertain uptake and outcomes.

2. The research illustrates how EC implementation needs to consider interactions with the other Tiers in the proposed Agricultural Support programme, and various forms of spatial and business interactions. There is also the potential for EC to become more effective over time by moving the less demanding measures to Tier 1 so that land managers undertake more challenging transformative EC measures, that may see initially limited uptake.

3. The research illustrates that some EC measures are one-off capital interventions and others are ongoing management actions. High-cost capital interventions were more likely to be relevant to biodiversity objectives; and were deemed to be transformational due to changes in land use. However, capital interventions may also need ongoing revenue payments to maintain functionality (e.g., creating and then maintaining farm ponds).

4. The budget envelope for EC will depend on decisions taken across other Tiers; on the total spend and these decisions will define the degree of ambition that can be expected for enhanced conditionality. There are difficult decisions to be made regarding regionalisation of payments (how funds are distributed across businesses and in space) and on budget allocations between EC measures, particularly as many are multi-functional.

5. Many measures are multi-functional and there is a challenge to design a comprehensible and tractable set of EC measure choices that can deliver the extent and mix of measure uptake needed to make substantive progress towards the ambitious objectives in the Vision.

6. There are key challenges for monitoring the efficacy of the new EC measures, due to a range of spatial and temporal dynamics that affect whether a positive action delivers a detectable positive outcome. Monitoring and evaluation must be effective enough to demonstrate verifiable progress towards the objectives and to guide the ongoing adaptation of the EC scheme that will be required.

7. The expertise within the screening team can contribute further to the development of the EC measures and further specific analysis options are identified that could be addressed in policy-led analysis from September 2023.

1 Introduction

This document is an output of the policy-led analysis within the Land Use Transformations (LUT) research project (C3-JHI-1) part of the 2022-27 Scottish Government (SG) Strategic Research Programme. The LUT project has a focus on how to deliver high level policy outcomes – especially achieving "Net Zero and other environmental objectives". The LUT project takes a broad approach to land use, recognising the need to understand and integrate multiple uses of land to deliver the Scottish Government's economic transformation [1] and the Bute House priorities.

Given the centrality of agricultural policy in shaping Scottish land use and the transition to a new policy regime after the UK's withdrawal from the EU, the implications of the proposed Agricultural (Scotland) Bill were an important place to start analysis [2]. The scope of the analysis was co-constructed with Hutton staff, policy leads and SG analysts (August to October 2022) and focuses on the Enhanced Conditionality (EC) measures as presented to the Agricultural Reform Implementation Oversight Board (ARIOB) in July 2022.

EC proposals are a qualitative change in the agricultural direct payments model, becoming more analogous to Ecological Focus Area (EFA) measures in Basic Payment Scheme (BPS) Greening yet applying to a much wider population of businesses (in Greening the EFA requirement was only on some of those with arable crops). This raises many interesting questions of who will do what, and where, and what are the consequences. While the focus of the screening is the EC measures, these are considered in the context of all the other elements (Tiers 1-4) of the Delivering our Vision for Scottish Agriculture, Proposals for a new Agriculture Bill – see Figure 1.

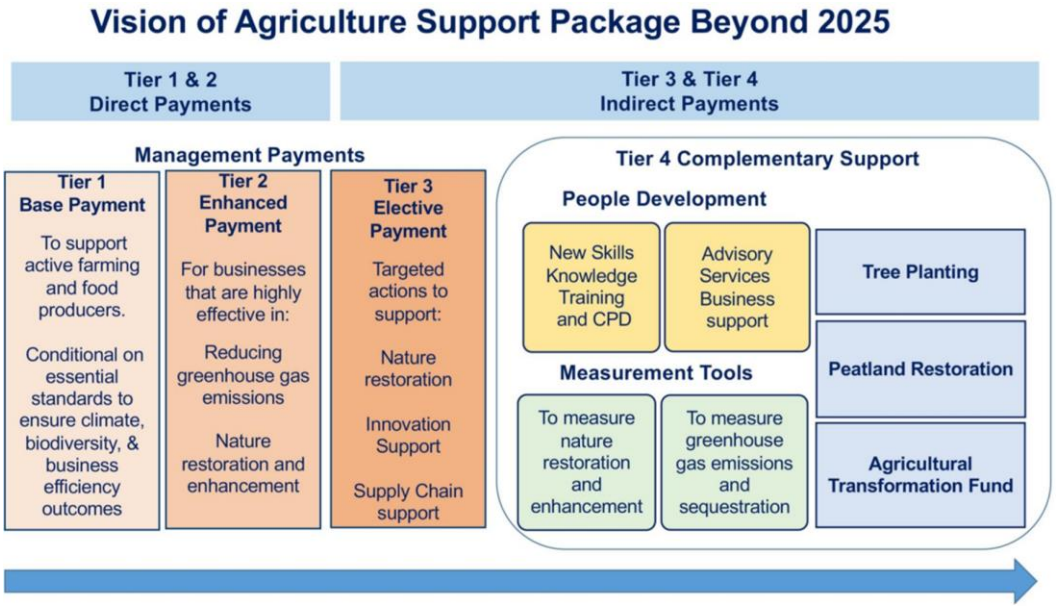

Figure 1: Proposal for how Agricultural Support might be reformed to deliver the SG Vision for Scottish Agriculture [2]

The research team proposed to screen the EC measures from a variety of perspectives, see Table 1), to synthesise the key findings, to highlight options for further analysis and to curate a set of research outputs relevant to the issues raised, and which could be used by RESAS analysts or SG policy leads for more in-depth consideration of the EC measures. The analysis sought to consider the coherence between Objectives, Measures and Implementation, part of the policy coherence framework within the Land Use Transformations project [3]. In other words, this screening considered, using expert knowledge, whether the measures are likely to achieve the objectives for the agriculture support package; and whether the measures are likely to be implemented in ways that will achieve the objectives for the support package.

Table 1: Perspectives used in the screening process.

Framing – what changes?	**SG Classifications**	**Multi-functionality**	**Measure definitions**	**Uptake**	Reduced financial capital value?
Land?	Cost	Meets Objective?	Compound?	Efficiency	More complex?
Livestock?	Complexity	GHG	**Standards**	Reduced inputs	**Tenure**
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Reversible?	GAEC2 or SMR?		Action/Detection	Extra Capital?	
			Time Lags	Reduced output?	

2 Screening Analysis

The EC screening synthesis report (this document) is based on workshop-based reviews of the listing and classification of EC measures as shared at the 28 July 2022 Agricultural Reform Implementation Oversight Board (ARIOB) meeting. This list contains 93 proposed EC measures, 36 for GHG emission reduction; 12 for soil health and 45 relevant to protecting or improving biodiversity.

The screening first focussed primarily on the biophysical sciences and how the proposed measures might achieve the Vision for Agriculture objectives, particularly for the twin biodiversity and climate emergencies. The listing was thus discussed with three thematic groups of researchers at Hutton – biodiversity, soils, waters. These staff work across a wide range of projects in the SRP and as such the screening was able to draw upon a very wide range of expertise.

Theme	**Contributing Staff**	**SRP Project Links**
Biodiversity	R. Pakeman, C. Hawes, J. Stockan	D4: Biodiversity, JHI-D4-2, JHI-D4-3
Soils	R. Neilson, N. Baggaley, M. Giles, A. Karley, K. Loades, E. Paterson	D3: Soils, JHI-D3-1
Waters	M. Stutter, S. Addy, M.E. Wilkinson, A. Juarez-Bourke [a]	D2: Waters, JHI-D2-2

Three discussions were undertaken with each group. First a scoping discussion with the thematic lead, second an initial review (~3hrs) followed by an in-depth workshop (~6 hrs). Deliberation on the issues was structured by a summary screening matrix. Comments and issues were either captured in the screening matrix or where there emerged a coherent area where more comment was needed (identifying issues or potential reformulations of the ECs) then these were articulated by the review team members as paragraphs to be included within the EC Screening Synthesis document (see Section 4 *Biodiversity, Soils, Crops and* Waters Issues).

This analysis was supplemented by analysis from other relevant perspectives.

Theme	**Contributing Staff**	**SRP Project Links**
Governance	K.L. Blackstock [a]	C3 Land Use, JHI-C3-1
Climate change resilience and adaptation	M. Rivington [a]	D5 Natural Capital, JHI-D5-2
Natural Capital	K.A. Waylen [a]	D5 Natural Capital, JHI-D5-3

Governance research within the Land Use Transformations project has also been considering how 60 different policy documents related to agriculture and other land use, environment, socio-economic and climate change issues contribute to Land Use Transformations. Through studying these policies, the governance team were able to add wider context to the screening and how issues faced in the EC relate to wider policy coherence dilemmas that need to be tackled to transform land use. The Scottish River Basin Management Plan (2021-27) states "*the need for urgent and transformative action to tackle these [climate and biodiversity] threats is clear*." There are calls for change to meet to the overarching ambitions for agri-food systems in the Good Food Nation (Scotland) Act. The need for significant change is also highlighted in the Land Use Strategy (2021) "*As Scotland moves towards being a net zero economy there will need to be significant land use change from current uses to forestry and peatland restoration*" and the Vision for Agriculture aims to "*transform how we support farming and food production in Scotland to become a global leader in sustainable and regenerative agriculture...cutting emissions, mitigating climate change and restoring and enhancing nature*". Therefore, EC sits within a wider context of transformation across many policies.

Climate change resilience and adaptation are considered as part of climate proofing the EC measures, see Section 3.8.2 *Temporal scale issues*, while noting that climate change resilience and adaptation may need to be considered in more depth as an explicit objective of for EC measures or at least as a criteria for assessing their impact, see Section 3.3 *What does EC expect to deliver?*

Natural Capital approaches and the potential role of private sector investments as they interact with EC measures were highlighted as potentially significant themes later in the screening process and an outline of the issuers and options for further work is provided in Section 5.1 *Natural Capital Approaches*.

Further Analysis Option – screen the measures with other Hutton research teams – e.g., multi-level governance and collective action, climate change adaptation, Natural Capital, Land Reform, Just Transitions, etc.

3 Synthesis

The Vision for Agriculture [2] recognises that current support systems have not yet delivered enough progress on net zero and other environmental goals, but that these goals need to be met while maintaining a viable agri-food system, especially where these activities represent a more substantial share of economic activity and social fabric. Debate is appropriate over the degree and rate of change, but a fundamental transformation[1] of the agri-food system is required to meet objectives[2].

EC is inherently uncertain and risky (see Section 3.2 Enhanced Conditionality and other Tiers – the "Policy Sudoku", below) – but the *status quo* is not an option. The National Testing Programme (now referred to as Preparing for Sustainable Farming) from 2022 is a form of adaptive management that plans, implements and evaluates measures to ensure the desired outcomes are met [4] and as such is an appropriate response to this uncertainty and risk. This EC screening seeks to add to the data from the Preparing for Sustainable Farming initiative, providing analysis of EC measures that are more challenging to test "on the ground". This is an "in theory" analysis based on previous analyses and expert knowledge, to enable issues to be identified and any early adaptations to be made where required.

3.1 Enhanced Conditionality as a new kind of scheme.

At the scale envisioned in the Vision for Agriculture, EC is a qualitatively different policy implementation mechanism from any of the existing CAP Pillar 1 Direct Payments (which it partially replaces). Basic Payment Scheme Greening, particularly Ecological Focus Areas are the closest analogous previous scheme, with a share of support payments requiring sufficient measures, chosen from a menu of options, to be enacted to meet a requirement (in the case of Greening defined as a fixed proportion of arable area). CAP Greening though applied only to n=3,470 of 19,292 SAF[3] businesses (those with >15 ha of arable crop areas) and had a limited range of measures that included fallow with minimal need for active management. See Matthews, Wardell-Johnson [5] for analysis of EFA uptake 2015 to 2021.

[1] Within the LUT project, the definition of transformation is "a degree of change is substantial, system wide, beyond incremental and is initiated rather reacted to (contrasting with system collapse)"see the LUT project glossary.

[2] For biodiversity there is no alternative and for net zero failure to reduce emissions will mean reliance on unproven negative emissions technologies (NETs). NETS are as of the 2018-32 Climate Change Plan are expected to deliver -5.7Mt or 24% of the 23.3 MtCO2e reduction to be achieved by 2032(Scottish Government, 2020).

[3] A SAF business fills in an annual single application form (SAF) as part of participating in any of the agricultural or environmental support schemes.

As a menu scheme EC also has similarities with Land Management Contract Menu Scheme (LMCMS), Pillar 2, 2000-2006, and Land Managers Options (LMO), Pillar 2- 2007-13, see Sutherland [6] for a review. Viewed in this way, EC is, in effect, mainstreaming CAP Pillar 2 Agri-Environment measures, that were previously elective, and is applying them to a much wider set of businesses. Note though that the maximum payments under EC are capped at the full value of BPS plus Greening, so this contrasts with elective payments where maximum values are limited only by the available budget and the business' ability to secure funds in competition with other applicants.

As a "menu" type of scheme each SAF business, unless otherwise constrained by EC measure targeting, will make a free choice of EC measures, their number, and extents. That choice balances the desirability for the business of each EC measure, considering the resources needed to deliver the EC measure and the weighting per measure (how much of the requirement it delivers). A mix of EC measures will be undertaken, and the outcomes of EC measures undertaken will vary depending on the specific environments in which they are undertaken.

This all implies that, even with a substantial share of available budgets (see Section 3.4 *Budgetary Considerations),* what EC will initially deliver will be much more uncertain. There will thus be a great need to closely monitor uptake and implementation of EC measures, and rapidly adapt the scheme over time to ensure that it progressively delivers more actions and outcomes that contribute towards the overall objectives. EC is thus likely to have a higher implementation cost but to have greater potential to deliver more than existing Direct Payment schemes (see section 3.4, *Budgetary Considerations*).

3.2 Enhanced Conditionality and other Tiers – the "Policy Sudoku"

EC measures seek to play a decisive role in the delivery of multiple Scottish Government objectives, but they are part of a complex *policy sudoku* illustrated in Figure 2.

The **macro challenge** is to get a mix of EC and other measures in place that deliver the required progress towards the national policy commitments. So, decisions made by up to n=19,292 SAF businesses need to collectively deliver (in Sudoku speak "add up to") the required progress towards all the national level commitments. These policy commitments include the land related parts of climate mitigation (Net-Zero), biodiversity and others such as climate adaptation/resilience, economic prosperity and social justice.

The **micro challenge** is in delivering the *right measures in the right place,* so they are most effective. This means all the components of agricultural support (from all Tiers) combining so appropriate EC measures are chosen and implemented to best effect within businesses, i.e., across holdings (n=22,474), on land parcels (n=450,880) and in space more generally (across 5.7M ha[4] of 7.8M ha land in Scotland).

[4] The total area of land declared in the Single Application Form used to administer farm payments.

The **meso challenge** is identifying and attributing the outcomes of EC measures to the actions undertaken, since there can be cases where interactions between businesses will confound or enhance their outcomes impacts. Other meso challenges are in agreeing any objectives at regional or sectoral levels, i.e., the priorities and degree of burden sharing expected below the level of Scotland as a whole.

