ECOSYSTEMS AND LAND USE POLICY EXCHANGE GROUP (ELPEG) BULLETIN

Issue 10, October 2019 (covering May 2019 – May 2020)

CONTENTS

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, policy-related outputs and stakeholder engagement during the period May 2019 - May 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 ELPEG webpage[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 May 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.

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

SUMMARY OF POLICY-RELEVANT OUTPUTS

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

Topic	Contact	Policy contacts	Activities	Outputs
Scottish Biodiversity Strategy				
Diversity effects on ecosystem function & resilience (1.3.1, O1.1a)	alison.karley@hutton.ac.uk	SNH		SEFARI Gateway Case Study (**Mar 2020**).
Agronomy and nutrition of bere barley (1.3.1, O1.2b)	tim.george@hutton.ac.uk	SASA, SG	Results on multiple micronutrient efficiencies in Bere barley **(Sep 2010).**	Research summary for SEFARI Gateway **(Jan 2020)**.
Monitor grazing pressure for *Cicerbita alping at reintroduction sites* (1.3.1, O1.2a)	a.finger@rbge.ac.uk	SNH, CNPA	Monitor survival at reintroduction sites, use cameras to detect grazing activities (**Aug 2019**).	Report (**Dec 2019**).
Impact of management regimes on biodiversity, ecosystem function and ecosystem service delivery (1.3.1, O1.3a)	robin.pakeman@hutton.ac.uk	SNH, 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	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)	C.Ellis@rbge.ac.uk	SNH & Atlantic Woodland Alliance	Identify specific sites for practical habitat restoration efforts (**Mar 2020**).	Data and tools for rainforest management and climate change resilience presented to CIEEM members at their Scottish Climate Change Conference (**Sept 2019**).
Animal diseases – squirrel pox virus (1.3.3, O3.2b)	Colin.Mcinnes@moredun.ac.uk	Scottish Squirrel Group, SWT	Tracking progression of SQPV (**Mar 2020).**	Data and advice on SQPV provided direct to appropriate stakeholders (**Mar 2020**).
Animal diseases – liver fluke (1.3.3, O3.2b)	Philip.Skuce@moredun.ac.uk			Article for SNH Science Newsletter (**Aug 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	SNH	Joint work with SNH to implement resilience assessments (**Jan 2020**).	
Consequences of environmental and climate change for ecosystem resilience (1.3.3, O2.2b)	Scott.Newey@hutton.ac.uk	SNH, GWCT	Develop a species distribution model for mountain hares in Scotland (**Mar 2020**).	A GIS based species distribution model of mountain hares in Scotland (**Mar 2020**).
Frost tolerance of Scots pine provenances (1.3.3, O2.1)	Alison.Hester@hutton.ac.uk	Scottish Forestry, Forest Research	Results from experimental work communicated to stakeholders (**Feb 2020**).	
Assessment of habitat/species distributions and impacts of habitat loss and gain (O1.4.2diii)	Alistair.Mcvittie@sruc.ac.uk	SNH	Developing offsetting assessment tools (**Mar 2020**).	Public presentation (**May 2019**); conference presentation (**Oct 2019**)
Test cases to examine feasibility of offsetting for woodlands (1.3.1, O3.3)	C.Ellis@rbge.ac.uk		Exploration of timescales for biodiversity restoration (**Nov 2019**).	

