ECOSYSTEMS AND LAND USE POLICY EXCHANGE GROUP (ELPEG) BULLETIN

Issue 11, June 2020 (covering Oct 2019 – Oct 2020)

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Photo: Natural woodland regeneration in the Cairngorms National Park

What is this document?

The ELPEG Bulletin provides updates for policy stakeholders on research activities being undertaken within the Biodiversity and Ecosystems, and Integrated Natural Assets work packages. The focus is the policy areas of:

• Scottish Biodiversity Strategy; Land Use Strategy for Scotland; Climate Change Plan and Climate Change Adaptation Programme; Scottish Rural Development Plan and CAP greening; Scottish Forestry Strategy.

This edition of the ELPEG Bulletin focuses on work where there has been, or will be, policyrelated outputs and stakeholder engagement during the period October 2019 - October 2020. In the Bulletin we outline the work which we believe will be of direct interest to policy makers working in these areas. We also have an <u>ELPEG webpage</u>¹ where you can find past copies of the Bulletin.

The text below includes information on what has happened to date and what is planned up until October 2020. The researchers involved would welcome any queries, input and discussions concerning their work, and can be contacted directly via the e-mail addresses provided. Given the post 'Brexit' context, we would particularly welcome any insights and suggestions from you regarding how and when work may need to be adjusted to take account of changes in policy objectives and/or policy delivery mechanisms, including funding availability.

Please do get in touch with the person named for the area to find out more information.

AECS	Agri-Environmental Climate Scheme
CCAP	Climate Change Adaptation Programme
ССР	Climate Change Plan
EHI	Ecosystem Health Indicators
ES/ESS	Ecosystem Services
GIS	Geographical Information System
GWCT	Game & Wildlife Conservation Trust
H2020 PROVIDE	EU project on public goods and bads from agriculture and forestry in
	Scotland
NAR	Natural Asset Register
NCAI	Natural Capital Asset Index
NGO	Non-Government Organisation
RSPB	Royal Society for the Protection of Birds
SBS	Scottish Biodiversity Strategy
SFNC	Scottish Forum on Natural Capital
SFS	Scottish Forestry Strategy
SG	Scottish Government
SI	Social Innovation
SLE	Scottish Land & Estates

ACRONYMS

¹ http://www.hutton.ac.uk/research/srp2016-21/elpeg-ecosystems-and-land-use-policy-engagement-group

SNH	Scottish Natural Heritage
SQPV	Squirrel pox virus
SRDP	Scottish Rural Development Programme
SRP	Strategic Research Programme
SWT	Scottish Wildlife Trust

SUMMARY OF POLICY-RELEVANT OUTPUTS

Expected delivery dates are included. As well as specific outputs mentioned, the research will also be discussed with the key policy contacts listed.

Торіс	Contact	Policy contacts	Activities	Outputs
Scottish Biodiversity St	rategy			
Diversity effects on ecosystem function & resilience (1.3.1, O1.1a).	<u>Alison.Karley@hutton.ac.uk</u>	Cecile Smith (SNH).		SEFARI Gateway Case Study (Mar 2020).
Agronomy and nutrition of bere barley (1.3.1, O1.2b).	Tim.George@hutton.ac.uk	Denise A'Hara (SASA), Susie Turpie (SG).		SEFARI Gateway Research Summary (Jan 2020) .
Impact of management regimes on biodiversity, ecosystem function and ecosystem service delivery (1.3.1, O1.3a).	<u>Robin.Pakeman@hutton.ac.u</u> <u>k</u>	Des Thompson (SNH), Phil Atkinson (Woodland Trust), Alan Bell (LLTNPA).	Linkages between plant digestibility/palatability, invertebrate species composition and bird foraging (Mar 2020).	
Ecosystem Health Indicators (1.3.1, O2.1) & Natural Capital Asset Index (1.4.1, biii).	Rob.Brooker@hutton.ac.uk	Tom McKenna, David O'Brien (SNH).	Publication of bryophyte indicator – (Dec 2019); Discussions re fellowship on innovative monitoring and the development of an indicator of monitoring effort (Feb 2020).	Information notes, research summaries, journal paper (Mar 2020).
Impacts of management regime on ecosystem service supply in upland ecosystems (1.3.2, O2.2).	Davy.McCracken@sruc.ac.uk	Crown Estates Scotland.		Revised Ecosystem Service supply maps (Mar 2020).