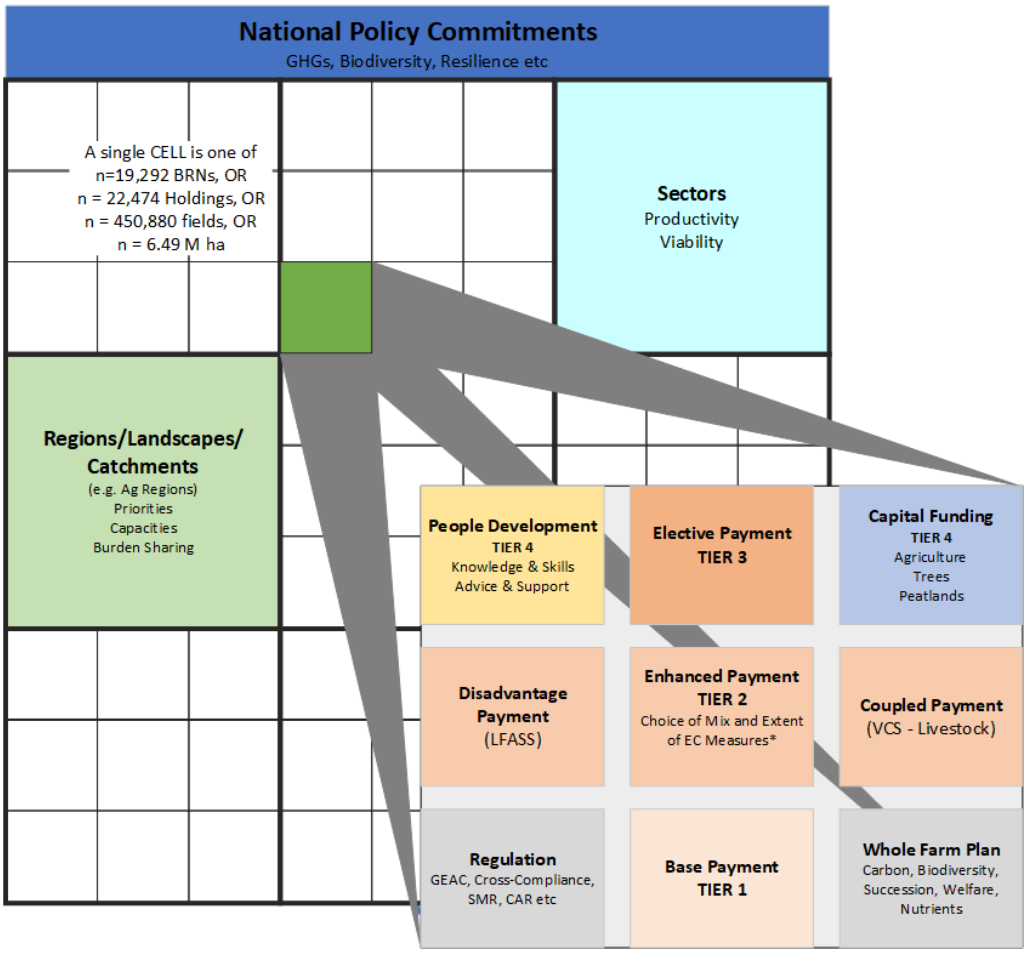

Figure 2: Policy Sudoku

Policy sudoku provides a potentially useful conceptual framework for assessing EC measures by simultaneously considering macro, meso and micro scales and outcomes. Yet, as illustrated, this complex Sudoku does not encompass the **full policy coherence challenge** with many other policies also acting on the same SAF businesses such as designated site management plans, river basin management plans or regional economic strategies and development plans.

EC payments are thus part of the wider suite of policy instruments that also include information, other types of incentives and regulations [3]. These policy instruments co-exist with market signals, and access to capital, labour and skills that influence farm decision making. So how these other factors interact at business level and at budget level will also shape how effective EC can be. This means the need make sure that the implementation of Measurement Tools for EC measures (in Tier 4, see Figure 1) can distinguish when and

where EC measures are effective, providing the data for adaptive management so SG can understand where outcomes are driven by other factors beyond EC payments or where despite EC measures being well implemented other factors may have constrained their impacts.

3.2.1 EC as one part of the portfolio of agriculture support measures

The EC measures are not undertaken in isolation, see Figure 2 again, being underpinned by other aspects of agricultural support such as Regulation, Base Payment and Whole Farm Plans (Tier 1), supplemented by Disadvantage Payment (moved in Figure 2 from Tier 4 to Tier 2) and Coupled Payments (also moved in Figure 2 to Tier 2) with each potentially having their own conditionality options or requirements. The EC measures are potentially supported or extended by People Development and funding for Agriculture Transformation, Tree Planting and Peatland Restoration[5] (Tier 4) with Elective Payment options (Tier 3) for more ambitious delivery or for coordinating between businesses to add value. EC is though, central to the delivery of the on-ground transformation needed to achieve the Vision of Agriculture objectives. There is the need to consider both how each of these other mechanisms can reinforce EC and the relative size of budgets required.

3.2.2 Outcomes between national and business scales

As with regular Sudoku the added complication is when there is the need to make intermediate combinations (subsets) of businesses deliver other objectives, and with those objectives not necessarily being defined at national level or even by SG alone. Examples here would include Regions (e.g., Local Authority or Regional Land Use Partnerships) and Sectors (as defined by farm types or commodity groups). Regions are geographical subsets in which different priorities and capacities for delivery may be present and across which a Just Transition compatible balance of burden and benefit sharing (distributional justice) needs to be achieved. Landscape and Catchment level regional outcomes would reflect habitat and species related designation objectives or River Basin Management Plans and are explored further in Section 3.8, *Scales and Granularity*. Sectoral breakdowns may imply productivity or business viability constraints on which EC measures are possible, their extent and effectiveness. Linkage to agri-food system objectives could be significant here. Regional and Sectoral perspectives will combine to provide a complex web of constraints within which the EC measures will have to be undertaken.

3.3 What does EC expect to deliver?

Judged from the number and diversity of measures in the July ARIOB paper (n=93) and the objectives used to group the measures (n=10) the expectation is that EC measures will

[5] Peatland Restoration is included in the Vision of Agriculture but has not as of 2022 been part of the Agriculture (and previous CAP) budgets.

deliver across the broad range of issues associated with agriculture (and wider rural land use), see Table 2.

Table 2: EC Objectives as used to group the EC measures by Scottish Government

Objectives	All Objectives Count
Soil Management for GHG Emission Reduction	6
Crop Management for GHG Emission Reduction	5
Livestock Management for GHG Emission Reduction	18
Nutrient Management for GHG Emission Reduction	7
Improve Cultivated Soil Health	12
Maintain and Enhance Field Margins and other Permanent Habitats	16
Create New Nature Rich Habitats	8
Manage for Species found on Farmed Land	17
Woodland Creation and Management	3
Cattle Feeding	1
All Objectives	**93**

The objective-based groupings of EC measures emphasise GHG emissions mitigation, biodiversity, and natural asset condition (soil health and permanent habitats). They do not state as objectives 'delivery of climate change resilience or adaptation', and the screening team queried why this did not appear to be within scope. Clarity would also be desirable on whether EC measures are expected to have an income or production support component (maintaining critical mass in regions or sectors and supporting prosperity of rural industries). This will be important for setting the level expectation for what the budget devoted to EC measures can reasonably be expected to deliver (see Section 3.4 *Budgetary Considerations*).

3.3.1 Diversity of EC measure framing

Beyond the objectives there is significant diversity in the ways in which EC measures are framed, that is what are the kinds of changes seen as desirable by the EC measures authors. Table 3 first classifies the EC measures as applying to *Land*, *Livestock* or *Both.* This highlights the degree to which the livestock measures are animal and technology focused rather that systemic (only 1 of 18 measures), though this is less the case for the *Nutrient Management for GHG Emissions Reduction* objective (n=4 of 7) with more consideration of land but still with a focus on manure management rather than an overall nutrient management planning across all enterprises. *Soil management for GHG Emission Reduction* is the only other objective where measures combining both land and livestock management are 50% of the measures being considered. The screening team noted the need for simplicity with EC measures but had concerns that separating land and livestock management might miss potential synergies or cause unintended negative consequences. The second classification of the EC measures distinguishes them in terms of changes in land cover, land use and land management[6]. The classification highlights that for EC measures with a biodiversity focus (those in greens in the table) there is a significant emphasis on land cover as well as land

[6] Cover, grass, could have multiple Uses silage/hay/grazing for sheep or cattle and contrasting Management, high versus low inputs, organic vs. conventional.

management with the expectation that land cover change is more challenging to achieve (see Section 3.10, *Uptake of EC Measures* for more discussion). Land management is the dominant framing of expected for some objectives, e.g., *Soil-* and *Crop Management for GHG Reduction* emphasising less transformational change and more the need to continue activities but considering GHG emissions to a much greater extent than now. Land use change is less prominent in the framing of the EC measures, though distinguishing cover, use and management is not always simple. The examples of use change tended to reflect more systemic changes or multi-functional uses like changes to flood plain hydrology that do not necessarily imply cover change.

Table 3: Framing of EC measures per objective

Objectives	All Objectives	Land?	Livestock?	Both?	Land Cover?	Land Use?	Land Management?	All Objectives
Livestock Management for GHG Emission Reduction	18	1	18	1			1	18
Manage for Species found on Farmed Land	17	17			9	1	7	17
Maintain and Enhance Field Margins and other Permanent Habitats	16	15	3	2	7	2	10	16
Improve Cultivated Soil Health	12	12	2	2	6	2	9	12
Create New Nature Rich Habitats	8	8			8		1	8
Nutrient Management for GHG Emission Reduction	7	5	6	4			5	7
Soil Management for GHG Emission Reduction	6	6	3	3	2	1	5	6
Crop Management for GHG Emission Reduction	5	5			4		4	5
Woodland Creation and Management	3	3			2		1	3
Cattle Feeding	1	1	1	1	1	1		1
All Objectives	**93**	**73**	**33**	**13**	**39**	**7**	**43**	**93**

The diversity of the ways in which the EC measures are framed raised questions for the screening team of what the EC measures can reasonably be expected to achieve? For some of the more ambitious or transformative measures, would they be taken up at all, and could EC scheme, overall, be judged as failing to deliver were such measures not taken up?

The distinction made by the screening team (and to a degree in the ARIOB paper) is in distinguishing EC measures that are capital focused (funding one off investments) from revenue focused (funding recurring actions over time). The view of the screening team was that given the magnitude of funds likely available (50% of previous Direct Payments), EC measures were more credible as sources for revenue funding. However, decisions on the Tier 4 funding of the Agricultural Transformation Fund and People Development were crucial here as otherwise the degree of system transformation sought could likely not be delivered.

3.3.2 Capital focused EC measures

EC measures with high capital costs were identified in the ARIOB paper (n=37 of 93, 15 with medium cost/complexity and 22 with high cost/complexity). Higher capital costs were associated more frequently with biodiversity measures related to habitat (n=17 of 37).

Capital focused EC measures might well be expected to see transformative or systemic changes. Such changes are thus also likely to be hard to reverse and therefore represent a longer-term commitment and a degree of reduced flexibility for future options. Assessed by the screening team, 17 measures were seen as transformative with a further 7 potentially so. Of these 17 transformative measures, 14 were SG high capital types but a further 19 measures were seen as being high capital without being transformational, highlighting that even incremental improvements may have capital implications. These high capital cost EC measures are also often linked with land take[7] (n=15) (e.g., *restore flood plain hydrology*) and land cover changes (n=17) (e.g., establishing *agroforestry*).

Some of terminology used to describe these EC measures is: *Create, Extend, Expand, Install*, that strongly implies capital funding. Sometimes, though, the capital focus had to be inferred by the degree and type of change expected, as it was not clear what capital inputs were needed. *Reduce, Transition* and *Shift* can appear less transformative, but the EC measures specified can still require significant changes that may also need capital type investments.

The screening team questioned if the ambition expressed in the capital EC measures could be met by the EC capital funding available in Tier 2 alone, or whether the intent of including such measures was to signal the need for such actions (funded by other means). They also wondered if EC measure revenue funding would in all cases be available to maintain and/or enhance them once created (e.g., ponds or wetlands).

3.3.3 Revenue focused EC measures

Revenue focused funding provides the means to undertake the *each-year* tasks required for improved agricultural and environmental management. This kind of funding has been noted as harder to access in some cases than capital funding (e.g., for maintaining ponds or wetlands using natural flow management approaches) [7].

The terminology used contrasts with Capital focused measures. There was frequent (n=10) use of *Manage*, though often this is more often (proportionately) included in the Objectives text. The screening team suggested that these Objectives could perhaps be restated with a more definite statement of outcome linked to, for example, the Biodiversity Strategy (e.g., halt species loss by 2030). *Reduce* also features prominently (n=5) particularly related to the use of inorganic fertilisers and crop protection products. For *Field Margins and Permanent Habitats*, the terminology is *Maintain, Enhance*, *Improve* and *Increase* recognising the need to reward those already delivering good condition, multi-functional habitats while at the same time encouraging others to reach those standards. *Maintain* and *Enhance* tends to be

[7] Land take here is where an EC measures sees the use or cover of land change – in some cases such that the land is no longer delivering a conventional agricultural production outputs. This links to the concept of land sparing.

associated with conservation or protection type measures whereas *Improve* and *Increase* are more often associated with technical management changes.

Where EC measure funding may also have an important role is in the funding of activities before the capital investments are made or measures enacted. That is using EC funding in:

- issue identification and framing, agreeing through deliberation the type and magnitude of the issues and how to tackle contested issues,
- creating bonding and bridging capitals, networks of actors with common causes and partnerships between these network members to tackle issues, and
- for coordination of actions to leverage new funding from public or private sources.

Such activities could also remain valuable as measures are enacted as ways to share good practice and to reshape the action taken to become more effective over time. Funding for this kind of activity could be delivered via Tier 3 Elective payments although the competitive nature of that funding is a potential barrier to access and funding via Tier 4 implies one-off or capital investment. Further consideration of how best such enabling or coordinating activities are funded is needed since they are the key to addressing the issues identified by the screening team in Section 3.8 *Scales and Granularity.*

3.3.4 Restoration as a special case

Restoration is an interesting case as it could be enacted as either a capital or revenue-based measure or in some cases as both, with long term commitments often implied as being needed [8]. Restoration also implies that a desirable state can be defined (e.g., Good Ecological Condition – in WFD) and that it existed "before". Such standards are required to create a "floor" and to ensure both good practice and condition are recognised and rewarded but can risk capping ambition or even levelling down. There is also the question of how to judge the relative value of restoration of habitat or species, versus ecosystem function creation as priorities.

The balance of funding within the EC measures will be crucial in defining the kinds of outcomes that can be expected and how well these match state policy objectives. These balancing decisions within the EC scheme and with other aspects of future funding is considered next.

3.4 Budgetary Considerations

The rationale for public funding of the EC measures is debated with a variety of internally coherent positions. For the EC measures screening process, alternative approaches were not considered beyond how EC measures might interact with measures in other Tiers. At this stage it is also not clear whether the funding will be a rolling programme of single year grants, or for longer fixed-term time periods.

The position of the screening team was that with a big enough budget, alone and/or when complemented by activity generated by budgets in other Tiers, EC is potentially a means of generating transformative change in agriculture and closely related forms of land management undertaken by farmers, crofters, and other land managers. Yet, even assuming maintenance of overall funding comparable to previous CAP programmes, see Figure 3, then it was not clear that this level of funding would be adequate to deliver on the kind of transformative change seen as necessary in a range of land related policy statements [9].