Natural Asset Register: Data Portal (1.4.1a)	David.Donnelly@hutton.ac.uk	CREW, SNH	Expand data sets as they become available (**Mar 2020**); Continue to improve the guidance to users and the usability of the site (**Dec 2019**); Evaluate an improved map section (**Oct 2019**).	Metadata tool implementation (**Mar 2019**); Natural Asset Register website: http://nar.hutton.ac.uk (**Continuing to Mar 2021**).
The importance of spatial habitat configuration in affecting resilience to drivers of change (1.4.2cii)	alison.hester@hutton.ac.uk	SNH	Presentation on our research findings at National Ecological Network event lead-organised by SELink (**Jun 2019**)	
Human-environment interactions in the supply of ecosystem services (1.3.2, O1.3)	antonia.eastwood@hutton.ac.uk	CNPA, Scottish Forestry, SWT, SEPA	Workshops to assess changes in ecosystem services in response to land management (**Dec 2019**); Participatory and citizen science approaches to monitor and evaluate woodland interventions (social and ecological) (**Dec 2019**). Analysis of data on the role of humans in the production of ecosystem services in remote locations (**Dec 2019**)	Workshop reports - Forest Wood and Cumbernauld Glen: Exploring the perceived impacts of different management interventions on woodland benefits (**Nov 2019**). Participatory videos and associated reports on monitoring and evaluation tools for greenspace interventions (**Oct 2019**). Research paper on citizen social science methodology (**Aug 2019**).
Land Use Strategy				
Modelling multiple ESS (1.4.2ci and cii)	alessandro.gimona@hutton.ac.uk	SNH	(i)Based on ESS maps a zonation of areas that have low delivery for multiple services was identified. These areas have relatively high intensity of use /management and could benefit from restoration e.g. through targeting of incentives. (ii)Biodiversity offsetting in metapopulations	(i)Maps of areas with low levels of key ESS; Priority areas for incentive targeting/restoration (**Nov 2019**) (ii) Model and presentation (**Sept 19**)
Using social innovation to deliver multiple benefits in forestry (1.4.2biii)	maria.nijnik@hutton.ac.uk	Forest Research, SG, JNCC, CNPA, ESCOM		Conference sessions at the IUFRO Congress, the Forum Carpaticum, ISIRC, a workshop with cross-sector stakeholders in Scotland (**May 2018**) and the forthcoming workshop with stakeholders linked to H2020 SIMRA project. Journal papers **(Oct 2019).**
Assessing economic impacts of changes in Ecosystem Services (1.4.2ciii)	Alistair.McVittie@sruc.ac.uk		Project ended (Mar 2019), new publication reported in the right-hand cell.	Publication in Food Policy (**Jul 2019**)
Opportunities to increase multiple benefits through policy and industry delivery mechanisms (1.4.2bi)	kirsty.blackstock@hutton.ac.uk	SEPA	Empirical data collection and analysis of four catchment partnerships that combine public policy and private sector mechanisms to deliver multiple benefits (in conjunction with WP 1.2.4) (**Mar 2020**).	Outputs already published (e.g. Briefings) can be found on our website[2]; Outputs from this phase will be available in Mar 2020 (interim report for discussion with case stakeholders).