Connectivity metrics for temperate rainforest systems (1.3.1, O3.3).	<u>C.Ellis@rbge.ac.uk</u>	David Genny, Jeanette Hall (SNH), Atlantic Woodland Alliance.	Preparation of a seminar on spatial planning for forest restoration, to be delivered to Scotland's Atlantic Rainforest Alliance (Oct 2020).	Paper outlining the use of riparian woodland to buffer the effects of climate change (Jan 2020).
<u>Animal diseases – squirrel</u> <u>pox virus</u> (1.3.3, O3.2b).	<u>Colin.Mcinnes@moredun.ac.</u> <u>uk</u>	Scottish Squirrel Group, Scottish Wildlife Trust.	Tracking progression of SQPV (Mar 2021).	Data and advice on SQPV provided direct to stakeholders (Mar 2021).
Animal diseases – liver fluke (1.3.3, O3.2b).	Philip.Skuce@moredun.ac.uk	Suzanne McIntyre (SNH), Nia Ball (SG AH&W).	Liver fluke risk and conservation grazing.	SEFARI Biodiversity Leaflet (produced 2019).
System – including ecosystem – resilience: identifying gaps in knowledge for Scotland's biodiversity and ecosystems (1.3.3, O1.1 and O3).	Ruth.Mitchell@hutton.ac.uk	Duncan Stone, Jeanette Hall (SNH).	Joint work with SNH to implement resilience assessments (Jan 2020).	
Response of Scots pine provenances to climate- driven weather events (1.3.3, O2.1)	Jenni.stockan@hutton.ac.uk/ Alison.Hester@hutton.ac.uk	Colin Edwards, Bob Frost (Scottish Forestry), Mike Perks (Forest Research).	Results from experimental work communicated to stakeholders (Feb 2021).	Research Summaries (Feb 2021).
<u>Consequences of</u> <u>environmental and climate</u> <u>change for ecosystem</u> <u>resilience</u> (1.3.3, O2.2b).	Scott.Newey@hutton.ac.uk	Rob Raynor (SNH), Adam Smith, Ross MacLeod (GWCT)	Assess the likely effects of woodland expansion on the distribution of mountain hare habitat (Mar 2021).	A GIS based habitat-species distribution model of mountain hares in CNP (Mar 2021).
<u>Test cases to examine</u> <u>feasibility of offsetting for</u> <u>woodlands</u> (1.3.1, O3.3).	C.Ellis@rbge.ac.uk		Completed analysis of datasets (Dec 2020).	

Assessment of habitat/species distributions and impacts of habitat loss and gain (O1.4.2diii)	<u>Alistair.Mcvittie@sruc.ac.uk</u>	John Uttley and Mareike Moeller- Holtkamp (SNH).	Developing offsetting assessment tools (Mar 2020).	
The importance of spatial habitat configuration in affecting resilience to drivers of change (1.4.2cii).	alison.hester@hutton.ac.uk	SNH (Mary Christie), SEPA (Scot Mathieson).	Co-organisation of Ecological Network workshop (including presentations of our WP1.4 work) at ECCI Edinburgh (Mar 2020).	Online publication of workshop report with presentations (Jun 2020).
Land Use Strategy				
Natural Asset Register: Data Portal (1.4.1a).	David.Donnelly@hutton.ac.uk	CREW, SNH.	Continue to improve the guidance to users and the usability of the site (Dec 2019); Expand data sets as they become available (Mar 2020).	Natural Asset Register website (Mar 2021).
<u>Learning from application</u> of natural capital accounting to land-based businesses (O1.4.2bi).	<u>Kirsty.Blackstock@hutton.ac.</u> <u>uk</u>		Analysis of existing reports supplemented with interviews across 8 cases in Scotland (Mar 2021).	Briefing (Sept 2020).
Modelling multiple ESS (1.4.2ci and cii).	Alessandro.Gimona@hutton.ac.uk	SNH (Debbie Basset).		Maps of areas with low levels of key ESS; Priority areas for incentive targeting/restoration (Nov 2019).
<u>Using social innovation to</u> <u>deliver multiple benefits in</u> <u>forestry</u> (1.4.2biii).	Maria.Nijnik@hutton.ac.uk	Bianca Ambrose-Oji (Forest Research), Richard Murray, Heather McCabe (SG), Matt Smith (JNCC) Andy Ford (CNPA),	Journal papers (Oct 2019).	

		Marc Metzger (ESCOM)		
Opportunities to increase multiple benefits through public-private partnerships (1.4.2bi)	<u>Kirsty.Blackstock@hutton.ac.</u> <u>uk</u>	SEPA	Analysis of four catchment partnerships that combine public policy and private sector mechanisms to deliver multiple benefits (in conjunction 1.2.4 Dec 2020).	Published outputs can be found on our <u>website</u> ² ; report/stakeholder KE from Dec 2020 .
Support Post-EU agricultural and environmental policy evidence and analysis needs (1.4.2bii)	<u>Kirsty.Blackstock@hutton.ac.</u> <u>uk</u>		Provision of tailored evidence to SLC to support provision of advice to Ministers on setting up Regional Land Use Partnerships.	Briefing with sources of evidence provided (Apr 2020); further information provided as requested (Sep 2020).
<u>Individual-based</u> <u>connectivity analysis tool</u> (O1.4.2cii).	<u>Marie.Castellazzi@hutton.ac.</u> <u>uk</u>	Debbie Basset; Brian Eardley (SNH).	Assess connectivity over large areas.	Movement simulator to answer questions about connectivity between habitat patches (Mar 2021).
Climate Change Plan a	nd Climate Change Adapt	ation Programme		
Scenarios of land use change (O1.4.2ciiD5).	<u>Alessandro.Gimona@hutton.ac.uk</u>		Model of land use change scenarios based on SSP1 and SSP5 narratives (based on Agent based modelling approach).	Initial land use change trends up to 2050 (Oct 2019) .
Response of key pest species to climate change (1.3.3, O2.2a).	Lucy.Gilbert@glasgow.ac.uk	Roger Evans (NHS), Dominic Mellor (RESAS), Nia Ball (CNPA), Nia Ball (SG),	Models predicting Lyme disease risk under climate change complete and risk maps published (Nov 2019). Major synthesis on the impact of climate change on	Literature review and a policy brief (Feb 2021).