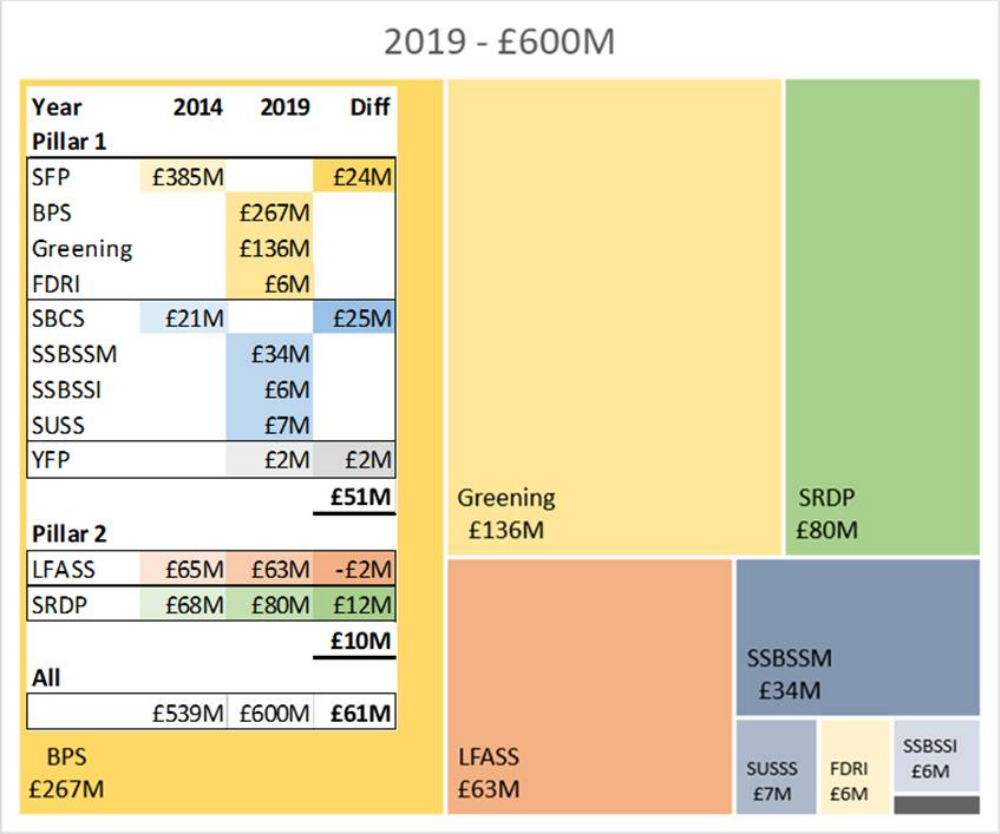

Figure 3: Breakdown of agricultural support payments in 2019

Analysis to date is based on current budgets, inherited from the previous EU CAP regime, but even if this total is maintained then there will be crucial decisions on the balance of funding between the Tiers and their component instruments, and the degree to which more conditionality is applied to all Tiers (potentially meaning EC has less that it is expected to deliver. The expectations for EC may be more limited if EC funding is also expected to deliver production or income support, that is, if the full value of the headline EC budget is not only for delivery of agri-environment and climate change outcomes.

While a substantial headline value, the value of the agriculture budget has in real terms declined 28% since 2005 while Total Income from Farming (TIFF) has an upward trend, see Figure 4.

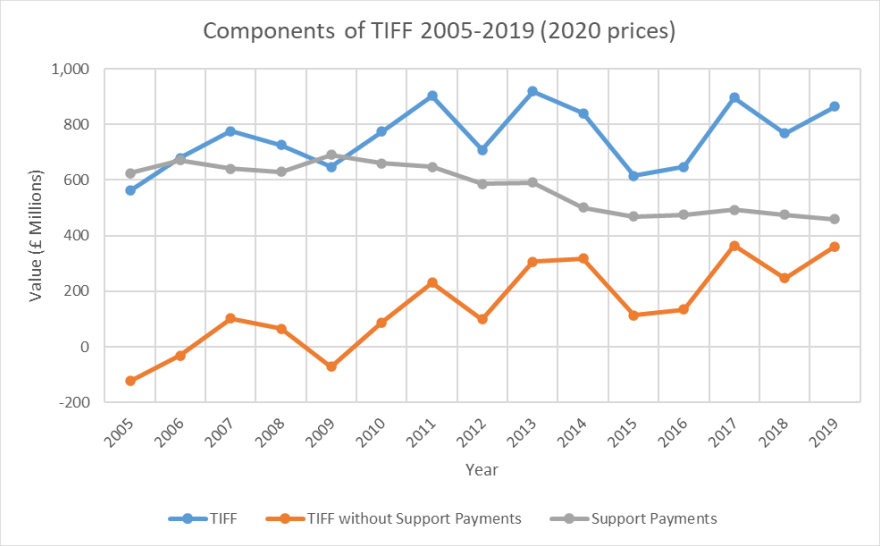

Figure 4: Comparing trends in Total Income from Farming and the value of Support Payments

A key implication is thus the diminishing leverage that agricultural support can have as it declines as a share of total income from farming[8]. The risk is that large enough numbers of land managers do not take up the support and the proposed EC measures are not implemented, leaving only a regulatory approach to deliver the transformations needed.

> **Further Analysis Option** – to assess at headline level the cost per Mt of GHG emissions reductions for other sectors e.g., for energy generation, and use this as a benchmark for the GHG mitigation components in Agriculture. Is the ask, for GHG reductions reasonable compared with the investment of public funds in other sectors?

3.4.1 Eligibility – the businesses and land area within EC

The analysis has considered all the 19,292 SAF businesses in 2019, with a total area of 5.7M ha, as they all could make positive contributions to delivery of the outcomes sought. If EC measures are enacted only by those businesses currently in receipt of Direct Payments (BPS, Greening) then this is a much smaller population (n=17,482) with a "paid on" area of 3.8M ha (BPS area) and a total area of 5.0M ha. For delivery of EC measures how many of the SAF businesses and how much of the area between 3.8M ha and 5.0M ha could become "eligible" were it seen as delivering EC outcomes?

The other businesses present beyond the Direct Payments populations are Pillar 2 only (n=1,049, 0.6M ha), with the latter including predominantly forestry business, mapped as part of Woodland Grant Scheme applications, but not undertaking agricultural activity. EC funding could be seen as desirable for businesses already undertaking land management with primarily environmental goals, funded by other public or private means, with the additional costs to access EC measures for such businesses being compliance with Tier 1

[8] Especially for the most profitable businesses.

eligibility criteria. This raises the question, if businesses currently in receipt of Direct Payments do not take up EC measures, then should other current direct payment recipients be able to undertake more activities for additional funding, or could the underspend be used by currently Pillar 2 only or even non-SAF businesses to undertake EC measures?

Any increase in the SAF population or area of businesses would (with fixed budgets) reduce rates of payment per ha in each region compared with the *status quo*, with the greatest redistributive effect likely felt in current BPS Region 3 since the new land would in most cases be classified as part of this region.

> **Further Analysis Option:** to assess the likelihood of EC measures making it more likely that businesses currently beyond the Direct Payments schemes making a SAF declaration.

3.4.2 Balance of budget across measures

While net zero is the most prominent objective, the objectives for EC measures go beyond just decarbonisation, so the share of resources between, at least, groups of EC measures needs to be explicit. These are likely complex decisions balancing the priorities across sectors and regions but opening up an options analysis of this was seen as crucial by the screening team, otherwise an appropriate balance across objectives may not be achieved – see Section 3.10.1 *Production efficiency* for a discussion of the balance between livestock and land based measures.

> **Further Analysis Option** – scenario analysis of options for budget allocations between groups of EC measures.

3.4.3 Regionalisation

Distribution of funds in space matters as this sets the budget envelop and thus the overall EC requirement per business[9]. The distribution in space is the outcome of policy choices on the number and basis of region(s), payment rates per region and the eligibility criteria used, with options for capping, degressive or frontloaded payments [10]

Using the existing region model 50% of businesses receive only 10% of the direct payment funding. This population contains many smallholders for whom the EC measures could be highly relevant, but the overhead of Tier 1 administration might be too burdensome and thus limit participation in EC measures. For these businesses consideration of opting into a simplified system of regulation has been seen as desirable. While there had been reference to a separate Smallholders scheme, stakeholders have expressed concern that a separate scheme could leave them marginalised so a simplified administration option within the existing scheme was proposed.

[9] Concern of EC not being taken up is sensible but note also the potential for EC to "cap" the ambitions of some businesses.

With current regionalisation the remaining 50% of businesses would have to do 90% of EC measure delivery. This raises the question of how this population maps onto "need" for transformative change and their capacity to deliver – in terms of both sectoral and regional dimensions. There are also questions of whether within the 50% population, larger businesses may have the capacity to achieve more than their current share of funding would indicate. Their financial resources, labour, skills, knowledge, and natural capital may mean that they can generate "economies of scale" for delivery of the EC measures.

> **Further Analysis Option** – analysis of how does a 90% of budget population map onto production, natural; capitals, and restoration need. Classify businesses in terms of their scale and capacity for delivery of EC measures.

3.4.4 Balance across regions

The existence of Regional Land Use Partnership (RLUPs) and their delivery of a Regional Land Use Framework implies that there is a recognition within SG that the mix of issues per region and therefore their priorities for EC measures could vary. RLUPs linked to one or more Local Authorities (LAs) is a governance model where there can be coordination between the granularity of business and pan-Scotland. By linking to LAs there is potential for democratic legitimacy for priority setting but currently the RLUPs remain implementation bodies without a mandate to set regional priorities or the desirable mix of EC measures. Regional perspectives also raised, for the screening team, issues of burden sharing, i.e., what a region can reasonably be expected to deliver given current land use configurations and farming systems, and how a fair regional contribution to agricultural objectives is determined. Regional adaptation and burden or benefit sharing whilst retaining pan-Scotland alignment therefore remains an issue of policy design by Scottish Government [11].

Even considering just the direct payment (BPS) Regions there are important questions of resource allocation adequacy. With 85-90% of budget linked to BPS Region 1 (permanent grassland and cropping) only 10-15% of the budget remains for priorities in BPS Region 2 and 3 - rough grazing (semi-natural habitats). Such a limited share of the overall EC budget could severely limit the potential for EC to make a meaningful contribution to delivery of the Vision objectives in these regions. For EC measure delivery it also may be necessary to consider merging BPS Regions 2 and 3 so that businesses with similar land cover are not expected to deliver different levels of EC measure activity. Otherwise, continuing to differentiate between Region 2 and Region 3 based only on historic stocking rates, does not be seen to align well with the EC objectives and might be subjected to legal challenge. Differentiating within BPS Region 1 between grasslands and cropland has also been suggested as desirable since the range of measures relevant to these regions is different and to ensure that the number and type of EC measures are enacted in an appropriately balanced way for both grasslands and croplands (see Section 3.10).

3.5 Delivery via Enhanced Conditionality or Regulation

Several of the proposed measures listed (n=13) were queried as EC measures when they represent "good" or "standard" practice. The suggestion from the screening team was that they should rather be considered for inclusion in Good Agricultural Environmental Condition (GAEC) or even Statutory Management Requirements (SMR) (e.g., pH management, avoiding and remediating soil compaction and no spray drift) [12, 13]. EC measures may need to be considered for delivery via GAEC or SMR where there can be identified minorities of businesses that are lagging behind widespread good practice and where information and incentives have not been effective. Where there is more widespread deviation from good practice or where compliance costs are much higher than typical for other GAEC or SMR measures, then there is the need for transitional funding, via EC, Disadvantage payments or Tier 4 Agricultural Transformation funding (grants or loans). In any case clear signalling of direction of travel and time scales for changes to GAEC or SMR will be needed to allow businesses to adapt.

Given the limited budgets for EC, it may also be necessary, within a defined timeframe, to progressively move some EC measures into GAEC and SMR to be able to free resources to deliver the depth of transformation needed to achieve the stated policy objectives for GHG emission reductions and halting biodiversity loss.

3.6 Challenges of Classifying and Defining Multi-functional Measures.

The screening team were only working with the EC Objectives and headings, not at any detail, but the measure screening team did highlight issues with EC measure classification and definitions that may be worth considering, particularly since many EC measures were seen as inherently multi-functional[10] and therefore delivering to more than one of the SG Objectives in the Vision.

3.6.1 Classifying and grouping measures

There is an inherent challenge in the classification/grouping and presenting any collection of diverse measures, many of which have potential to deliver to **multiple objectives,** creating multiple benefits**.** There is no perfect classification/grouping for all purposes but alternative (re)grouping to those used in the ARIOB paper and alternative visualisations may be informative (see Further Analysis Options). As classified in the ARIOB paper, the measures align well with the stated objectives if one treats these are the primary outcome being sought (n=77). For a further n=15 there was some questioning of the EC measures fit with objectives, mainly in Cultivated Soil Health (n=9) but also in soil management for GHG emission reductions (n= 3), crop management for GHG emission reductions (n=2), and cattle feeding (n=1). Only for one case, Integrated Pest Management (IPM), did the screening

[10] Multi-objective refers to the designed intent to cover more than one objective, however some measures perform multiple functions even if they are designed for a single objective, here any multiple benefits delivered are potentially seen as co-benefits (Blackstock et al, 2020).

team judge that the main outcome (*Crop Management for GHG Emissions Reduction*) did not express the main benefit of adopting such measures, with IPM perhaps better linked primarily to the Cultivated Soil Health objective.

3.6.2 Multi-functionality

A repeated observation by the screening team was how often proposed EC measures delivered to more than one objective and to objectives that were not explicitly presented in the EC listing. The degree of multi-functionality is important for how much weighting a measure should be given as part of delivery to the EC objectives. Making sure that all the relevant benefits of measures are captured is important as otherwise the measures may be underselling their benefits.

Summarising multi-functionality at the levels of the EC Measure groupings by objectives in Table 4 highlights how some measures deliver limited benefits beyond those implied by their stated objectives (the coloured table cells). This is especially true for more technical and specific measures such as those for *Livestock*- and *Nutrient Management- (for GHGs)* and to a lesser degree for *Crop*- and *Soil Management- (for GHG Emission Reduction)*. Other groups of measures though seem to generate (by more systemic changes to cover, use or management) a wider range of benefits across the range of objectives considered by the screening team, particularly measures in *Improve Cultivated Soil Health* but also *Maintain and Enhance Field Margins and other Permanent Habitats*.