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

Using Monitoring and Evaluation to deliver multiple benefits Support Post-EU agricultural and environmental policy evidence and analysis needs (1.4.2bii)	kirsty.blackstock@hutton.ac.uk		Preparation of briefing and slideshow, submission of academic paper for monitoring and evaluation (**Jun 2019**). Responsive mode requests (e.g. RSE roundtable on Environmental Principles, HIE rural evidence workshop) (**Mar 2020**).	Monitoring outputs including Presentation at the ALTERNET-EKLIPSE conference (**Jun 2019**) can be found on our website[3]. Oral or written material as requested (**Mar 2020**).
Biodiversity management mechanisms (1.4.2, O1.4.2dii)	Paula.Novo@sruc.ac.uk	SNH, SEPA	Data collection through Q-methodology and interviews to investigate influence of social values, place and identify (**Jan 2020**).	The role of values in biodiversity management; uploaded as case study on SEFARI website by **Jan 2020.**
Landscape level collaborative arrangements for the management of natural assets for multiple benefits (1.4.3a).	kit.macleod@hutton.ac.uk	SNH, SEPA, SWT, CNPA	Analysis of five case studies spanning uplands to lowlands and coastal areas (**Jan 2020)**	Research Briefing (**Jan 2020**).
Adaptive co-management in the Scottish Uplands (1.4.3c)	antonia.eastwood@hutton.ac.uk		Completion of research brief and paper on adaptive management in the Scottish Uplands (**Sept 2019**).	Research briefing (**May 2019**), Research paper (**Sep 2019**); Conference presentation (**Aug 2019**).
Climate Change Plan and Climate Change Adaptation Programme				
Response of key pest species to climate change (1.3.3, O2.2a)	Lucy.Gilbert@glasgow.ac.uk	NHS, RESAS, CNPA, SG, GWCT, RSBP	Final model complete predicting range shifts in ticks and Lyme disease over Europe (published), so currently assimilating data on tick responses to temperature rise (**Nov 2019**) to parameterise models of tick resilience to climate change (**Mar 2020**).	Paper published (**Jun 2019**): Li, S, **Gilbert, L**, Vanwambeke, SO, Yu, J, Purse, BV, Harrison, PA (2019). Lyme disease risks in Europe under multiple uncertain drivers of change. *Environmental Health Perspectives*. 127(6) 067010-1-13. doi.org/10.1289/EHP4615 Invited talk at: Lyme disease conference, Liverpool (**Nov 2019**). Predictions of tick response to temperature rise (**Mar 2020**).
Peatland restoration (1.3.3, O2.2c).	rebekka.artz@hutton.ac.uk	SEPA, SNH, Forest Research, RSPB, Scottish Water	Regional assessment of peatland restoration success. Completion of a regional scale restoration trajectory model (Northern Scotland 100 km2) using Sentinel-2 data (**Nov 2019**).	Invited Conference presentation (WETSCAPES, **Sep 2019**).
Ecosystem service flows and our inventory of natural assets (1.4.1bii)	alessandro.gimona@hutton.ac.uk		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)**
Scenarios of Land Use change O1.4.2ciiD5	alessandro.gimona@hutton.ac.uk		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)**

[3] https://www.hutton.ac.uk/research/projects/monitoring-and-evaluation-ecosystem-management-meem-comparing-theory-and-practice

Scottish Rural Development Plan & CAP Greening				
New management options for agri-environment schemes (1.3.1, O4)	robin.pakeman@hutton.ac.uk	SNH, SG	Establishment of new experimental investigation(s) (**Mar 2021**).	
Impact of liming (1.3.1, O1.3b)	scott.newey@hutton.ac.uk	SNH, GWCT, BTO, RSPB, SLE	Continue ongoing monitoring and data collection of established field level lime trials (**Mar 2020**).	
Innovative and collective approaches to water management (1.4.3d)	andy.vinten@hutton.ac.uk	SG, SEPA, SNH	Finalise case study of the Lunan Water catchment (**Dec 2019**) Comparative analysis with Loch Leven catchment area (**Apr 2020**)	Presentation at the Land Use and Water Quality conference in Denmark (**Jun 2019**) Publication in the *Journal of Environmental Management* (**Sep 2019**)
Improving the environmental performance of beef supply chains (1.4.2biv)	Ilkka.Leinonen@sruc.ac.uk	SG, SEPA	Assessing quantity and quality of protein in alternative agricultural production scenarios. 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 Strategy				
Impacts of tree pests and diseases - risk assessment for service provision (1.3.3, O3.1a).	ruth.mitchell@hutton.ac.uk	SNH		Forest Research Note (**Dec 2019**).
Detailed studies of key pathogens – *Phytopthora* monitoring programme (1.3.3, O3.1b)	K.Hayden@rbge.ac.uk	SASA		Website on disease risks in the natural environment (**May 2019**) and written report (**Jun 2019**).
Using social innovation to deliver multiple benefits in forestry (1.4.2biii)	maria.nijnik@hutton.ac.uk	Forest Research, SEPA, SG, JNCC, CNPA, 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 discussed in Bonn, Prague and at the EFI conference, Hutton **(Sep 2019)** to be launched for policy/ decision-makers/politicians at the EC, in Brussels, **Dec 2019**
Visualisation tool for integrated open data kit and google earth (1.4.2 cii D9)	chen.wang@hutton.ac.uk	Scottish Forestry, CNPA	Developing new method for forest data collection using mobile devises. Design and Implementation of an Integrated Platform for Forest Landscape Visualization	Conference abstract and oral presentation at 10th IALE WORLD CONGRESS (**Jul 2019**)
Approaches that reconcile woodland expansion with other land use priorities (1.4.3c)	antonia.eastwood@hutton.ac.uk	CNPA, FCS, SNH	Capturing a range of digital stories with communities of interest in the Cairngorms National Park has been completed, as have the qualitative interviews with land managers on adapting management to change. (**May 2019**).	Research brief (**May 2019**) and paper on the roles of stakeholders and relationships in adaptive co-management (**Jul 2019**).
Multiple benefits from woodland expansion (O1.4.2ciiD5)	Alessandro.gimona@hutton.ac.uk		Development of an approach to account for multiple benefits-piloted in the Cairngorms National Park	Web story **(Jul 2019)**