² https://www.hutton.ac.uk/research/projects/analysing-how-policy-instruments-shape-soil-water-and-biodiversity

		Adam Smith (GWCT), Ian Francis (RSPB)	different ticks and tick-borne diseases globally.	
Peatland restoration (1.3.3, O2.2c).	<u>Rebekka.Artz@hutton.ac.uk</u>	Johan Schulten, Claire Campbell (SEPA), Andrew McBride and Andrew Coupar (SNH), Russell Anderson, Mike Perks (Forest Research), Neil Cowie, Mark Hancock, Jeremy Wilson (RSPB), Zoe Frogbrook (Scottish Water)	Regional assessment of peatland restoration success. Completion of a draft regional scale restoration trajectory model (Northern Scotland 100 km ²) using Sentinel- 2 data (Nov 2019).	Policy note distributed to stakeholders and available on request (May 2020) .
Ecosystem service flows and our inventory of natural assets (1.4.1bii).	<u>Alessandro.Gimona@hutton.ac.uk</u>		Remote-sensing - based soil moisture estimation exploiting different sensors.	Demonstration on how to achieve a statistical model of soil moisture based on downscaling and fusion of multiple sensors (Dec 2019).
Scottish Rural Develop	ment Plan & CAP Greenir	g		
<u>New management options</u> <u>for agri-environment</u> <u>schemes</u> (1.3.1, O4).	<u>Robin.Pakeman@hutton.ac.uk</u>	Jenny Johnson (SNH), Hugh Dignon (SG)	Establishment of new experimental investigation(s) (Mar 2021).	
Impact of liming (1.3.1, O1.3b).	Scott.Newey@hutton.ac.uk	Jessica Findlay, Alastair MacGugan (SNH), Adam Smith (GWCT), Chris Wernham (BTO), Duncan Orr-Ewing (RSPB), Karen Ramoo (SLE)	Continue ongoing monitoring and data collection of established field level lime trials and data analyses (Mar 2021).	

Implementation of agri- environment schemes at a landscape scale to deliver multiple benefits and protect natural assets (1.4.3 b).	Laure.Kuhfuss@hutton.ac.uk	NFU	Environmental performance assessment, results discussed directly with stakeholders (Dec 2020).	Farmers workshop and report (Jan 2021).
Innovative and collective approaches to water management (1.4.3d)	Andy.Vinten@hutton.ac.uk	lan Spiers, Joyce Carr (SG), Brian McCreadie, Richard Gosling, Stuart McGowan (SEPA), Peter McPhail, Deborah Spray (SNH)	Finalise case study of the Lunan Water catchment (Dec 2019); comparative analysis with Loch Leven catchment area (Apr 2020).	
Improving the environmental performance of beef supply chains (1.4.2biv).	<u>llkka.Leinonen@sruc.ac.uk</u>	Keith McWhinnie, Gordon Jackson, Nia Ball (SG), Nicola Melville (SEPA).	Modelling the land capability for future production of sustainable high-quality protein (either animal or plant-based) in Scotland (Mar 2020).	Publication in SAC Consulting Sheep & Beef News (Nov 2019).
Scottish Forestry Strate	зду			·
Human-environment interactions in the supply of ecosystem services (1.3.2, O1.3).	Antonia.Eastwood@hutton.ac.uk	David Hetherington, Hamish Trench, Andy Ford (CNPA), Louise Sing, Duncan Ray, Bob Frost, Sasha Laing (Scottish Forestry), Dougie Peedle (SWT), Louise Bond, Nicola Melville (SEPA).	Workshops to assess changes in ecosystem services in response to land management; Participatory and citizen science approaches to monitor and evaluate woodland interventions (social and ecological); Analysis of data on the role of humans in the production of ecosystem services in remote locations (Dec 2019).	Participatory videos and associated reports on monitoring and evaluation tools for greenspace interventions (Oct 2019). Workshop reports - Forest Wood and Cumbernauld Glen: Exploring the perceived impacts of different management interventions on woodland benefits (Nov 2019).

Development of a user- friendly tool for visualising woodland expansion through stereo-panorama Images (1.4.2 cii).	Chen.Wang@hutton.ac.uk	Bob Frost (Scottish Forestry), Will Boyd- Wallis, Andy Ford (CNPA).	Results from woodland expansion scenarios presented at EGU2020: Sharing Geoscience Online (May 2020).	
Impacts of tree pests and diseases - risk assessment for service provision (1.3.3, O3.1a).	Ruth.Mitchell@hutton.ac.uk	Duncan Stone, Jeanette Hall (SNH)		Forest Research Note (Dec 2019) (a draft has been produced and will be published by Forest Research shortly).
Using social innovation to deliver multiple benefits in forestry (1.4.2biii)	<u>Maria.Nijnik@hutton.ac.uk</u>	Bianca Ambrose-Oji (Forest Research),SEPA, Richard Murray, Heather McCabe (SG), Matt Smith (JNCC), Andy Ford (CNPA), Marc Metzger (ESCOM)	Afforestation (challenges and opportunities), pan-European network activities and a publication under the EFI facility "from Science to Policy" (Dec 2019).	This collaborative product was launched for policy/ decision-makers/politicians at the EC, in Brussels, Dec 2019.
Adaptive co-management: comparative studies from rural and urban land Uplands (1.4.3c).	Antonia.Eastwood@hutton.ac.uk		Completed data collection research on adaptive management of urban land in Central Scotland and paper submitted on adaptive management in the Scottish uplands. Invited talk to Landscape Leadership programme – Soil Association (Mar 2020).	

SCOTTISH BIODIVERSITY STRATEGY

This work is aimed at supporting delivery of the Scottish Biodiversity Strategy. It involves studies examining the ecology of keystone species of conservation concern, both native and non-native (including pests and diseases), as well as the relationships between biodiversity, people and the delivery of ecosystem services. It also includes work helping support delivery processes for the SBS, including for example the development of Ecosystem Health Indicators, or development of a National Ecological Network for Scotland.