Table 4: Delivery for EC measures to multiple objectives

	Objectives delivered to by measures - from screening					
Objectives	**GHG**	**BioDiv/Conser**	**Soils**	**Water**	**Adaptation**	**All Objectives**
Livestock Management for GHG Emission Reduction	18				1	18
Manage for Species found on Farmed Land		17	1	4	2	17
Maintain and Enhance Field Margins and other Permanent Habitats		16		7	5	16
Improve Cultivated Soil Health	12	5	6	7	8	12
Create New Nature Rich Habitats		8		7	7	8
Nutrient Management for GHG Emission Reduction	7			1		7
Soil Management for GHG Emission Reduction	6	1	2	4	2	6
Crop Management for GHG Emission Reduction	5	3	4	2	2	5
Woodland Creation and Management	3	3	3	3	3	3
Cattle Feeding	1	1				1
All Objectives	**52**	**54**	**16**	**35**	**30**	**93**

Other objectives suggested within the screening process included *Water* where n= 22 measures were seen as potentially relevant and climate *Adaptation* where n=30. For Water the assessment was both in terms of quality and ecological condition (as it links to WFD commitments) and water quantity, both in terms of flooding and the emerging issue of water scarcity (for agricultural use, other rural industries, domestic private water supplies and ecological flow). For waters the screening team identified instances where research is well placed to provide options for EC measures, see Section 4.4. Other objectives or perspectives on the EC measures have also been the basis of discussion between research projects within the 2022-27 SRP. Of particular note is the potential to take natural capital perspectives on assessing the sustainability of existing farming and wider land use systems

and using nature based solutions to deliver multiple benefits (some of which are already being considered within the set of EC measures – see Section 5.1.1 *Why a Natural Capital approach for agriculture and land use policy?* for an outline of what a natural capital approach could add to the screening.

> **Further Analysis Option** – to (re)-brigade measures – e.g., to see how the overall set of measures reads across to key policy objectives or functional groupings (for example nutrient management, IPM, flood management, natural capital assessments or nature-based solutions etc.), that are considered in scope.
>
> **Further Analysis Option** – it may also be useful to generate a view of the EC measures as family trees (dendrograms) or other visualisations that differentiate the measures by delivery to key policy objectives, degree of change implied or other criteria.

3.6.3 Measure definitions

The importance of measure definitions is that they need to be sufficiently specific that they provide a basis for implementation by land managers and to define any weighting to be assigned.

The issues relating to measure definitions raised by the screening team are:

Specificity – some measures are perhaps better viewed as sub-objectives or measure "collections" (n=18). There are cases where an often very desirable and relevant outcome is stated but not the means in terms of what and how e.g., *low input management, regenerative grazing or Improving sheep/cattle health*. For such measures it would be desirable to be explicit on specific measures and where possible identify *step-on*, *mainstream* and *stretch* measures. Such collections may also be a useful way to simplify the presentation of the list of EC measures. IPM for example represents an overarching approach that could include measures included elsewhere in the EC measures list (n=20). This could allow a means of brigading together measures into more coherent sets and with a progression in term of challenge and ability to deliver to objectives. For regenerative agriculture see discussion in Section 4.3.1and for IPM, Section 4.3.7.

It was however seen as undesirable when an EC measure related only to a very specific geographical or activity niche, in which case it might be preferable for them to be amalgamated with other similar measures as options within a more generic EC measure.

Compound – is a variant of above but there are cases (n=21) of measures with two or more activities are included in the specification of an EC measure. Sometimes these are closely related examples e.g., *pulses or legumes to reduce inorganic fertiliser use*, but in other cases the elements are more distinct e.g., *cover and catch crops*, or imply non-equivalent actions e.g., *install or expand arable field margins*. In some cases, there may be benefits in listing these separately, especially where there are varying degrees of compliance costs, but in other cases there may be value in generating intermediate "type of measure" or further "objective" groups that then contain specific measure instances.

Overlap – there are a small number of EC measures (n=6) where there is more apparent overlap in measure definition than occurs in the other measures, e.g., *extend and expand permanent habitats for connectivity.* Others are variants of similar measures e.g., options for winter cover, where a more generic measure with options might be preferrable. That these variations occur across objectives reflects the multi-functionality of some measures and the challenges of how best to present this as discussed above.

For most Objectives the screening team were also able to suggest more or different EC measures and some of these are elaborated on in Section 4 *Biodiversity, Soils, Crops and Waters Issues* yet there is perhaps the need to be cautious in ensuring that the number of measures remains tractably comprehensible.

3.7 Targeting, Effectiveness and Standards

In the discussion of the EC measures, it was noted, based on natural science expertise, that in nearly all cases there could be circumstances in which a measure could be ineffective or even counterproductive. This raises questions of both targeting for EC measures and evaluation standards (linking to Tier 4 Measurement Tools).

For targeting it was noted that in many cases there is research-based knowledge of the conditions in which measures may not work, but the specific locations, at land parcel level, in which such conditions occur may not be mapped or otherwise known[11]. Relevant mapping does (or could) exist to make strategic targeting decisions in terms of relevance of measures (in terms of risk to soil types, habitats, and catchments) or to say where there may be specific pressures or opportunities for improvements.

Without sufficiently specific state-of-the-environment data though, it is hard for a measure's effectiveness to be known with certainty. This is compounded when the effectiveness of measures can depend on a wider catchment or landscape context, or the actions of others; see Section 3.8, *Scales and Granularity* for more detail on targeting and evaluation and Section 3.9 - *Interactions*.

This also suggested that, in evaluating measures, a heuristic standard be used which states that:

"*a measure, in most cases, will likely deliver a net benefit, on aggregate*".

This takes a pragmatic line that tries to ensure uptake of a measure at a scale that can deliver net benefits, without being excessively cautious or prescriptive.

Any negative outcomes could be minimised via clear guidance in EC measures to flag where such measures could be counterproductive. This could be a worthwhile follow up to the EC Measures Screening, but would certainty need to be part of the investments by SG in knowledge and skills in People Development (Tier 4). Where negative outcomes are

[11] Data on sub-soil conditions was noted as being notably lacking.

apparent, and the measures have been undertaken in good faith and within the guidance, then there should be no question of any penalty, but there does need to be a mechanism by which such failures are detected and rectified e.g., by undertaking other measures or activities (linking to both the Inspections Regime, and the Tier 4 People Development & Measurement Tools).

Few of the measures used specific standards (n=7) and none are quantified – though change versus a standard is often (n=31) implied by terms like *improve, reduce, enhance etc.* and could be included in any guidance detail, see Table 5 for a breakdown by Objective. It is important that such standards are defined so that those already meeting them are not disadvantaged by having to demonstrate additionality over existing good practice. Most measures (n=55) are specified in terms of *presence/absence*, and these are often associated with measures linked to a transformative management or land cover/use change, or habitat/cover change. While presence is likely simpler to quantify and increasing the area of such measures is likely to be beneficial, the active, ongoing management, especially of habitat measures, in terms of their quality will still need to be verified if such measures are to be fully effective.

Table 5: Standards associated with EC measures

Objectves	Qualitative	Improve/ Reduce	Presence/ Absence	All Standards
Livestock Management for GHG Emission Reduction	2	9	7	18
Manage for Species found on Farmed Land		3	14	17
Maintain and Enhance Field Margins and other Permanent Habitats	2	10	4	16
Improve Cultivated Soil Health		8	4	12
Create New Nature Rich Habitats			8	8
Nutrient Management for GHG Emission Reduction			7	7
Soil Management for GHG Emission Reduction	2		4	6
Crop Management for GHG Emission Reduction			5	5
Woodland Creation and Management		1	2	3
Cattle Feeding	1			1
All Standards	**7**	**31**	**55**	**93**

3.8 Scales and Granularity

In discussing the EC measures several issues related to scale (spatial and temporal) and granularity were highlighted as worth considering.

3.8.1 Spatial scale issues

In terms of the level at which the EC measures imply acting, the screening team distinguished individual *Animals*, *Fields* or other land parcels and *Holding* (all or part of a business). The predominant action scale looks to be Field (n=65) with Holding level changes (typically to the mix of enterprises, system of production or wider habitat management) occurring less frequently (n=19) and per animal measures the least common (n=9). The mix of these types varies between objectives (see Table 6) with for example *Livestock management for GHGs* being a balance of individual animal and holding level actions. Most other objectives are predominantly or exclusively field based measures except for *Nutrient*

management for GHGs with technical holding level improvements. The view of the screening team was that the Holding level changes looked to be more challenging and potentially less likely to see uptake and that EC will need ways to encourage (potentially incremental) progress towards these more transformational changes and to make visible cases where such practices are already in place.

Table 6: Scales of action for EC measures

Objectives	Animal	Field	Holding	All Scales
Livestock Management for GHG Emission Reduction	9		9	18
Manage for Species found on Farmed Land		16	1	17
Maintain and Enhance Field Margins and other Permanent Habitats		15	1	16
Improve Cultivated Soil Health		10	2	12
Create New Nature Rich Habitats		8		8
Nutrient Management for GHG Emission Reduction		2	5	7
Soil Management for GHG Emission Reduction		6		6
Crop Management for GHG Emission Reduction		5		5
Woodland Creation and Management		3		3
Cattle Feeding			1	1
All Objectives	**9**	**65**	**19**	**93**

The screening team also considered the scale at which the benefits of the measures can be detected. Evaluation of their outcomes (rather than actions) can be scale dependent, that is the measure implies a spatial extent at which its effects can be detected – land parcel, holding, catchment, landscape etc. The breakdown by scale for each objective is shown in Table 7. This highlights that for *crop*, *livestock*, *nutrient* and *soil* management for GHGs, the outcomes of most measures are likely to be measurable scales of holding or below. The screening team did though note the need for a *life-cycle* based assessment at least to holding level and preferably beyond when changes to net GHG emissions are assessed to avoid cases where savings in one part of the system e.g. soils are offset by greater losses elsewhere. Most (n=53) measures linked to habitats and biodiversity are, however, only able to be evaluated at catchment or landscape levels. Improving Cultivated Soil Health is the exception with measures noted across all the scales.

Table 7: Scales of detectable outcomes for EC measures

Objectives	Animal	Field	Holding	Catchment	Landscape	All Scales
Livestock Management for GHG Emission Reduction	8		10			18
Manage for Species found on Farmed Land					17	17
Maintain and Enhance Field Margins and other Permanent Habitats				1	15	16
Improve Cultivated Soil Health		3	1	4	4	12
Create New Nature Rich Habitats				2	6	8
Nutrient Management for GHG Emission Reduction		2	5			7
Soil Management for GHG Emission Reduction		3	2		1	6
Crop Management for GHG Emission Reduction		4	1			5
Woodland Creation and Management					3	3
Cattle Feeding			1			1
All Objectives	**8**	**12**	**20**	**7**	**46**	**93**

Evaluation of measures whose effects can only be detected at broader scales (beyond the holding), or that are context dependent, present several problems.

- **Verification** of outcomes may be impossible when the signal generated by the measure is small relative to the noise (random variation in the system generated by effect like climate).

- **Attribution** of effects to causes (the EC measures undertaken) can be a challenge where an outcome (positive or negative) may be the outcome of actions by several businesses. Free-riding and/or windfalls are challenges here (see also Section 3.9 *Interactions*).

- **Thresholds** occur where for a measure to be effective there is the need to achieve a concentration or density of measures within a region, to make an appreciable difference. There can be a period, before that threshold is achieved, in which the measure is likely ineffective in terms of measurable outcomes, but its potential is improving over time. The challenge is to evaluate if the trajectory of potential can be sustained so that the thresholds needed to deliver outcomes will be reached – see also Section 3.8.2 *Temporal scale issues,* next. See Appendix I - Maps, Figure 6 for an example density map for AECS measures, 2015-19.

3.8.2 Temporal scale issues

Timeliness for delivering outcomes is a big challenge for the EC measures. For both GHG emissions reductions objectives, *net zero by 2045* [14] and biodiversity objectives, *increasing protected areas to 30% of land* and becoming *Nature Positive by 2030* [15] mean the need for rapidly enacted systemic change. This raises the question of how much of the change is expected to be delivered by EC measures, by other Tiers of the agriculture policy, or by other Scottish/UK policies. More specifically, how do these public policy measures interact with existing public or private financial investment that is locked in and defined rather than being aspirational. With EC measures likely to be phased in post-2026, existing policy instruments will also need to make progress in the interim and there will need to be a steep ramping up of expectations for delivery in the post-2026 period.

Time Lags from Actions to Outcome. Another key issue highlighted by the EC measures screening team, and by others working both in the research and policy evaluation domains, is the potential for lag between measures being enacted and any measurable effects (for example, continuing losses to water after changes in the types and amounts of fertilisers, or biodiversity changes in response to habitat restoration or expansion). Lags are particularly challenging as they imply the need to closely monitor how well measures are deployed (quality of implementation) as well as the types and areas of EC measures (quantity of implementation). Otherwise lack of delivery of outcomes could be a result of implementation failure, not from the expected delay due to buffering or other natural processes.

Lags were seen as likely for n=69 of the 93 EC measures, see Table 8. Lags are most apparent for habitat and biodiversity objectives, while noting that associated benefits like improved hydrology may be apparent more quickly. For GHG emissions objectives most of

the livestock measures with a technical basis (e.g., *diet, health, and manure management*) were seen as having the potential to deliver rapid outcomes after their implementation but some might be limited by progress elsewhere (e.g., *livestock breeding programmes*) or where there was more systemic change (e.g., *better grazing systems*). For cropping systems, emerging research emphasises the need to carefully match plant phenotypes with soil biomes to realise net GHG reductions, discussed further in Section 4.3.6. The screening team, taking an abundance of caution approach therefore noted that a time lag should be assumed before *crop management for GHG emissions* would fully deliver the outcomes sought.

Table 8: Potential for time lags in detecting outcomes of EC measures

Objectves	Y	N	All Objectives
Livestock Management for GHG Emission Reduction	3	15	18
Manage for Species found on Farmed Land	17		17
Maintain and Enhance Field Margins and other Permanent Habitats	16		16
Improve Cultivated Soil Health	12		12
Create New Nature Rich Habitats	8		8
Nutrient Management for GHG Emission Reduction		7	7
Soil Management for GHG Emission Reduction	4	2	6
Crop Management for GHG Emission Reduction	5		5
Woodland Creation and Management	3		3
Cattle Feeding	1		1
All Objectives	**69**	**24**	**93**

Funding Timescales. The timescale over which the effects of measures can be detected may not fit well with evaluation periods set for programmes of measures (5-7 years in previous CAP regimes with the potential for mid-programme review) or by periods for which budgets are in place (now no longer based on EU multi-annual financial frameworks but UK Treasury decisions). Longer evaluation periods also mean greater challenges of verification and attribution as noted for spatial scale (above). This strongly implies that the Measurement Tools in Tier 4 need more resources than are deployed for existing schemes and that there needs to be institutional support for much longer-term monitoring and evaluation and that systematic look-back studies of previous interventions would also have value.

Climate Proofing. Another temporal scale issue is the need to consider the challenges of climate proofing EC measures. Three aspects are relevant to the EC measures. The first is to ensure that where difficult-to-reverse measures are undertaken (typically changes in land cover, permanent habitats or where there is significant capital investment e.g. creation of ponds or wetlands) then these are reviewed and judged as long term viable under the range of alternative future climates seen as likely to occur [16] or taking a precautionary [17], worst-case precautionary, [18] or extreme event indicators [19]. Second, is the need to plan for actions to protect natural assets currently in good condition but which may be vulnerable under future climates, particularly to increases in water deficits (e.g. *maintaining peatland restoration* and *create wetlands* in the drier east of Scotland) and fire risk [19]. Third, there is the need to assess how measures enacted may contribute to overall

resilience and/or adaption of natural and human systems to the increased risks under climate change. Climate proofing ecosystem resilience also means considering the spatial configuration, extent and connectivity of habitats to support ecosystem functions and flows of ecosystem services. Hence spatially planning the coordination of EC measures will also be a part of climate proofing.

Resilience and adaptation are not apparent as primary goals of the EC measures with their mitigation and biodiversity focus, but screening the measures for resilience and adaptation implications may be worthwhile.