Development of a user-friendly tool for visualising woodland expansion through Stereo panorama Images (1.4.2 cii)	chen.wang@hutton.ac.uk	Scottish Forestry, CNPA	Visualisation of woodland expansion scenarios. Afforestation animation has been attached in Google My Maps. Stereopanorama images are created which are available to be viewed with mobile technology or VR equipment. (**Sep 2019**).	Invited presentation at the Imaging the Environment Workshop in Queen Mary University of London (**Sep 2019**).

SPOTLIGHT: AN OPEN GATEWAY TO THE STRATEGIC RESEARCH PROGRAMME – CHARLES BESWICK

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The SEFARI Gateway, SEFARI's Knowledge Exchange and Impact Centre, remit extends across the Scottish Government Strategic Portfolio. This involves delivering support for and promotion of the impact for the mid- to longer- term focused Strategic Research Programme, SEFARI national resources, SRP linked innovation projects and to the policy facing Centres of Expertise.

Our Gateway funding schemes enable individual and interdisciplinary teams of Portfolio researchers to work in (often new) partnership with stakeholders and help such expertise to be responsive to emerging priorities across climate, environment, land, agriculture, food and rural community agendas (set within Programme for Government and Sustainable Development Goals as enshrined within the National Performance Framework). In so doing, this also brings new knowledge and capacity to the Portfolio and influences SRP research objectives.

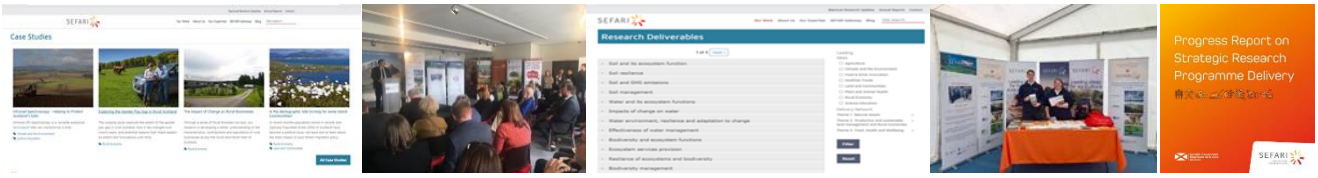
Our ground-breaking Fellowship programme (e.g. as currently working with the Just Transition [for net zero carbon] Commission; NFUS on agricultural greenhouse gas emissions; Loch Lomond and Trossachs National Park Authority in support of Woodland Creation Strategy) provides individual expert placements with stakeholders, iteratively and collectively designed between stakeholder, Gateway and the Fellow. Our Responsive Opportunity Fund for knowledge exchange (e.g. 'Islands Revival': Exploring the Potential for Repopulation; Climate Change Projections for Scotland Workshop) and Think Tanks (e.g. for the SEPA Crop Production Sector Plan; The Islands (Scotland) Act 2018: Evidence needs for improving outcomes for island communities) provide interdisciplinary and transdisciplinary input to key issues. Whatever the mechanism, Gateway requires a projected benefit and clear route to impact and works to support a sustained legacy from the relationships and networks developed.