The underlying **mechanisms linking biodiversity and ecosystem service delivery** are being explored through focussed experimental studies (1.3.1, O1.1a).



Photo: Pea-barley mixtures emerging in conventional plough (left) and direct drill (right) treatments in a trial at the James Hutton Institute, Dundee (May 2020).

We have published a <u>SEFARI Gateway Case Study</u> summarising results from our 2016 and 2017 experimental studies. These show the potential win-wins of increasing biodiversity in crop systems. Further analysis of data from our 2017 experiment revealed some of the **mechanisms behind diversity-function relations**. For example, increasing the diversity of barley genotypes altered the expression of weed traits and reduced their ability to compete for resources. A field study was conducted in 2019 to test whether benefits in diverse vegetation depend on greater diversity of plant traits which could minimise plant-plant competition and improve complementary resource use. We published modelling work which revealed a novel mechanism explaining how diversity could be maintained within insect herbivore populations, by variation in natural enemy efficiency when attacking rarely- or commonly-encountered prey. In 2020, we have established a network of farm sites for testing diverse crop mixtures in commercial settings (Nov 2020; audience: SG, academics, land managers, policy; Alison.Karley@hutton.ac.uk).

Detailed studies continue to examine the genetic resource available within traditional bere barley landraces, including assessing the growth of different landraces under a range of environmental conditions and producing crosses between Bere barley and commercial cultivars to unravel the genetic control of useful traits (1.3.1, O1.2b). Research so far has shown that extant barley landraces selected over many generations on marginal soils have adapted to tolerate limited micronutrient availability. Field trials in 2018 demonstrated that there is significant variation in manganese efficiency in the progeny of a cross between Bere barley and an elite cultivar Irina, this will inform the strategy for isolation of this useful trait for sustainability from Bere. In addition, a field trial in 2019 assessed the performance of Bere barley lines in comparison to the industry recommended list for spring barley. Information on the research was disseminated to industry at Cereals in Lincolnshire in July 2019, to policy makers through the ELPEG meeting in Edinburgh in May 2019 and to a range of other stakeholders at the Sustainable Agriculture and Food Systems Summit in Berlin, September 2019 and the Barley Away Days in Dunkeld in February 2020. In 2020 we will continue to unravel the genetic control of the unique Bere traits in advanced progeny of the

crosses grown in the field in Orkney and work will begin on the physiological mechanisms involved when a EU Marie Curie Fellowship building on the RESAS work, starts in August (**Jun 2020**; intended audience: SG, academics, land managers; <u>Tim.George@hutton.ac.uk</u>).

Understanding the impacts of genetic factors on reintroduction success is critical for the conservation of threatened plants and animals (1.3.1, O1.2a). We will continue to monitor the survival of germinating plants resulting from cross-pollination and monitor the survival of plants. Furthermore, reintroduced cameras installed at Cicerbita alpina reintroduction sites showed that black slugs (Arion ater) were the main grazers. Translocations across the four Botanic Gardens (Edinburgh, Dawyck, Benmore, Logan) tested the resilience of *Cicerbita alpina* to varying climates. Work in 2020 will test the drought resistance of Woodsia ilvensis and whether this can linked to genetics or provenance (Oct 2020; audience: SG, SNH, academics; A.Finger@rbge.ac.uk).

The impact of management regimes on ecosystem function biodiversity, and ecosystem service delivery (1.3.1, O1.3a) are being examined in upland ecosystems. A manuscript has been accepted that shows that the mosaic of vegetation communities at Glen Finglas has been remarkably stable in terms of their functional characteristics despite the large shifts in management (including tripling or complete removal). The focus of the work to investigate how management affects the linkages between digestibility/palatability, plant invertebrate species composition and bird foraging has moved on to characterising the quality of plants and invertebrates as food (Mar 2021; audience: SG, SNH, academics; Robin.Pakeman@hutton.ac.uk).



Photo: Sampling at Glen Finglas to characterise plant quality.

The development and exploration of environmental monitoring indicators, including the Natural Capital Asset Index (1.4.1, biii), continues through work in the Strategic Research Programme (SRP), and collaboration between SRP researchers and key stakeholders (e.g. SNH staff). Recent activities have focussed in particular on promoting the work already undertaken, including peer review publications on the NCAI and Scotland's Environmental Health Indicators, through a SEFARI Gateway case study on indicators. The bryophyte-based EHI indicators have also been published on SE Web (EHI 14a: Bryophyte nitrogen; EHI 14b: Bryophyte summer temperatures). Work in 2020-2021 is currently being defined through discussions with SNH colleagues but will continue to support development of the NCAI, and may also explore ways to monitor the impacts of IPBES drivers in Scottish environments (Feb 2021; intended audience: agencies, SG, SRP researchers; Rob.Brooker@hutton.ac.uk).



Photo: Frames were used to measure the experimental growth of woodland epiphytes for different landscape contexts, including the distance from watercourses.

Connectivity metrics for temperate rainforest systems (1.3.1, O3.3) have been used to identify spatial strategies for woodland regeneration that allow for the persistence of extant populations and gains terms of the in colonisation/establishment of new populations. These metrics have now been complemented by experimental studies to examine in more detail the role of woodlands with respect to their topographic position in the landscape. Results demonstrated the importance of riparian woodland buffers with an extent of c. 500 metres, in providing refugia for biodiversity under future climate change. This is being prepared as a series of recommendations for landowners contributing to the Atlantic Woodland Alliance, to protect and

expand Scotland's rainforest (**Oct 2020**; audience: land managers; <u>C.Ellis@rbge.ac.uk</u>).