> **Further Analysis Option** – screen the measures for resilience and adaptation implications.

3.8.3 Granularity

This issue refers to the decision-making units through which the EC measures are implemented. While a range of relevant spatial scales have been identified above (see Section 3.8.1), pragmatically the granularity of decision making for EC measures is the farm business, which may include land holdings that are not spatially contiguous or temporary use of other land parcels through seasonal lets and informal arrangements. Therefore information about EC must be targeted to the decision makers (which can vary from a sole trader/family farm to an agri-business) but the EC measures could be deployed across a range of farm systems and land cover types managed by the same business [20]. These decision makers may also participate in voluntary measures via e.g., Tier 3 Elective Measures or collective action through other partnerships (e.g. catchment partnerships, landscape partnerships or local enterprise networks) [21]. In these cases, decision making by individual businesses is framed within wider objectives characterised by the specific challenges faced by that spatial unit.

There are potential complications of multi-holding businesses that provide a variant of the modifiable areal unit problem[12]. If EC funds are implemented to a business, it may be possible that the performance of a holding many miles away can be used to deliver the EC requirements of another wholly separate management entity. Therefore, this complicates the ability to target, or evaluate, how EC measures are delivering changes on the ground. Within business, for some activities, the degree of benefit delivered by measures will vary – "right measures in the right place" - but there may be trade-offs with higher implementation costs. The EC may rely on Skills, Knowledge, and Training so managers can know where is best (and potentially identify this in their whole farm plans) for Advisory Services to support planning and implementation and Tier 3 Elective Payments where these support between-business coordination. See also Interactions below.

[12] Colloquially where defining the shape and size of the unit used to measure a phenomenon has a significant influence on the answer you get – for example the process of gerrymandering voting districts.

Further Analysis Option: Consider how to address targeting at field, animal or holding scale if payments are made to businesses; and whether additional screening based on farm business decision making may contribute further insights.

3.9 Interactions

As noted previously, interactions between businesses can matter and it is not safe to assume that the outcomes for each business and overall depend only on their independent, individual decisions. Key interaction issues identified in the EC measures screening are set out below.

3.9.1 Interactions with non-SAF businesses

While SAF businesses (n=19,292) have a declared 5.7M ha out of 7.8M ha for Scotland as a whole, the non-SAF area (2.1M ha) can be locally significant and there are 4,969 agricultural holdings beyond the SAF population. This also includes large areas of "public land" e.g., in the National Forest Estate, Scottish Water, Transport Scotland, Crown Estate and Ministry of Defence [13]. Interactions with this "other" land can be significant.

Non-SAF businesses can enhance or undermine EC measure outcomes. Where actions by non-SAF businesses could be undermining the success of EC measures (e.g. through diffuse pollution from agrochemical use, limited actions to control deer numbers, or allowing habitats to be degraded) then this needs to be identified, meaning the need to consider monitoring beyond the extent of the SAF population of businesses, see Section 3.7 earlier. This also implies the need for regulation of the non-SAF business population (e.g., via SMRs) to be effective in avoiding any limiting of delivery of EC outcomes by SAF businesses.

On the other hand, given that there are examples of non-SAF land-based businesses that have primarily environmental objectives, then there is also the need for care when assessing EC measure outcomes that SAF businesses do not "free-ride" on landscape or catchment scale outcomes partially or wholly provided by other non-SAF businesses, see the discussion of Verification , Attribution and Thresholds in Section 3.8.1 *Spatial scale issues*

3.9.2 Interactions between SAF businesses

As previously noted in Section 3.8.1, the effectiveness of some EC measures depends on achieving above threshold levels of concentration per EC measure. This implies that it would be preferrable in some circumstances for there to be coordination in terms of the kinds of measures and where they are enacted in an area. This is especially important for permanent habitat measures seeking to improve habitat connectivity between SAF businesses[14] (see Table 7).

[13] REF Peter Phillips - Public Land dataset.

[14] *Extend and expand existing permanent habitats to ensure connectivity across the holding and between holding* in both *Maintain and Enhance Field Margins and other Permanent Habitats* and *Create New Nature Rich Habitats* objectives.

This raises issues of how such coordination could be facilitated, how priorities would be agreed and how the EC measures scheme or other parts of the agricultural support payments system could be used to encourage, evaluate, and reward such actions. This presents administrative challenges since all the linked businesses would to some degree need to be assessed together. It would be highly undesirable to delay payments until the last business in a group is assessed but if coordination or a payment uplift for cooperation were a Tier 3 Elective Payment then this would potentially avoid delays in payments with a significant income support element (Tier 1, Coupled Support and Disadvantage payments).

Relevant experience of enacting cooperative action could potentially be gleaned from the institutions of Crofting and Common Grazing such as Grazing Committees [22]. Note though, that Common Grazing is a special case backed by legal definitions of land rights and responsibilities rather than voluntarily entered. Conversely, there was concern on how EC measures would be enacted on Common Grazing where issues of delineation and attribution of condition, action and impacts are potentially even more complex than for single user businesses. Of particular concern was how the estimated 0.25M ha of peatland on Common Grazing within the SAF population are managed [23].

3.9.3 Teleconnections

A special case for interactions is teleconnections where undertaking activities such as EC measures can have effects at considerable distances from the sites on which the measures take place. This is again a form of evaluation and attribution challenge, with a good example being measures that affect the quantities of water available – e.g., *restore flood plain connectivity*. These could help with mitigating flooding or ensuring water supplies or ecological flows further down the water network, potentially beyond the local sub-catchment.

Where these activities deliver public goods (the ecological flow outcomes) then EC measures look to be appropriate. Where the actions mitigate harms (the flooding case) then there is potentially merit in considering other funding models, such as payment for ecosystem services by downstream beneficiaries [24]. Therefore, beyond addressing interactions within the public policy sudoku (see Section 3.2), the extent to which EC delivers objectives in combination with private investment activities may need to be addressed. This is particularly in relation to estimates of a funding gap between the need for action to mitigate climate and biodiversity impacts and available public grants [25].

> **Further Analysis Option –** consider how EC measures might interact with private finance – e.g., via voluntary carbon markets, biodiversity offsetting or other investments in natural capital.

3.9.4 Between EC measures

The potential for synergies between the measures listed was noted by the screening team, i.e., sets of measures that might deliver more when conducted together adding up to a

more systemic change. A clear example was hedge-creation which is enhanced by hedge management (frequency and seasonality of cutting etc) and complemented by wider no spray zones (potentially involving cooperation between SAF and/or non-SAF businesses– i.e., no spray from either side). This highlights that EC measures could deliver more than the sum of their parts; however, how this could be evaluated, administered, or communicated to land managers remains challenging to define. Potentially the assessment of measures together as part of a whole farm planning process (in Tier 1) could formalise how well the chosen EC measures "stack" and systems of menus, linked measures, or extra expectations over time for the same measure could be used to maximise benefits. The role of advice and knowledge transfer in Tier 4 People Development and proactive sharing of the Measurement Tools results with land managers and other stakeholders will be crucial.

3.9.5 Interactions with other Tiers

The interactions between EC measures and other Tiers have been noted elsewhere (see Section 3.4 *Budgetary Considerations)* but it is worth reiterating that there is the need for clarity on which objectives are delivered by EC measures and the principles for making such budgetary decisions.

> **Further Analysis Option:** to consider to what extent EC measures relate to coordinated or collaborative actions by SAF or non-SAF holdings (especially for common grazing) and the implications for the EC scheme design and delivery.

3.10 Uptake of EC Measures

The measures proposed for inclusion in the Tier 2 EC are not wholly new with (n=21) EC measures being like those funded via Basic Payment Scheme Greening (Pillar 1, 2015-present), see Table 9. This highlights that the existing EFA measures can make up a substantial proportion of those proposed for EC (a maximum of 80% of the measures for *Crop Management for GHG reduction*), with others in the 17% to 42% range. EC measures are clearly going well beyond EFA but there is sufficient overlap that the uptake of EFA measures can meaningfully inform the development of EC measures at least where cropped land is a significant part of the overall enterprise mix.

Table 9: Where EFA measures are like EC measures, per objective.

Objectves	3 Crop Rule	Agro-Forestry	Hedges	Nitrogen Fixing Crops	Cover/Catch Crops & Green Cover	Margins	EFA Measures	No EFA Meaure	All Objectives	EFA as % of EC
Improve Cultivated Soil Health	2			1	1	1	5	7	12	42%
Manage for Species found on Farmed Land					1	3	4	13	17	24%
Maintain and Enhance Field Margins and other Permanent Habitats			1			3	4	12	16	25%
Crop Management for GHG Emission Reduction				3	1		4	1	5	80%
Create New Nature Rich Habitats			1			1	2	6	8	25%
Soil Management for GHG Emission Reduction					1		1	5	6	17%
Woodland Creation and Management		1					1	2	3	33%
Livestock Management for GHG Emission Reduction							0	18	18	0%
Nutrient Management for GHG Emission Reduction							0	7	7	0%
Cattle Feeding							0	1	1	0%
All Objectives	**2**	**1**	**2**	**4**	**4**	**8**	**21**	**72**	**93**	**23%**

Many of the measures (n=50) have also been seen previously in CAP Pillar 2 AECS (Pillar 2 from 2015) and previously Rural Priorities (Pillar 2, 2007-13). Earlier research suggests that future uptake is strongly associated with past experiences of similar schemes [26].

The uptake of measures within the EFA part of CAP Greening from 2015-21 has been undertaken in a separate analysis in the Land use Transformations project (JHI-C3-1) [5]. This study has informed the screening of the EC measures, but it is worth noting that the EFA CAP Greening requirement was only for some businesses (n=3,740 of 19,292) but did apply to nearly 90% of the arable area. EC will apply to the whole Tier 1 & 2 population (potentially excepting businesses in a smallholders scheme) and could have more demanding expectations (see Section 3.4.1, *Eligibility – the businesses and land area within EC*).

The ARIOB paper highlights cost and complexity (see section 3.3.1) as factors that might limit uptake and the Screening team agreed these were useful diagnostic factors. The screening team did though express concern that if the expectation was that only the low cost and complexity measures were expected to be adopted as new activities then their potential for delivering the outcomes sought was limited.

None of the compliance costs of the EC measures was quantified in the Measure Screening but factors that affect costs and the nature of the costs and how this might affect uptake of measures by the individual businesses were discussed in qualitative terms. The issues raised by the screening discussions are outlined below.

3.10.1 Production efficiency

Production efficiency measures (n=26) would seem the clearest case of when there are potential win-wins, i.e., where there can be savings in terms of the resources needed to deliver the same outputs or more output per unit of inputs. Such measures would, on that basis, be more likely to be taken up.

Table 10: EC measures with a production efficiency basis

Objectives	Y	N	All Objectives
Livestock Management for GHG Emission Reduction	18		18
Manage for Species found on Farmed Land		17	17
Maintain and Enhance Field Margins and other Permanent Habitats		16	16
Improve Cultivated Soil Health	1	11	12
Create New Nature Rich Habitats		8	8
Nutrient Management for GHG Emission Reduction	6	1	7
Soil Management for GHG Emission Reduction	1	5	6
Crop Management for GHG Emission Reduction		5	5
Woodland Creation and Management		3	3
Cattle Feeding		1	1
All Objectives	**26**	**67**	**93**

Most of the clearest production efficiency-based measures are for livestock systems (n=24 of 26). This is important for Scotland given the quantity of emissions from animals. The

screening team thought it also worth considering similar measures for plant-based systems (e.g., new varieties to deliver low C emissions grasslands, increase N or water efficiency) – see Section 4.3.6. Crop *cultivar selection and genetic improvement*.

Uptake of efficiency measures where the win-win is defined in terms of operational costs may be limited when either the operational costs are higher, or efficiency gains are more limited. The distributions of such factors are difficult to quantify in general terms and it might be expected that smaller, less capital intensive and more remote business might struggle to realise the anticipated gains. Uptake of such measures may also be blocked by capital costs – financial (investment funds to underpin new plant and machinery) or human (in terms of time and other resources needed to acquire necessary new knowledge). Both barriers could however be addressed via Tier 4 Measures Skills, Knowledge, Training and CPD and Agricultural Transformation Fund.

A further question is whether such technical production efficiency EC measures for livestock are conditions just for VCS funding? If not, then what proportion of wider EC requirements per business can be fulfilled by such measures? Displacement by livestock production efficiency measures, of all land-based measures would be particularly undesirable for soil, biodiversity and water objectives as noted in Section 3.4.2 *Balance of budget across measures.*

Where efficiency gains are linked to reducing inputs or minimising losses to the wider environment (n=10) – e.g., a change away from artificial N fertilisers to organic N for the *Crop Management for GHG Emissions Reduction* objective, then this needs careful consideration of lifecycles to be sure that there are clear and unambiguous gains to be made and the circumstances in which such gains can be demonstrated, see Section 3.8 *Scales and Granularity* and Section 4.3 *Soils and Crops*. Such measures were more often judged to be transformational in nature, with changes in both cropping patterns and the machinery used for their management. While often desirable, the resources of EC may be too limited to trigger uptake more widely given the potential capital costs. Such changes may again need to be supported via the Tier 4 Agricultural Transformation Funding with only maintaining of such systems supported through EC.

Efficiency measures are also not on their own a panacea, since more efficient use can be more profitable and lead to increased overall levels of production with higher aggregate resource use or emissions through intensification (the Jevons Paradox). Therefore, it is important to monitor whether the efficiency EC measures are having their desired outcomes for GHG reductions, soil health and biodiversity, and adjust if required. Caps on production via national/regional quotas are challenging to implement and are complicated by questions of relative production efficiencies and impacts beyond Scotland.

3.10.2 Margin-based measures

From the analysis of the EFA measures within CAP Greening it was clear that there was a preference for margin-based measures (17,457 land parcels with margin only measures,

10,748 land parcels with field only and 2,520 with both[15]). The relative lack of margin-based measures (n=7 of 93) and the lack specifically of riparian buffer strips as measures perhaps reflects a focus on GHG emissions mitigation and farmland biodiversity. The members of the screening team with waters expertise noted a range of innovative and "ready to implement" riparian buffer management options that deliver a variety of enhancements to riparian habitats, water quality and aquatic ecology [27]. Riparian woodlands and their potential to mitigate higher water temperatures were not clearly explicit within the listed measures but may be included within EC measures in the *Maintain and Enhance Field Margins and other Permanent Habitats* objective.

The screening team did also note that juxtaposing conventional intensity and field management with improved margins was likely to limit tangible improvements for biodiversity in farmlands. More desirable would be an integrated fields and margins approach, however recognising that this might need to be the ambition not the initial starting point for EC measures. Further consideration of whether encouraging Field+Margin approaches should be formalised in EC measure scoring should be carried out.

3.10.3 Other characteristics of the EC measures

Uptake of the EC measures will likely be influenced by a wide variety of factors, not least being the relevance of the measures to existing patterns of land cover, use and management as noted in Section 3.3 *What does EC expect to deliver?* Specific potential barriers considered in the screening are summarised in Table 11.