In looking specifically at the SRP: the Gateway adds to SRP-KE and does not, nor is it intended to supplant the innate KE (such as in ELPEG) embedded within the SRP. SRP outputs have been promoted through general and targeted distribution of individual case studies and cross-SRP highlights (www.sefari.scot). We see the launch (July 2019) and continued development of the online SRP Research Deliverable progress reports (https://sefari.scot/research) as a vital resource, linking to SEFARI's web based 'Directory of Expertise' (https://sefari.scot/directory-of-expertise). Such resources support the one-to-one and multi stakeholder contacts or events that are such a key part of partnership building. As an example of the latter and highly relevant to ELPEG, SEFARI are a sponsor of the SAGES Conference: "Global Climate Challenges for a Blue Green Economy, Edinburgh 27-28 November" which will provide a timely opportunity for emerging Portfolio research to be discussed before a policy wide audience within the Climate Emergency.

With the impending culmination of the SRP, we are setting aside a range of further measures to disseminate outputs and support their use, in particularly on the connections between research from differing areas of the SRP. Our sector leads for 'Environment', 'Soils and Crops', 'Livestock', 'Food and Drink', 'Rural Communities and Industries' are an integral part of this and work closely with Themes to identify key outcomes and the dissemination and discussion of these is and will be supported via :

- A component of Gateway Responsive Opportunity and workshop/events fund allocated specifically for dissemination (incl. for relevant geographic locations) of theme and cross- theme priority research outcomes
- Reports sent directly to stakeholders and more broadly made available under our 'leading ideas' for 'climate and environment', 'agriculture', 'animal and plant health', 'land and communities', 'rural economy', 'food & drink innovation'; 'healthier foods' categories
- Improving SEFARI website to increase the utility of the online Research Deliverable progress reports and search-ability of the Director of expertise.
- Identify with Institutes key highlights to be promoted by online and broadcast media

Ultimately Gateway, both via bringing Portfolio expertise to stakeholders and in the direct dissemination and informing of strategic research, is committed to building partnerships and to work with fellow knowledge brokers to ensure research, its assessment and use is available when and where it is needed to maximise impact.



Photos: Multiple approaches tailored to audiences, to ensure that SRP outcomes are available to those who need it, how and when they need it.

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). Results from our 2016 experimental study showed changes in functional richness of the weed community related to crop genetic diversity, and a positive relationship between weed diversity and barley productivity. Further trials have manipulated the composition of the arable plant community (weed and crop) to identify the mechanisms underpinning diversity effects on productivity and other ecosystem services (e.g. pollination) in multi-species plant mixtures. Analysis of data from our 2017 study of the links between plant genetic diversity and **resilience of ecosystem functions** showed that while increased cultivar diversity did not mitigate the negative effects of drought on productivity, other positive biodiversity effects (e.g. weed and disease suppression) were maintained under drought. This work will be summarised as a SEFARI Gateway Case Study (**Mar 2020;** audience: SG, academics, land managers; alison.karley@hutton.ac.uk).

Also relevant to Climate Change Adaptation

Photo: Field trial in 2019 at the James Hutton Institute's Balruddery Farm to identify the mechanisms underpinning diversity effects on ecosystem services.

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 have been analysed and have 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 has assessed the performance of Bere barley lines in comparison to the industry recommended list for spring barley. Information on the research has been disseminated to industry at Cereals in Lincolnshire in July 2019, to policy makers through the ELPEG meeting in Edinburgh in May 2019 and to the scientific community at the Sustainable Agriculture and Food Systems Summit in Berlin, September 2019 (**Jan 2020**; intended audience: SG, academics, land managers; Tim.George@hutton.ac.uk).

Photo: Aerial phot of a field trial of Bere barley lines and elite cultivars (taken from the industry recommended list) grown on a marginal site (high pH soil) in Orkney. This shows that the Bere lines stay green under these marginal conditions as they retain photosynthetic activity by being able to supply adequate manganese to photosystem II. The Bere's went on to yield adequately, while the elite lines failed to yield at all.