Larger-scale studies in upland management systems (1.3.2, O2.2) are exploring how **changes in management regime alter ecosystem service** supply. Through discussion with science and policy stakeholders, we have investigated how best to incorporate missing data (e.g. risks to drinking water) into the Ecosystem Services mapping process (**Mar 2020**; audience: agencies, SG; <u>Davy.McCracken@sruc.ac.uk</u>).

Animal diseases play a regulatory role in, and can threaten, Scotland's natural environments. Work within the SRP (1.3.3, O3.2b) examines the role of squirrelpox virus (SQPV) in the replacement of native red squirrels by invasive grey squirrels. Researchers provide blood testing as required by SWT and other landowners to track the prevalence of squirrelpox virus in grey squirrels and therefore the potential threat to red squirrels. Data and advice on the general problem of SQPV and recommendations for animal and disease management will be provided to appropriate stakeholders (Mar 2021; audience: SG, NGOs, agencies; Colin.Mcinnes@moredun.ac.uk).



Photo: Site visit to Caerlaverock Estate with SNH Project Team.

We continue to work with the local SNH Project team and the Wildfowl & Wetlands Trust, on selected monitoring livestock grazing saltmarsh (merse) habitat on the Solway Firth, home to Scotland's only breeding population of natterjack toads (1.3.3; 1.4.3). Conservation grazing is required to maintain the optimal habitat for toad feeding and breeding but brings with it a potential risk to the livestock from infection with liver fluke, which can cause significant health and production impacts in both sheep and cattle. There was a legacy of the hot dry summer of 2018, in that potential fluke intermediate host snails proved hard to find this season, but the New Zealand Mud Snail dominated. This species has been shown to harbour liver fluke stages, but those collected and analysed proved to be negative for fluke by DNAbased testing. We also progressed some labbased pilot studies, which demonstrate that liver fluke and eggs did not hatch well in high salinity Solway water, suggesting the risk of snails becoming infected on the merse (saltmarsh), from fluke eggs deposited by infected livestock, is actually quite low. (Mar 2021; audience: SG, agencies, NGOs, land managers, farmers: Philip.Skuce@moredun.ac.uk).



Photos: New Zealand mud snail, potential host of liver fluke and rumen fluke (left). Liver fluke eggs extracted from cattle faeces (right).

System – including ecosystem – resilience (1.3.3, O1 and O3) is an emerging focus for research and policy. Our current activities build on foundation work undertaken in 2016-19 including a focussed workshop run jointly with SNH to identify main gaps in knowledge of ecological resilience in Scotland's biodiversity and ecosystems (see workshop report). We are now specifically looking at the impact of multiple tree diseases on woodland biodiversity and assessing the diversity of tree species present within our woodlands and if they provide resilience (**Jan 2020**; audience: SG, agencies, NGOs, land managers; <u>Ruth.Mitchell@hutton.ac.uk.</u>

The resilience of ecosystem foundation tree species to environmental and climate change and how this is affected by provenance and genotype (1.3.3, O2.1) is being investigated using native Scots pine trees in a long-term experiment. We have demonstrated that associated insect and fungi with pine trees is linked to provenance. Work in 2020 - 2021 will investigate the response of provenances to climate-driven extreme weather events such as summer drought (Feb 2021, audience: agencies; Jenni.Stockan@hutton.ac.uk/ Alison.Hester@hutton.ac.uk).



Photo: Pine seedlings growing in randomised experimental design ready for extreme weather treatments.

will continue Research to explore the consequences of environmental and climate change for ecosystem resilience (1.3.3, O2.2b) by focussing on the possible redistribution of high impact and umbrella vertebrate species. Mountain hares remain a high priority species in Scotland. In collaboration with the GWCT we will continue developing species-habitat а distribution models for mountain hares in Scotland. We will use this model to explore how land use change, wood land expansion for example, may affect the distribution of mountain hares. (Mar 2020; audience: SNH, National Park Authorities, NGOs, agencies; Scott.Newey@hutton.ac.uk).

The conservation genetics of a keystone pinewood specialist, the rare Narrow-headed ant Formica exsecta, has being investigated (1.3.3, O2.1). Analysis showed that Scottish populations lack the genetic diversity showed elsewhere in the distribution range but geographically ants' remote populations are not isolated, rather connectivity maintained genetic is bv contemporary gene flow. A research summary is available here (Feb 2020; audience: agencies, NGOs. land managers; jenni.stockan@hutton.ac.uk). Work in year 5 will involve trialling novel techniques such as captive breeding and nest translocations to boost and secure populations.

Research is developing specific **test cases to examine feasibility of offsetting for woodlands** (1.3.1, O3.3). The focus habitat is upland oak woodland, and analysis is asking whether recently regenerated wood can be substituted for more ancient woodland. The initial phase of this work has characterised the chronosequence of sites enabling contrasts between stands of different age. Sites have also now been identified within which additional sampling can take place to understand the number and types of species that are absent from woodlands affected by negative pressures (**Dec 2020**; audience: SG and agencies, land managers; <u>C.Ellis@rbge.ac.uk</u>).