Non-productive land take highlighted where EC measures might see smaller areas of a business used for production activities (land sparing), with n=23 measures associated with this, or 25% of all EC measures. The non-productive land take is associated most strongly with the *Create New Nature Rich Habitats* objective (n=7 of 8 measures) but 9 of 17 measures in *Manage for Species found on Farmed Land* are also land sparing. While the latter measures will also serve to maintain and improve existing habitats the screening team highlighted that a substantial increase in such areas and in the most intensively managed parts of Scotland would likely be needed to make progress towards reversing farmland biodiversity loss trends.

Extra labour highlighted where there could be limitations on the uptake of measures since they were associated with actions where there were extra requirements, and it was difficult to substitute with equipment or other means. There was some uncertainty for some measures and thus the screening team only recoded a yes value for *Extra Labour?* Where it was clear and/or substantial. Measures in *Manage for Species found on Farmed Land* and *Maintain and Enhance Field Margins and other Permanent Habitats* objectives were highlighted as most often potentially limited. For the *Create New Nature Rich Habitats* objectives there was some uncertainty on labour as a limit as the option for using

[15] The land parcels with both infield and margin measures are included in both the infield and margin counts.

contractors for the capital phases was seen as possible, though this might in turn mean being limited by availability of capital resources. Overall, Extra Labour requirements were identified as potentially affecting 43% of EC measures, this being the second most frequently occurring limit on uptake. Lack of available labour was seen as particularly likely to be a constraint for smaller, particularly part-time, or pluri-active businesses.

Table 11: Factors affecting uptake for EC measures per Objective

Objectives	All Objectives	Non-productive Land Take?		Extra Labour?		New Skills?		Reduced Yeild per ha*		Extra Capital?		Reduced land value?		More complex systems?		All Objectives
		Y	Y	?	Y	?	Y	?	Y	?	Y	?	Y	?		
Livestock Management for GHG Emission Reduction	18				5	12								1		18
Manage for Species found on Farmed Land	17	9	5	4	6	1		2								17
Maintain and Enhance Field Margins and other Permanent Habitats	16	3	8	3	3	7		1	1		1			4		16
Improve Cultivated Soil Health	12	2	1		4	3	4	4	2	2	1	1		3	5	12
Create New Nature Rich Habitats	8	7		8	4	4		1	2		1	1			2	8
Nutrient Management for GHG Emission Reduction	7			2	2	4			4	1				3		7
Soil Management for GHG Emission Reduction	6		1		2	1	3		1	1		1			1	6
Crop Management for GHG Emission Reduction	5		2	3	3		2			4					1	5
Woodland Creation and Management	3	2	1	2	2	1						2		2	1	3
Cattle Feeding	1													1		1
All Objectives	**93**	**23**	**18**	**22**	**31**	**33**	**9**	**8**	**10**	**8**	**3**	**5**	**14**	**10**		**93**
Percentage of all measures		**25%**	**19%**	**24%**	**33%**	**35%**	**10%**	**9%**	**11%**	**9%**	**3%**	**5%**	**15%**	**11%**		
Percentage combining Yes with ?		**25%**	**43%**		**69%**		**18%**		**19%**		**9%**		**26%**			

*In all cases the losses were seens a temporary

New Skills is a factor already acknowledged in the discourse on EC measures and was highlighted by the screening team as the most frequently occurring limitation on uptake of measures with 69% of measures flagged. Again, there was some uncertainty in interpreting the measures, so a 'yes' value was reserved for systemic changes or where additional enterprises were added into a farm system or when the measures were either the outcomes of recent Research and Development or were judged as not having a critical mass to generate a demonstration effect or to support sector-wide peer to peer learning. The biodiversity management objectives *Manage for Species found on Farmed Land* and *Maintain and Enhance Field Margins and other Permanent Habitats* were again prominent, as were the *Livestock* and *Nutrient management for GHG Emissions Reduction* objectives, though in no case was less than 50% of each objective seen as potentially being skills limited.

Reduced Yield per ha focused on the changes to production systems disregarding any potential changes in overall farm yield caused by changes in the area under productive management (covered above under *Non-Productive land take*). The focus was thus on how often the EC measures might be limited in uptake by limits on productivity per unit area. Relatively few cases were positively identified (n=9) and in all these the view of the screening team was that yield reductions would be a transitional phenomenon. The objectives where uptake might be affected were in *Improve Cultivated Soil Heath* and *Soil Management for GHG Emissions Reduction*. The screening team acknowledged that concerns on yields and thus linkage to the food production components of food security

could make this transition challenging. The importance of enhancing advice and demonstration of outcomes via research platforms, Monitor Farms, and other industry groups, the 'Preparing for Sustainable Farming' Programmes and via Tier 4 People Development was highlighted.

Extra Capital sought to identify measures where the most substantial capital investments were likely needed. This is a narrower subset of the measures identified by SG as high capital, as the screening team questioned whether the SG high capital costs for some of the measures (including land take) were accounted for elsewhere in the screening analysis. The higher capital investments were seen as linking with using new technologies or facilities for manure management (in *Nutrient Management for GHG Emission Reduction*) but also across other objectives where measures were undertaking modifications to the hydrology (e.g., *restoring floodplain hydrology* or *sustainable drainage systems*). For the latter it is, however, worth noting that high capital costs were assuming conventional engineering interventions rather than more extensive nature-based approaches that may be more compatible with incremental improvements supported by revenue-based EC funding.

Reduced Land Value focussed on whether undertaking the EC measure might reduce the financial value of the land, either permanently or in a way that would be hard to reverse. The interpretation focused on the value per hectare, since land take was covered in *Non-productive land take* The measures highlighted therefore tended to be a limited number where the measure would see limitations in the way that land could be used (e.g. having access to land limited by its use as flood storage in Restore Floodplain Hydrology), or changes to land cover with more limited productive potential (e.g. conversion of temporary to permanent pastures) or afforestation. Some caution is needed in making this interpretation as with recent changes in land prices in Scotland (seeing less differential between lowland and upland prices) there may be anticipation in the markets of the potential for land in delivering services beyond provisioning, most obviously for GHG offsetting or insetting but potentially for other metrics such as biodiversity offsetting or net gain.

More complex systems reflected the screening team's view that increasing specialisation within faming systems (limiting the number of enterprises per business) may be a trend that could limit uptake of some measures. This was going beyond the need for New Skills referred to previously and the screening team tried to identify where proposed measures would see new enterprises added, particularly adding livestock into arable-only businesses, or adding new management regimes such as intercropping. Overall, there are a limited subset of measures identified (n=14 with a further n=10 possible) but these are to a degree concentrated in a small number of objectives (highlighted in Table 11), particularly *Improve Cultivated Soil Health.* Encouraging the uptake of such measures is however essential since they could be widely applicable across the arable areas of Scotland and deliver benefits across the widest range of objectives (see Table 4, in Section 3.6.2, *Multi-functionality*).

The issue of **cumulative complexity** was also raised by the screening team. The possibility for monocultures of EC measures was seen as having the potential to limit the delivery of the range of benefits being sought, yet the screening team acknowledged that undertaking more measures could be more complex in terms of managing delivery. The EFA uptake analysis showed the largest number of businesses had only a single measure (42%) but this was less than 25% of the EFA area. Two measures were present on 32% of businesses and 24% had three or more. This tended to indicate that expecting large numbers of measures to be taken up is not likely, and that it will be important that where multiple objectives are seen as important, then either fully multi-functional measures are encouraged or a floor in terms of number and types of measures should be established. The suggestion was that there should be a minimum number of EC measures per business that could be linked to size or level of funding being received or be driven by the number of land-types present (BPS region or another basis).

3.10.4 Tenure

The importance of tenure in the uptake of EC measures was highlighted in the screening for compatibility with tenanted land (1.18 M ha) and seasonal rented land (0.35 M ha) of the 5.4 M ha used by SAF businesses, see Table 12. This highlights that for longer term (beyond seasonal rental) the plurality of measures (n=63) could be compatible with a tenanted business (considering only tenure, not other related factors). Where the EC measures were in terms of changes to management of existing natural assets or enterprises then these were in nearly all cases compatible with tenanted land. None of the remaining measures (n=30) was ruled out, but in these cases the kinds of change were likely to need permission from, or cooperation with, landowners, particularly where there could be creation of new habitats or changes to hydrology. For seasonal land there was a smaller than tenanted, but still wide range of measures (n=51) that could be undertaken; again with nearly all those for livestock and existing habitat features being compatible. There were however measures (n=24) where the transition or multi-annual nature of the EC measures mean they were not likely compatible with seasonal rented land. Where seasonal rented land is undertaken over an extended period then more of the measures may become relevant but again likely with the need for cooperation between landowner and renter.

Table 12: Compatibility of EC measures with Tenanted and Seasonal rented land.

		Tennant Compatible?		Seasonal Compatible?			
Objectives	**All Objectives**	**Y**	**?**	**Y**	**?**	**N**	**All Objectives**
Livestock Management for GHG Emission Reduction	18	18		18			18
Manage for Species found on Farmed Land	17	17		14	3		17
Maintain and Enhance Field Margins and other Permanent Habitats	16	4	12	4	4	8	16
Improve Cultivated Soil Health	12	9	3	6	4	2	12
Create New Nature Rich Habitats	8		8			8	8
Nutrient Management for GHG Emission Reduction	7	6	1	1	5	1	7
Soil Management for GHG Emission Reduction	6	3	3	3		3	6
Crop Management for GHG Emission Reduction	5	4	1	4	1		5
Woodland Creation and Management	3	1	2		1	2	3
Cattle Feeding	1	1		1			1
All Objectives	**93**	**63**	**30**	**51**	**18**	**24**	**93**

The complex mix of tenures present in Scotland (166 combinations of the 9 types in JAC prior to 2022[16]) means that EC and tenure measures potentially needs more consideration than was possible in the Screening.

> **Further Analysis Option**: more in-depth study of tenure implications for EC measures.

Given the potential importance of tenure and the recent assessment by RESAS that the JAC tenure data is unreliable, and that from 2023 the data will not form part of the annual JAC, then serious consideration needs to be given to how such data should be improved and collected, preferably on an annual basis since that make it compatible with other data sources used for policy analysis.

3.11 Transformative Change

Given the importance of the policy objectives it is certainly important for the EC measures to deliver tangible outcomes quickly and over time to expect more of these outcomes to be delivered. Measures identified as transformative (n=22, with n=5 possible) were those that see the most substantial changes to land cover, use or management. There are examples of such measures in most of the objectives, see Table 13. The exception here is the management of species found on farmed land where, while the individual measures were not seen as transformative, if implemented with sufficient extent and density their aggregate effects would count as transformational (see Section 3.8.1, *Spatial scale issues*).

[16] The 166 combinations include differences in the size of tenure elements – e.g., large owned + small rented is qualitatively different from small owned+ large rented.

Table 13: Degree of transformation from EC measures per Objective

		Transformative?			
Objectives	**All Objectives**	**Y**	**?**	**N**	**All Objectives**
Livestock Management for GHG Emission Reduction	18	3		15	18
Manage for Species found on Farmed Land	17			17	17
Maintain and Enhance Field Margins and other Permanent Habitats	16	3	2	11	16
Improve Cultivated Soil Health	12	2	2	8	12
Create New Nature Rich Habitats	8	7		1	8
Nutrient Management for GHG Emission Reduction	7	1		6	7
Soil Management for GHG Emission Reduction	6	3		3	6
Crop Management for GHG Emission Reduction	5	1		4	5
Woodland Creation and Management	3	2		1	3
Cattle Feeding	1		1		1
All Objectives	**93**	**22**	**5**	**66**	**93**

The concern for the screening team was that the measures identified as transformational were those judged least likely to be taken up. The screening team assumed that funding via EC measures would apply to those businesses that had already undertaken transformational change, in line with not wishing to require additionality from those already delivering against the EC measure objectives. Making sure that good practice is recognised and maintained over time is important but funding from EC measures was not seen as likely to deliver additional transformational outcomes. As more widespread transformational change is needed, then funding of transformational EC measures would most naturally be part of deploying the Agricultural Transformation fund (Tier 4). Such support was seen as having similarities to funds supporting Organic Conversion and Maintenance with both the conversion (transformation) phases and longer-term maintenance supported.

4 Biodiversity, Soils, Crops and Waters Issues

4.1 Biodiversity

4.1.1 Missing measures?

A previous study by Pakeman [28] considered whether there were gaps in the measures included in AECS between 2014 and 2020. This study included a review of other AECS measures in the EU member-states and other UK administrations with measures, species and habitats perspectives. The report also included interpretation of the options with stakeholders in the Ecosystems and Land Use Stakeholder Engagement Group (ELSEG) in November 2016. The report highlighted the need for measures relevant to cropped and grazed land; this is a key concern for the EC scheme given the large portion of budget likely to be associated with such land cover/use. The report also highlighted the continuing challenge of balancing specificity and complexity of measures and whether to use groups of measures as options within a smaller number of measure types linked to key objectives.

4.1.2 Species and habitats as a basis for EC measures

Both species and habitats were recognised as a valid basis for EC measures but there was some concern from the screening team that for the *Manage for Species found on Farmed Land* objective there were habitat measures that seemed at first look to be more appropriate in other objectives (e.g. *Maintain* or *Create Habitats*) and introduced some degree of duplication in the EC measure list (see Table 14). An option to present all measures based on habitat managed was discussed but it was agreed that a way of presenting the linkages between species and habitats and choosing EC measures starting from either perspective could be valuable.

Table 14: Habitat and Species based measures

Objectives	Habitat	Species	Species?	All Objectives
Manage for Species found on Farmed Land	7	9	1	17
Maintain and Enhance Field Margins and other Permanent Habitats	13	1	2	16
Create New Nature Rich Habitats	7	1		8
Woodland Creation and Management	3			3
All Objectives	**30**	**11**	**3**	**44**

Grouping biodiversity linked EC measures (n=59) by habitat and activity emphasises that even with 93 total measures there are limited number of options for some combinations, see Table 15. There were also relatively small numbers of EC measures seen as relevant across multiple broad habitats (n=3). While overall the mix of measures may reflect where funding per hectare is likely to be highest (farmland in current BPS region 1) – n=31 of 62 measures for in-field crop/grass fields - there was concern in the screening team that some businesses would have limited options with which to deliver the EC measure requirements.

Table 15: EC measures grouped by Action types and broad Habitats

Action types	Broad Habitats Peatland	Wetland	Heathland	Species rich grassland	Crop/Grass Fields	Margin/hedgerow	Woodland	All Habitats
Create		4		2	8	6	3	**23**
Enhance		2		1	21	3		**27**
Maintain	1		2	4	2	1	2	**12**
All Action types	**1**	**6**	**2**	**7**	**31**	**10**	**5**	**62**

4.2 Transition versus Maintenance Phases of Adopting EC Measures

Measures that involved significant disruption to the existing farm system (soil amendments, reducing tillage, stopping or reducing agrochemical inputs, creating new habitat, water management that changes flow pathways etc.) will incur an initial cost not only in equipment and materials, but also in terms of potential yield loss. This is due to the disturbance which creates an imbalance in the existing network of organisms and processes (e.g., adding soil organic matter and reducing tillage will likely result in an initial population surge of soil borne pathogens). These costs and increased risk factors during the transition phase need to be considered when designing appropriate incentive schemes for conversion of farming practices from intensive production to more biodiversity-driven and regenerative approaches.