Understanding the **impacts of genetic factors on reintroduction success** is critical for the conservation of threatened plants and animals. We will continue to monitor the survival of germinating plants resulting from cross-pollination and monitor the survival of reintroduced plants (**Oct 2019**) (1.3.1, O1.2a). Furthermore, 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) will test the resilience of *Cicerbita alpina* to varying climates **(Oct 2019)**. A publication is currently being prepared looking at the amount of clonal reproduction in Scottish *Saxifraga hirculus populations* (**Dec 2019**; audience: SG, SNH, academics; a.finger@rbge.ac.uk).

The **impact of management regimes on biodiversity, ecosystem function and ecosystem service delivery** (1.3.1, O1.3a) are being examined in upland ecosystems. A manuscript has been published focussing on the vegetation dynamics across the first fifteen years of a controlled grazing experiment at Glen Finglas, identifying the impacts of removing or intensifying grazing. In 2019-2020 we will be extending the work to investigate how management affects the linkages between plant digestibility/ palatability, invertebrate species composition and bird foraging (**Mar 2020**; audience: SG, SNH, academics; robin.pakeman@hutton.ac.uk).

The development of **Ecosystem Health Indicators** (EHI) (1.3.1, O2.1) and 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 the publication of peer reviewed scientific papers detailing the calculation and working of both indices; these papers are both published in the journal Ecological Indicators (Bryophyte-based EHI; Natural Capital Asset Index). We are now working to further promote the completed indicators more widely, for example publishing the bryophyte-based EHI indicator on SE Web (**Dec 2019**; intended audience: agencies, SG, researchers). Future work in 2019-2020 will continue this collaborative approach, including discussions about a SEFARI Gateway fellowship on innovative monitoring, and the possibility of developing a system for assessing environmental monitoring effort (**Feb 2020**; intended audience: agencies, SG, SRP researchers; rob.brooker@hutton.ac.uk).

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 in terms of the colonisation/establishment of new populations. These results have been contributed as a management report to SNH focussed on their Glasdrum NNR. Future work continues to identify specific sites for practical habitat restoration efforts and informs the activities of members in the Atlantic Woodland Alliance. Supporting data and toolkits for woodland management under climate change scenarios were presented to CIEEM at their Scottish Climate Change Conference (**Sept 2020**; audience: agencies, land managers, consultants; C.Ellis@rbge.ac.uk).

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 are investigating how best to incorporate missing data (e.g. risks to drinking water) into the Ecosystem Services mapping process (**Mar 2020**; audience: agencies, SG; Davy.McCracken@sruc.ac.uk).

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 2020**; audience: SG, NGOs, agencies; Colin.Mcinnes@moredun.ac.uk).

Photo: Monitoring liver fluke risk to cattle grazing on the Solway Firth.

Working with the local SNH Project team and the Wildfowl & WetlandsTrust, we have continued monitoring livestock grazing on selected 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 of liver fluke infection to livestock. Results indicate that asignificant proportion of grazing livestock are already infected with liver fluke (and rumen fluke) before they reach the merse,and are shedding fluke eggs into the environment. However, we have yet to find significant numbers of the fluke's favoured intermediate mud snail host, *Galba truncatula*, rather the merse is dominated by its New Zealand cousin and other marine snails, but none appear to carry fluke infection. Taken together, these results would indicate that saltmarsh (merse) grazing represents a relatively low fluke risk to livestock. Work is ongoing to test the viability of fluke larval stages (eggs & cysts) to definitively evaluate whether saltmarsh habitat can support the fluke lifecycle. (**Mar 2020**; audience: SG, agencies, NGOs, land managers, farmers; Philip.Skuce@moredun.ac.uk).