In support of Scotland's National Ecological Network, we are examining the role of patch size and connectivity in affecting the resilience of species and habitats to climate and other drivers of change (1.4.2cii). We have been testing the potential and limitations of different national land cover datasets in providing information at a scale that can be related to ground survey data (our two papers can be downloaded from the Hutton website). Our second paper (Mar 2020) summarises our findings from delving deep into SNH's NVC mapping data GIS files and assessing in fine detail their potential and their limitations for use in documenting the influence of habitat patch size and connectivity on long-term changes in vegetation composition. We also co-organised a workshop ecological on networks and connectivity (where work from WP1.4 was amongst showcased other important presentations from practitioners and researchers) at ECCI Edinburgh (Mar 2020; main audience: government, agencies and NGOs). The report of this workshop, together with the presentations, is about to be published on the ESCom website as well as being sent to all attendees and associates (Jun 2020; Alison.Hester@hutton.ac.uk).

LAND USE STRATEGY FOR SCOTLAND

This research is designed to support the delivery of the Land Use Strategy 2016-21, including the vision, objectives, principles and particularly the policies 1, 2, 4, 6, 7, 8 and 9; and the proposals 1, 3 and 5.

Case studies of Natural Capital Accounting (1.4.1c) focusing on agriculture and forests have been completed. These utilised primary valuation studies on forest recreation (pan European, with Scottish element funded by the SRP) and water quality and biodiversity impacts of agriculture (funded by H2020 PROVIDE). A summary of survey rationale, methods, and results and planned future analysis is available. A case-study on urban green space is underway. This utilises both existing valuation data and a primary valuation study covering biodiversity and recreation. A scientific paper on the impacts of greenspace on mental health was produced and presented at the Ecosystem Services Partnership Conference, Hannover (Oct 2019) and submitted for journal publication. The urban greenspace accounts have been completed (Mar 2020; intended audience: SG and agencies; Alistair.McVittie@sruc.ac.uk). Year 5 plans include developing marine natural capital accounts.

Learning from application of natural capital land-based accounting to businesses (O1.4.2bi). Additional work in 2020-21 includes a study to learn lessons from pilot approaches to using natural capital accounting processes for land-based businesses is underway, working with University of Edinburgh. A briefing on findings should be available in September 2020; and potential issues at the national scale have been discussed with Helen Duncan and Harriet Houlsby (RESAS) in April 2020. (Intended audience: Scottish Forum for Natural Capital Sustainable Land Use working group; Kirsty.Blackstock@hutton.ac.uk).

Based on ESS maps a **zonation of areas that have high and low delivery** for multiple services was identified (1.4.2ci and cii). The areas have relatively high intensity of use/management and could benefit from restoration e.g. through targeting of incentives. This zonation was combined with a zonation based on priority species in agricultural areas (**Nov 2019**; <u>Alessandro.Gimona@hutton.ac.uk</u>).

Research into the use of Social Innovation deliver multiple (1.4.2biii) to benefits is continuing. Barriers and opportunities for expansion green energy woodland and development are being investigated; findings communicated to SG agencies and cross-sector stakeholders at a workshop at Hutton (as reported in Jan 2019) and disseminated including via organised sessions at the 125 IUFRO Congress, the Forum Carpaticum and the ISIRC Conference. The journal articles produced included 7 published in a special issue of Forest Policy and Economics. This RESAS work was underpinned by H2020 SIMRA project that we coordinate. Innovative solutions and sustainable forestry considerations, ideas potentially useful for policy makers and practice communities of different levels have been elaborated, with some presented at the workshop of **Oct 2019** at Hutton (Intended audience: SG and wider stakeholders; Maria.Nijnik@hutton.ac.uk).



Photo: Social innovation workshop.

Opportunities to increase multiple benefits through partnership working (1.4.2bi). We are currently analysing data from selected four case studies in Scotland and England (Dee, Spey, Hampshire Avon and Poole Harbour) to consider how catchment partnerships combine public policy and private sector mechanisms to deliver multiple benefits (in conjunction with WP 1.2.4). An interim report is now available and has been shared with SG water policy and the RBMP leads in SEPA. and a full report will be available (Dec 2020) which further feedback will be sought. Earlier work on the coordination or integration of policy instruments has been published (jointly with work on biodiversity governance) (audience: SG, agencies and NGOs; Kirsty.Blackstock@hutton.ac.uk).

The findings (from 1.4.2bi) referred to in the preceding paragraph was one of several projects from across the SRP summarised in a paper to the Scottish Land Commission (contact: Harriet Donald) as potential evidence for the four main questions being considered as advice to Ministers on setting up Regional Land Use Partnerships in **April 2020**. We will continue to share insights and provide support over the summer and will discuss further activity after the response from Ministers is received (**Sep 2020**). This was the main request received for evidence to **support Post-EU environmental and agricultural policy** (1.4.2bii) (audience: SG and agencies; Kirsty.Blackstock@hutton.ac.uk).

LEMMINGS, an Individual-based movement simulator, has been created to assess habitat connectivity and applied to assess some of the consequences of land use change scenarios for the whole of Scotland (O1.4.2cii). Analysis will continue throughout 2020 including a Net-Zero scenario (Feb 2021; audience: NGOs, agencies; Marie.Castellazzi@hutton.ac.uk).

CLIMATE CHANGE PLAN & ADAPTATION PROGRAMME

This research addresses some of the major challenges arising from the CCP and CCAP, including understanding how climate-induced land-use change might alter the delivery of climate-relevant ecosystem services such as soil carbon storage and forestry. It will also look ahead to support development of the next Scottish Climate Change Bill.