Over time, the system will find a new stable state with a balance of functional types of organisms in the cropped fields and surrounding farmland habitats. How long this takes is a measure of the resilience of the system to disturbance and will depend on the type of disturbance imposed, and how "healthy" the system was to start with. Once the new stable state is reached (e.g., 4-6 years in the soil pathogen example), then the transition phase is over and the benefits of enhanced biodiversity and soil health in terms of increased yield, yield stability and reduced inputs, will outweigh the initial costs.

Incentive payments therefore need to be targeted at a) *initial set up costs* (material and equipment) – perhaps linked to Tier 4 Agricultural Transformation Fund, b) *short-term losses in earning over the transition phase* before ecological benefits are evident, c) any *specific long-term costs for maintenance* of the established habitat/system that relate to the delivery of additional public goods or ecosystem services.

4.2.1 Rush pasture

Manage for Species found on Farmed Land: Improvement of Rush Pasture for Wildlife. There is significant potential for confusion regarding what is meant by rush pasture. This term can be interpreted in two ways:

(1) Species-rich pasture on more calcareous and neutral soils derived from grazing wetlands that have been partially drained. These can have high biodiversity value and may harbour several rare species such as pearl-bordered fritillary.

(2) Species-poor pastures that have likely developed from trying to improve pasture on damp soils which have seen significant invasion of rushes.

Both of these grassland types can be improved by management, but the potential for inappropriate management to damage type (1) grasslands is high. For type (1) habitats it will very much depends on the suite of species that are to be managed for what actual management regime should be followed. For type (2), rush control to make these pastures more attractive to wading birds can be done without affecting the biodiversity interest.

4.2.2 Woodland issues

There are three options listed for woodland creation: *Management of small woodlands*, *Agroforestry/ Agroforestry with low tree density* and *Small scale native woodland creation*.

Regarding Management of small woodlands, it is not clear how this differs from the Woodland Improvement grants available under the Forestry Grant Scheme (FGS). Is this applicable to woodland smaller than allowed under FGS, or will payment rates be higher to compensate for the lack of savings when work is done at scale? Similarly, Small scale native woodland creation seems to be covered by FGS in terms of the potential options including the FGS option of Small or Farm woodland (mixed woodlands less than 10ha).

Agroforestry is also included as an option under the FGS. It is not clear, however, how the proposal under this scheme differs from that under FGA or how different costs for

alternative forms of agro-forestry (silvo-pastural and silvo-arable systems) will be reflected in support. As silvo-pastoral systems will need protection from grazing livestock, they may need a higher initial capital cost. The potential for silvo-pastoral systems to aid in animal welfare, improved shelter in winter and increased shade in summer needs to be highlighted to farmers as well as the potential for carbon sequestration. As temperatures increase, protecting crops from heat stress could also be important. By choosing trees that produce crops, i.e., fruit and nut trees, there is the potential to boost farm incomes as integrating trees and crops/grassland is a form of row cropping that typically yields more together than single crops. Clear guidance must be developed to allow appropriate design to maximise the benefits.

In conclusion it is not clear if these options are different from those in the FGS or if the options in Tier 2 are intended as a gateway into FGS. It needs to be made clear what is the focus of this option. If the aims are different from FGS, then there must be clear complementarity with FGS and detailed guidance on both how to achieve targets (perhaps developed with the Woodland Trust) and the policy background which is considering more woodland on agricultural land. Thought ought to be given to how these options could be used to support the creation of woody buffer strips that have greater multifunctionality than open habitat buffer strips, e.g., shade as well as erosion and nutrient management, as well as introducing species into understoreys to create more diverse woodlands.

4.3 Soils and Crops

4.3.1 Regenerative agriculture – defining the term

Regenerative agriculture has gained traction as a term in recent years. The term is taken to imply new agronomic and sustainable interventions for current agricultural production systems that stakeholders throughout the agricultural supply chain appear keen to align with. There is an acknowledged lack of clarity as to what regenerative agriculture represents given the many definitions and descriptions that are used [29]. Furthermore, soil conservation is considered by some as a springboard to regenerative practices [30]. However, a recent review concluded that regenerative agriculture is a bringing together of two contrasting approaches to agricultural futures, namely *agroecology* and *sustainable intensification*, under the same banner [31]. A robust definition and measurable assessment indicators are therefore needed to ensure that ecological knowledge supports the transition towards more sustainable agricultural practices, and that the terminology does not become a byword for “greenwashing”. In a UK context, the British Ecological Society has recently convened an expert panel that will generate a policy report to provide an ecologically-based definition for the term “regenerative agriculture”, summarise the most relevant scientific evidence and thinking, discuss benefits and challenges for land managers and society as a whole, including potential trade-offs and synergies between food production and other ecosystem services, and provide policy recommendations for the transition to a more

sustainable, regenerative agriculture in the UK. It is anticipated that this report will be published by Autumn 2023.

4.3.2 Soil pH management

Recent meta-analyses [32, 33] (Wang et al., 2021; Zhang et al, 2022) on the consequences of lime addition to acidic soils (pH < 6.0) for greenhouse gas (GHG) emissions, soil carbon stocks and crop production found overall positive impacts, i.e., reduced GHG emissions, increased soil C and enhanced crop growth with liming. This indicates that recommendations to maintain optimal soil pH for crop growth would have a mean positive effect on GHG mitigation, while also supporting enhanced crop productivity.

However, these studies also identified that there were substantial context-specific variations in the magnitude and direction of effects. This context-specificity relates to the interactions between processes and their controls in soils; and how liming affects these interactions with respect to GHG fluxes.

For soil CO_2 emissions for example, liming of acid soils generally increases microbial activity which promotes elevated rates of microbial decomposition of soil organic matter (SOM), resulting in an increased gross flux of CO_2 to the atmosphere. However, in most agricultural soils this effect is offset by increased plant-derived C inputs to soil, associated with plant growth promotion following liming. The additional consideration is that the neutralisation of soil acidity via liming involves dissolution of carbonate that is also a source of CO_2 to the atmosphere. Consequently, the net benefit of liming for soil CO_2 emissions may be marginal, and potentially negative for soils with high organic matter content, or for soils where acidity is a minimal constraint on plant growth.

For nitrous oxide (N_2O), while liming is generally found to reduce emissions, this effect is a consequence of multiple factors and in some scenarios reduced emissions of N_2O are not observed, with increased emissions found from some soils. The overall reduction of N_2O emissions (on average across soils) following liming are driven by increased abundance/ activity of bacterial components (over fungi) that tends toward production of di-nitrogen (N_2) as the final product of denitrification (as opposed to N_2O) and reduced mineral nitrogen availability in soil that is associated with increased plant growth. However, N_2O emissions are also impacted by soil physical structure (that is affected by liming), soil moisture content and availability of carbon substrates for microbial communities in soil. These interactions underpin the variability in N_2O fluxes from soils following liming.

For methane (CH_4) emissions, there is less research available for the impacts of liming, but again net fluxes are the balance of the gross rates of CH_4 production (methanogenic) and consumption (methanotrophic) processes, each affected by soil pH. Available evidence suggests that liming results in a small net benefit in reducing CH_4 emissions across soils. Further research directed to quantifying liming effects on GHG emissions across soils may support provision of targeted liming recommendations that include recognition of the context-specificity of benefits.

4.3.3 Loosening compacted soils and preventing soil compaction

As agricultural machinery weights have increased, this has led to an increase in compaction risk. Improving soil structure and reducing compaction can reduce standing water, runoff and associated diffuse pollution [34]. Loosening compacted soil can be done in several ways, both mechanically and using potentially deeper rooting crops to develop structure within soils. There are however risks associated with loosening compacted soils that depend on the mechanism used, especially in relation to subsoil compaction. Deep tillage to alleviate subsoil compaction can cause an exacerbation of the issue, with compaction being driven deeper into the soil. Soil physical characteristics (texture, packing density and drainage) and climatic conditions will drive the risk of compaction and also the most appropriate approach to remediation (see here for more information and risk maps).

Aligned with this EC measure there needs to be clear support to ensure that the risk of compaction is reduced, for example through the use of low ground pressure tyres or the use of tools to assess compaction risk (for example the Terranimo tool).

Fundamentally, it is critical to manage soils to reduce trafficking when the soil is most vulnerable to compaction, for example after wet periods, and managing soils to maintain functions, such as hydraulic conductivity, through a good soil structure. Trafficking when soils have a sufficient bearing capacity for machinery is critical for both topsoil and subsoil compaction, with increases in soil moisture content causing increases in depth at which compaction can occur, for example in subsoils. Structure may be improved through a change in tillage, however this again will be governed by the soil type and texture [35]. It should also be noted that some soils contain naturally compacted subsoils and farmers should not be penalized where this is the case [34].

4.3.4 Nutrient management in arable systems.

Cultivated soils are major sources of greenhouse gas (GHG) emissions, contributing a quarter of the total nitrous oxide flux to the atmosphere, globally [36]. Nitrous oxide (N_2O) production in soil is predominantly the result of inorganic fertilizers being transformed, from immobile ammonium forms to leachable nitrate and gaseous N_2O, by the microbially mediated processes of nitrification and denitrification [37](Tian et al., 2020). Therefore, management practices that aim to replace inorganic fertilizers with alternative organic nitrogen sources have potential to reduce in-field emissions; GHGs associated with the energy-intensive process of inorganic fertilizer manufacture; and reduce nitrate leaching from soils. Reuse of organic materials with high nutrient content (e.g., slurry, composted material, digestate from anaerobic digestion) offer potential as slow-release sources of nitrogen to soils, reducing N_2O emissions and nitrate leaching, with additional soil health benefits associated with increasing soil carbon stocks.

Caveats associated with replacement of mineral fertilizers with organic materials include the potential for reduced yields, at least in the early years of transition [38]; pollutant-swapping inherent in GHG costs of transportation of bulky organic materials; impacts on local air quality from in-field volatilization (e.g., ammonia) and potential for contaminants in organic

materials to impact soil health (e.g., antibiotics, antibiotic resistance genes, microplastics). Therefore, an important consideration in use of organic materials as fertilizers is that they are certified as safe for application to land (e.g., PAS100 Scheme). Research is ongoing to evaluate the use of chemical inhibitors of biological transformation of ammonium to nitrate (nitrification), with reductions in N_2O emissions of up to 40% reported for some soils [39]. However, research on field-use of chemical inhibitors of the soil nitrogen cycle is not yet fully mature, and impacts on crop yields and non-target effects on the soil biota and other soil functions have yet to be resolved.

4.3.5 Cover crops

Cover crops, defined as planting to maintain soil cover between main cropping cycles, are recognised as providing multiple benefits for crop production [40] and the sustainability of agricultural systems [41]. Over-winter cover crops may be grown as part of systems to enhance biodiversity [42], control of crop diseases [43], soil carbon stocks [44], improved soil structure [45], weed suppression [46], and increase yield of subsequent cash crops [47]. The potential of cover crops to maximise these benefits varies depending on soil type, location, topography, crop rotation and their management, but they will not be appropriate for all environments.

Maintaining plant cover year-round protects soils from wind and water erosion, reducing loss of particulates to water courses. The growing plants remove potentially leachable nitrogen (primarily nitrate) from soil and the plant biomass that is generated provides a nutrient source for the subsequent crop. Maintaining plant cover also has a benefit in terms of soil carbon stocks, maintaining plant-derived inputs to counter soil organic matter decomposition (loss as carbon dioxide) by soil microbial communities.

Existing evidence suggests that the strongest benefits of cover cropping relate to soil protection from erosion (thereby also preventing off-field GHG emissions) and reduced nitrate leaching, with lesser impacts on in-field GHG fluxes (nitrous oxide and carbon dioxide). Recent research is revealing significant opportunities to tailor cover crop species mixes to reduce erosion and GHG emissions, particularly when these selections are made in the context of local soil and climate conditions.

A potential trade-off for cover crops is reduction in yield of the following crop (a consequence of reducing nitrate concentrations in soil), but this yield loss can be mitigated by inclusion of legumes in mixed species covers. For Scottish conditions, establishment of cover crops can be problematic due to low temperature and short daylength, meaning that the effectiveness of cover cropping is likely subject to strong inter-annual variations. It is currently unclear whether failure of a cover crop simply results in reduced net benefits, or whether significant (environmental) dis-benefits could occur.

4.3.6 Crop cultivar selection and genetic improvement

Many of the suggested measures for changed management of agricultural soils, particularly reduced fertiliser inputs, use of organic sources of nutrients and reduced tillage, will require

parallel development of the crops used under altered management to maintain productive yields. That is, current elite cultivars have been selected for optimal productivity under intensive management practices and are therefore adapted to exploitation of nutrients applied in chemically available forms (mineral fertilisers), under soil physical conditions that support root system development (ploughed soils). Current research, including within the RESAS SRP (2022-27), is identifying existing crop (including grass) varieties adapted to reduced inputs and minimal tillage [48]. Further, this research is identifying genetic bases for crop exploitation of organic nutrient sources in soil and productivity under soil physical conditions constraining root growth [49, 50]. Medium-term outputs from this research will be the development of new crop varieties adapted to 'restorative' soil management practices, for example, through breeding of beneficial root-soil interaction traits into current elite varieties that already exhibit beneficial attributes, such as nutritional quality and resistance to biotic and abiotic stresses.

4.3.7 Integrated pest management

Integrated Pest Management (IPM) is an approach to manage the impact of a crop's pests, pathogens and weeds that achieves environmental and economic sustainability and cuts across domains relating to climate change, biodiversity, and national food resilience. In a European context (Framework Directive 2009/128/EC), IPM is framed by eight guiding principles [51]. IPM strategies combine available methods (IPM tools) for monitoring, predicting risk and control of pest, pathogen and weed populations into programmes (IPM toolboxes) where the tools operate synergistically to reduce environmental impact and economic risk. The delivery of IPM includes a broad spectrum of interventions, for example, the use of cover crops to manage pathogenic free-living nematode with co-benefits of reduced soil erosion, enhanced support for pollinators and potentially increased carbon input to soils; reduced pesticide use; effective crop rotation focussed on pathogen and pest suppression rather than yield; and utilising tillage methods that minimise disturbance.

Current research, including within the RESAS SRP (2022-27), is seeking to identify which management practices are optimal to deliver not only climate resilience for Scotland's production systems but protect soils, through an increased understanding of their management across a range of land-use scenarios. This is being achieved by utilising long-term research platforms to quantify interactions between plant genotype, novel crop rotations, reduced tillage, reduced nutrient inputs, cover cropping, intercropping, grassland mixtures, and soil amendments. Research outcomes from these studies will inform best practice not only for reducing pest and pathogen burden but also for maintaining soil function (health) and achieving sustainable yields.

4.3.8 Grazing changes - semi-natural grasslands

There is a lack of data demonstrating increasing carbon sequestration as a direct effect consequence of increasing plant species-richness in semi-natural grassland [52]. However, it is associated with reduced fertilizer use and a reduction in grazing intensity and has been

shown to have clear benefits for biodiversity, both of plants and of associated species (e.g., invertebrates, birds) both above and below ground and an associated reduction in emissions. Where grazing intensity is altered there may be trade-offs between plant species groups.

4.4 Waters

4.4.1 Instream wood

The measures related to river management are grouped in topics such as river and floodplain management. This topic is quite large and broad and could be more specific. One measure that was missing was an explicit mention of creating in-stream woody structures (also referred to as leaky barriers, Large Woody debris). These measures are small but can help reconnect floodplains and slow flood flows if designed correctly. There is also potential to adapt such measures in order to better connect and slow water on floodplains (this approach is being tested in AiM NBS project (JHI-D2-2). Such measures are currently being supported in England for both small and large leaky wooden dams. There is growing evidence on their functioning to reduce flood flows and manage sediment but further monitoring is helping to fill evidence gaps (e.g., AiM NBS project). They could also be useful measures to mitigate water scarcity if positioned correctly.