We are developing land use change scenarios (O1.4.2ciiD5) under climate change. The work so far has followed the SSP1 and SSP5 narratives adopted by IPCC as backdrop and adapted them to the Scottish case (in collaboration with the CEH SPEED project), and used an agent- Agent based modelling approach, to provide likely spatially explicit changes between 2020 and 2050. Land use change results for these 2 narratives have been produced and environmental consequences are being assessed, with focus on catchmentwide ecosystem services (nutrients and soil retention) and habitat connectivity. (Alessandro.Gimona@hutton.ac.uk).

To understand the **range shifts and resilience of key pest species to climate change** we developed models and produced risk maps that predict the response to climate change of ticks and Lyme disease (the most prevalent vectorborne disease in the northern hemisphere) (1.3.3, O2.2a). These were published for Scotland-wide predictions in 2016-17 in the *Journal of the Royal Society Interface* and for Europe-wide predictions in 2018-2019 in the journal *Environmental Health Perspectives* (Impact Factor 8.1). We are now conducting a major synthesis for the journal *Annual Review of Entomology* (Impact Factor 11.8) on the response and resilience of ticks and tickborne diseases to climate change globally. (audience: SG, agencies, SNH, NHS, land managers, public; <u>Lucy.Gilbert@glasgow.ac.uk</u>).

Peatland systems are a key component of the natural environment's contribution to climate change mitigation. We have developed an initial local test model at high resolution of peatland restoration success for the area surrounding RSPB Forsinard using Sentinel-2 data, which we developed further (Nov 2019) and are currently continuing to test for a wider 100 km² regional area. Research findings to date were shared at the European Geoscience Union conference (May 2020) and a manuscript is in preparation. We are now also testing the model across multiple years to assess longer term stability of restoration success. A research note with our interim findings was prepared and distributed to stakeholders and is available more widely on request (audience: SG and agencies/NGOs with an interest in peatland Mar 2020), systems; Rebekka.Artz@hutton.ac.uk).

Many projects listed under other headings include an aspect of climate change adaptation understanding role including: the of biodiversity in delivering ecosystem resilience (1.3.1, O1.1a); woodland supply of ecosystem (1.3.2a)**;** adaptive services management approach to facilitate the evaluation and coordination of measures to deliver multiple benefits (1.4.3a); assessing multiple land use options (1.4.2cii)).

SRDP AND CAP GREENING

This research is designed to support the implementation of the Scottish Rural Development Programme (2014-20) in particular, the implementation of the Agri-Environment

Climate Scheme management and capital options; and the Forestry Grant Scheme. However, research may also inform the implementation of Areas of Natural Constraint, beef efficiency scheme, and the advisory services plus we support and contribute to the Scottish Rural Network.

Using information from our assessment of gaps in the current agri-environment schemes we have developed an experimental study to assess a new management option for agri-environment (1.3.4, O2). schemes An experiment was established in spring 2018 to assess the longterm potential and cost-effectiveness of grassland sward diversification to improve foraging resources for pollinators and increase the digestibility of forage for livestock. This work will continue through 2018-2021 (Mar 2021; intended audience: SG and agencies involved in AECS implementation; Robin.Pakeman@hutton.ac.uk).



Photo: *Bombus terrestris* on grassland sward diversification plots.

One farmland management action that will be investigated in detail is the **impact of liming** (1.3.1, O1.3b). In collaboration with RD 1.1.2 and RD 1.1.4 field level studies will be used to assess the effects of lime application to extensively managed grassland on sward diversity and key invertebrates (earthworms) for breeding and over wintering waders. Over 2020-21 we will continue some monitoring, but focus on collating and

analysing data to try to understand the effects of lime addition on soil characteristics, the abundance and biomass of earthworms, and vegetation community structure and productivity (**Mar 2021**; audience: SG, agencies, land managers; <u>Scott.Newey@hutton.ac.uk</u>).

Research into the implementation of agrienvironment schemes at a landscape scale to deliver multiple benefits and protect natural assets (1.4.3b) has continued monitoring the environmental benefits of 'magic-margins' that were implemented in collaboration with farmers on the Balruddery catchment in 2019. Magic margins are an innovative, award-winning agrienvironment management option developed at the James Hutton Institute, as a measure to multiple benefits associated deliver with sediment loss, flood management, biodiversity conservation and associated ecosystem services (ESS), and the promotion of positive social benefits (cultural ESS) while restricting access in pursuit of illegal activities (e.g. hare coursing). The environmental performance of the magic margins' measure at Balruddery will be assessed (Dec 2020). The investigation of potential agrienvironmental scheme design and related payment to support the coordination of farmers' adoption of magic margins to deliver multiple benefits at the landscape scale through a participatory economic experiment approach is now scheduled for Feb 2021 (audience: SG, land managers and advisors: Laure.Kuhfuss@hutton.ac.uk).

The investigation of mechanisms for the delivery of **multiple benefits through innovative and collective approaches to water management** (1.4.3d) has investigated a new case study in Loch Leven catchment for a comparative analysis. Our research has shown that loch leven shares similar characteristics with the Lunan catchment with

hydraulic structures and inherited related governance that can impend adaptive management. We aim at investigating how governance rules can be best adapted to suit multiple needs from evolving current stakeholders and environmental needs on the catchments. Two more case studies will be investigated in 2020 with a full comparative analysis expected by Mar 2021 (audience: agencies, local authorities: Andy.Vinten@hutton.ac.uk).

Following a stakeholder workshop, presentation at the ELSEG meeting on (Jan 2019), and further discussions with the stakeholders, work on improving the environmental performance of beef supply chains (1.4.2biv) has been expanded to cover the entire protein supply chain in Scotland and to highlight the role of livestock in current and future sustainable, high quality protein production (article accessible here). A framework was developed to assess both the quantity and quality of protein in alternative agricultural production scenarios. This framework was applied for the global protein supply (partly funded by a SEFARI Gateway project "Pathways towards a sustainable-protein economy") and a summary of the results was published in SAC Consulting Sheep & Beef News (Nov 2019). The latest work has included expanding the framework for modelling land capability for future production of sustainable high-quality protein (either animal or plant-based) in Scotland (Mar 2020; audience: SG, NGOs, industry; Ilkka.Leinonen@sruc.ac.uk).

SCOTTISH FORESTRY STRATEGY

This research aims to support the implementation of the Scottish Forestry Strategy, including the vision, objectives, outcomes and themes, particularly climate change, biodiversity, environmental quality, community development and access and health. The research will also provide evidence, as requested for the SFS review (as highlighted in the Land Use Strategy and Programme for Government).

Woodland systems, including in urban areas, will continue to be the focus of work considering how management interventions (e.g. restoration, public engagement), and their effect on the between relationship people and the environment, can alter the co-production of ecosystem services (1.3.2, O1.3). We have completed two case-studies; Glen Creran and Cumbernauld. Workshop reports from the four stakeholder panel workshops exploring the changes in ecosystem services in response to land management, are available for stakeholder and policy audiences (intended audience: land managers, policy makers). We have secured the Woodland Trust and Loch Archaig Community Trust as partners for our third case study and plan to hold the workshops when feasible. The research on the potential of participatory video as a monitoring and evaluation tool has been presented at numerous conferences and is being written up into papers and a research brief. The participatory videos and supplementary reports by school pupils and Neighbourhood Network Cumbernauld will be used as monitoring and evaluation baselines for the Creating Natural Connections project. The research on citizen social science approaches to monitoring impacts management interventions of has been completed and submitted for publication as scientific paper (**Jan 2020**; audience: land managers; <u>Antonia.Eastwood@hutton.ac.uk</u>).



Photo: Members of Neighbourhood Networks Cumbernauld making a film on their experience of a Five Ways to Well-being (in Nature) programme.

Development of a user-friendly tool for visualising woodland expansion through Stereo panorama Images (O1.4.2 cii). Virtual reality models have been created for the presentation of current woodland scenarios in the Cairngorms National Park. The Future woodland scenario has been presented in 3D Environment in Cairngorms National Park within preferred areas (Cairngorms National Park Forest Strategy 2018). Afforestation animation has been attached in Google My Maps (video accessible here). Stereo-panorama images of woodland expansion scenarios have been created. They are available to be view from PCs, Mobile Devices and VR equipment. Results from woodland expansion scenarios were presented at EGU2020: Sharing Geoscience Online 2020; (May Chen.Wang@hutton.ac.uk).

The **impacts of tree pests and diseases** are being considered. In particular, the wider environmental risks from tree diseases. This work explores methods to link assessment of service provision by woodland habitats to assessment of priority habitats likely to be affected by tree diseases (1.3.3, O3.1a). We have developed a database of over 2000 species that are found on oak trees and included an assessment of if they will use any of 30 other alternative tree species. The information has been used to develop 30 case studies across the UK to provide examples of how to manage oak woods to conserve oakassociated biodiversity in the face of a decline in the health of oak trees. Data from six sites across the UK has been collected to test the suitability of other tree species to replace oak in terms of biodiversity supported and ecosystem function the database is available here (Dec 2019; audience: SG, agencies, land managers; Ruth.Mitchell@hutton.ac.uk).



Photo: Storying session at Glenmore.

Woodland management and digital storytelling (1.4.3c). Digital storytelling (taking the form of short videos) is being used to gain a deeper understanding of the social issues associated with natural asset management, including reconciling competing interests, collaboration strengthening between stakeholders, and reducing environmental conflict. The production of the digital stories that aim to deeply communicate multiple ways of storying actual and potential woodlands are nearing completion (Jul 2020). These will be embedded within an online mapping platform (Sept 20) and will be explored and discussed in a stakeholder workshop with a view to co-creating adaptive or collaborative ways more of envisioning and planning for new and upland woodland (Nov 20). Due to current social

distancing requirements and the uncertainty that this creates for holding workshops, we are currently developing ways to use the digital story mapping technique to gain an understanding of people's interaction with their local woodlands during the lock down period. (Katrina.Brown@hutton.ac.uk).

Work on **social innovation to deliver multiple benefits in forestry** (1.4.2biii). The development of pan-European network activities and publications under the EFI facility "from Science to Policy" (**Dec 2019**). This collaborative product was launched at the EC, in Brussels (**Dec 2019**) and published for open access (audience: policy makers, decision-makers, politicians, wider stakeholders; Maria.Nijnik@hutton.ac.uk).

Approaches that reconcile woodland expansion with other land use priorities (1.4.3c). Qualitative interviews and social maps have been conducted with land managers in the Cairngorms National Park on adaptive management and woodland expansion. These have been analysed to provide a research brief and a journal paper on stakeholder roles and relationships in AM for realising multiple land use benefits (submitted to journal Mar 2020) ; audience: NGOs; stakeholders, policy makers: Antonia.Eastwood@hutton.ac.uk). The research has now been expanded to include urban areas (Cumbernauld and Seven Lochs) as a comparison and data is currently being analysed (May 2020).



Photo: Natural Woodland regeneration in Cairngorms National Park.