4.4.2 Runoff attenuation features

There is potential for measures listed here to be designed better in order to attenuate floods and drought conditions. For example, measures such as 'creating ponds' need to be carefully designed in order to manage flood peaks. Ponds should be designed to have 'temporary' storage in order to manage flood peaks effectively at the correct time. Therefore, in flood prone areas, such 'ponds' should not remain full and have capacity to attenuate flood runoff. The Belford case study in Northumberland is an excellent example of creating new storage in catchments to manage flood flows with promising evidence to show an impact on flood peaks. Also, these studies have been summarised by Roberts et al., 2022.the AiM NBS project.

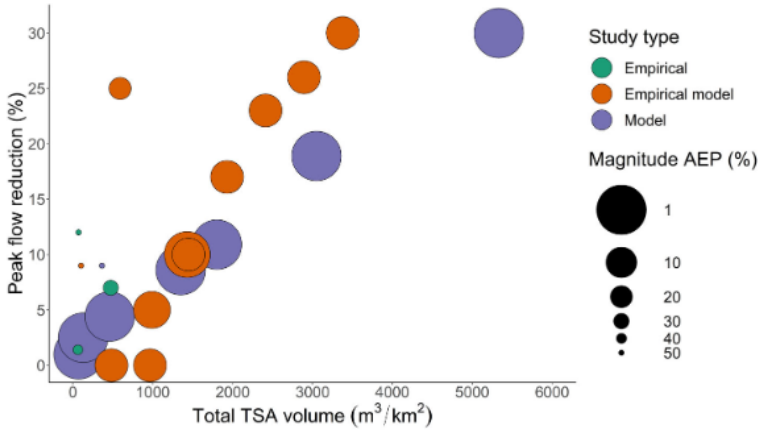

Figure 5: Effectiveness of offline temporary storage areas (TSA) for peak flow reduction (percentage of peak flow exceedance)

4.4.3 Right measure, right place

Measures such as riparian buffer strips could be augmented with additional measures to provide wider water benefits. These augmented measures can be tailored to the environmental pressure and targeted into focus points on the farm. This approach could result in less land take. For further information, please refer to recent CREW publication on better buffer design, placement and management work. Work in the AiM NBS project is investigating some of these augmented measures such as "magic margins". The UK Environment Agency 3D buffer approach, which was developed by Hutton staff and Forest Research, is currently being considered in the new ELMS approach in England.

4.4.4 Derogations and within-farm trade-offs

Here the concept is of being able to breach limits in one management 'dimension' where it is (more) than offset by other verifiable measures taken. An example from Ireland saw the limit of 170 kg/ha of N use raised to 250/300 kg/ha if other mitigation measures taken. There was some concern if the mitigation is weakly implemented and is not verifiably effective (maybe even with a safety buffer).

4.4.5 Comparison with Flood Risk and River Basin Management Plans

As agricultural support is an important way to ensure land managers protect water resources, a screen of the proposed EC measures compared to measures in the Flood Risk Management Plans (FRMPs) and River Basin Management Plans (RBMPs) was carried out.

There are 11 FRMPs in Scotland, one for each Local Plan District. Each of these include 16 shared actions, of which two actions relate to the EC measures (drainage, restoration of natural features, and natural flood management). Two actions for all 11 FRMPs mention Sustainable Drainage Systems: the action **'Guidance development'**, includes guidance to 'help local authorities understand the requirements for mapping relevant bodies of water and sustainable urban drainage systems' [e.g. 53]. The action '**Land use planning**' includes: 'promote flood reduction via natural and structural flood management measures and restoration of natural features; avoid increased surface water flooding through sustainable drainage; and wetland creation as a measure for NFM ' [e.g. 53]. It would be useful to explore how these actions coordinated by local authorities might complement the delivery of EC measures. These land use planning measures relate to the EC measures under GHG emission reduction and the biodiversity measures (sustainable drainage systems; small scale native woodland creation; restore flood plain hydrology).

There are two RBMPs in Scotland: one for the Solway Tweed River Basin District, and one for the rest of Scotland. The RBMPs also highlight the need to address **GHG emission reduction**: the RBMP for Scotland includes 'Identifying opportunities for riparian tree planting and natural regeneration will be particularly important part of this work and could realise many multiple benefits for biodiversity and fisheries, while mitigating flooding and erosion.' [54]. The RBMP for Solway Tweed mentions promoting a circular economy by 'minimising

nutrient and soil loss' [55]. In terms of biodiversity measures the main connection is regarding **invasive non-native plant species.** The RBMP for Solway Tweed mentions: 'Partners such as the Solway Firth Partnership and Tweed Forum have set out objectives for the sites that they oversee' re invasive species, and the Tweed Forum has published a 'best practice manual' regarding invasive species' [55]p. 14). There may be links to **reduced use of pesticides**. The RBMPs focus on diffuse pollution more broadly, working with 'a focused approach in diffuse pollution priority catchments to drive compliance with environmental legislation to help achieve water quality objectives and improve bathing water quality' [54] p. 17). Likewise, there may be links with **manage and maintain peatland restoration** - The RBMP for Scotland mentions: 'Planting trees, grassland management and restoring peatlands can all increase the amount of carbon stored in soils and vegetation' (p. 16); and notes that the RBMP aims to deliver over 50 restoration projects but is not clear how many of these are peatland restoration.

It is worth noting that the RBMPs include actions relevant to agriculture, which are **not included** in the EC list. For example, the RBMP for Scotland includes actions relating to managing water abstraction from rivers for irrigation to reduce abstraction peaks as well as restricting water abstraction, the construction of lagoons to store water for irrigation, reviewing irrigation licences, and raising awareness of regulatory requirements and good practice [54] pp. 15 -20). The RBMP for Solway Tweed includes an action for SEPA to work with farmers to review water use licences [55] (p. 13). These may be related to Tier 1 activities and therefore not included in the Tier 2 measures. Either way, the interaction between FRMPs and RBMPs could be made clearer within the Policy Sudoku framework.

5 Related Work and Further Analysis

Included in this section are the outcomes of discussions with research teams beyond the screening team, where there is interest in the EC measures and wider agricultural reform processes but where policy-led analysis has not yet been undertaken. Outlines of the related work that could be included within further analysis is provided along with tabulation of the options for further analysis that have been set out in the rest of this document.

5.1 Natural Capital Approaches

The 2022-27 SRP project Galvanising Change via Natural Capital (JHI-D5-3) focuses directly on exploring if and how a Natural Capital perspective or issue framing can improve decision-making to support a Just Transition. One area it is commissioned to focus on is policy development across the portfolio of the Net-Zero Director General.

5.1.1 Why a Natural Capital approach for agriculture and land use policy?

Natural Capital approaches are specifically relevant to delivering the objectives set out in the Vision for Scottish Agriculture. Firstly, Natural Capital approaches reflects the need to consider multiple natural assets and balance different flows (ecosystem services) arising from them: this echoes the multiple goals that agricultural policy is expected to support.

Secondly, the NatureScot Farming with Nature Programme is developing approaches to farm-level Natural Capital Appraisals that could be a basis for future access to Elective Measures (Tier 3).

Natural Capital Approaches are referenced by SG e.g. in its National Performance Framework, the Natural Capital Asset Index and a briefing by the Natural Capital Policy Team that was developed in 2021. Working with this concept is also recommended to support policy analysis see ENCA supplementary guidance to the Green Book.

5.1.2 What would a natural capital approach offer?

A Natural Capital assessment highlights the need to consider (i) the quality of underlying natural assets such as soil, air, water etc, and (ii) the mix of benefits and services provided. Such approaches can deepen insight on multifunctionality and strengthen evidence for, and interpretation of, whether underlying systems are being managed sustainability.

5.1.3 Practically, what would a natural capital approach consist of?

There are immediate options that can be supported via the Galvanising Change via Natural Capital project (JHI-D5-3) to build on the existing analysis reported here.

- Reconsidering the EC measures using a Natural Capital framing, identifying the funds of Natural Capital on which EC measure act and how they would change flows of ecosystem goods and services.
- There are choices as to the precisely appropriate mix of assets and services to be supported by EC measures; these can be suggested by the JHI-D5-3 researchers, but the scope of any analysis would need to be agreed with relevant SG teams developing the EC measures and related policy instruments.

Examples of issues that might typically be included in a Natural Capital assessment, but are not highlighted in the present analysis, include accounting for effects on *air quality*, and consideration of *cultural services*.

5.2 The Role of Private Sector Investment

Related to Natural Capital is interest in enabling and shaping external private sector investment in land (c.f. the Interim Principles for Responsible Investment in Natural Capital). Those investments currently often focus on maximising carbon sequestration via carbon credits. Looking more widely, research could explore how private sector investment and future agricultural policy could be coordinated to enhance natural capital and encourage multi-functional land use.

5.3 Further Analysis Options

Here are collated the options for further research that are generated throughout the document. These are options for SG analysts or researchers within the Strategic Research Programme and could be options for policy led analysis in the Land Use Transformations Project.

Table 16: Collated further analysis options from across this document

1	Screen the measures with other Hutton research teams – e.g., climate change adaptation, multi-level governance and collective action, land reform, Just Transitions, Natural Capital etc.
2	To assess at headline level the cost per Mt of GHG emissions reductions for other sectors e.g., for energy generation, and use this as a benchmark for the GHG mitigation components in Agriculture. Is the expectation for GHG reductions in agriculture reasonable compared with the investment of public funds in other sectors?
3	To assess the likelihood of EC measures making it more likely that businesses currently beyond the Direct Payments schemes making a SAF declaration.
4	Scenario analysis of options for budget allocations between groups of EC measures.
5	Analysis of how does a 90% of budget population map onto production, natural; capitals, and restoration need. Classify businesses in terms of their scale and capacity for delivery of EC measures.
6	To (re)-brigade measures – e.g., to see how the overall set of measures reads across to key policy objectives or functional groupings (nutrient management, IPM, flood management, natural capital assessments or nature-based solutions etc.), that are considered in scope.
7	To generate a view of the EC measures as family trees (dendrograms) or other visualisations that differentiate the measures by delivery to key policy objectives, degree of change implied or other criteria.
8	Screen the EC measures for resilience and adaptation implications.
9	Consider how to address targeting at field, animal or holding scale if payments are made to businesses; and whether additional screening based on farm business decision making may contribute further insights.
10	Consider how EC measures might interact with private finance e.g., via voluntary carbon markets, biodiversity offsetting or other investments in natural capital.
11	Consider to what extent EC measures relate to coordinated or collaborative actions by SAF or non-SAF holdings (especially for common grazing) and the implications for the EC scheme design and delivery.
12	More in-depth study of tenure implications for EC measures

6 Conclusions

The expectation in conducting the analysis is that any conclusions or recommendations are generated via interactions with RESAS analysts, relevant SG officials and policy makers and potentially via discussion with other stakeholders where this is seen as appropriate. The outputs from the Screening Analysis were discussed with the project steering group in February 2023 and with RPID leads for Tier 2 implementation in April 2023, with both presentations available from the Land Use Transformation project website. Further deliberations on the Screening Report will be undertaken during Summer 2023, with any outcomes linked back to this document.

Appendix I – Maps

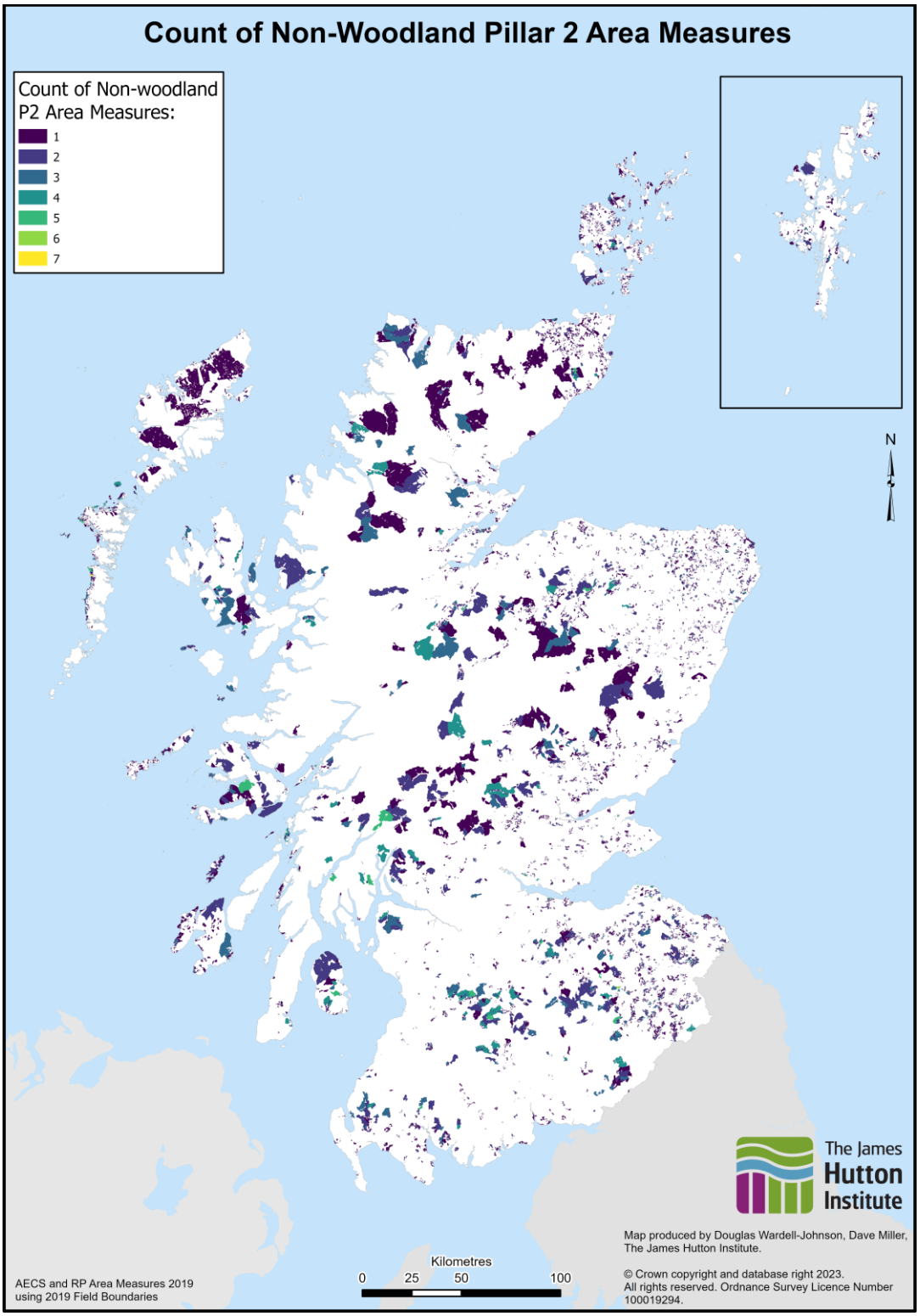

Figure 6: Numbers of non-woodland AECS measures present per land parcel (2019)

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