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[4]). We are now working with Duncan Stone and Chrissie Valluri (SNH), contributing directly to SNH's Site Level Resilience Planning project, where we can feed our conceptual work on resilience planning into a project aiming to deliver this on the ground for key woodland habitats (**Jan 2020**; audience: SG, agencies, NGOs, land managers; Ruth.Mitchell@hutton.ac.uk.

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. Work in 2019 - 2020 will focus on adaptation to extreme weather events, e.g. summer drought and late spring frost (**Feb 2020**, audience: agencies; jenni.stockan@hutton.ac.uk/ alison.hester@hutton.ac.uk).

Photo: Aerial photo of long-term pinewood experiment at Glensaugh, Aberdeenshire (one of three sites in Scotland).

Research will continue 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 a species distribution model for mountain hares in Scotland. As well as informing our understanding of the factors that determine the distribution of mountain hares, 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).

Photo: Narrow-headed ant, *Formica exsecta*, rebuilding nest following muirburn

The **conservation genetics** of a keystone pinewood specialist, the rare Narrow-headed ant *Formica exsecta*, are being investigated (1.3.3, O2.1). Information from microsatellite markers and mitochondrial DNA is currently being analysed and will provide information on social structure, genetic variability and potential inbreeding which will be used to inform forest and conservation management (**Feb 2020;** audience: agencies, NGOs, land managers; jenni.stockan@hutton.ac.uk).

Assessments of **habitat/species distributions and impacts of habitat loss and gain in the context of planning** have been developed (1.3.4, O3). ES maps developed during 2016-17 have been used to prepare a research paper on biodiversity and ES impacts from proposed development. This considered both habitats at risk from development (identified at local level) and where habitats might be created (e.g. green infrastructure investments such as in the Central Scotland Green Network). A paper was presented at the Valuing Nature Programme Conference, Cardiff (**Nov 2018**) and a journal submission to Ecosystem Services is currently in review (**Oct 19**). Current work is integrating valuation evidence to further develop offsetting assessment tools (**Mar 2020**; audience: SG and agencies, land managers; Alistair.Mcvittie@sruc.ac.uk).

As well as looking in a more general sense at the impacts of habitat losses and gains on biodiversity, 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 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. Work in 2018-2019 will continue to develop the woodland test cases, including an exploration of the time needed for biodiversity regeneration in restored woodland (**Nov 2019**; audience: SG and agencies, land managers; c.ellis@rbge.ac.uk).

The effectiveness of offsetting habitat loss by creating new habitat patches for metapopulations has been investigated using a dynamic modelling approach. The effectiveness of offsetting before vs after habitat is lost has been compared (with the former resulting more effective). Alessandro.gimona@hutton.ac.uk.

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 paper can be downloaded from the Hutton website). This year we have focused on moorland as a test habitat - unlike woodlands, there is currently no national-level ground survey dataset for moorland. But the commitment made in the SBS to produce a comprehensive map of Scotland's main habitats (HabMoS – see SNH website) represents an important new development in this area. We have been invited to present a summary of our work in this area at a NEN workshop lead-organised by SELink (**Jun 2019**; main audience: government, agencies and NGOs; 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.

The **Natural Asset Register: Data Portal** (NAR:DP) (1.4.1a) which may be viewed here, continues to develop and had been updated with the addition of further data including a soil water capacity map (RD1.1.4). A metadata creation tool is now in use and has been shared with RBGE. This is intended to improve the efficiency with which data can be uploaded to the NAR by scientists. A steering group with membership from SEFARI, Scottish Government, SEPA and SNH has been formed. The group has provided guidance on improving the usability of the NAR and will continue to guide, inform and support its development. Following a review and discussions with the Steering Group, the work for this year has been refocussed to improve the overall usability of the site rather than to develop a standalone app. The CKAN platform used by the site works equally well on mobile devices as on PCs, meaning that developing an app would not be a good use of resources (**Jun 2019**; audience: SG, agencies; david.donnelly@hutton.ac.uk).

Work on Cultural Ecosystem Services (CES) indicators and mapping (1.4.1bvi) has evaluated participatory research methods for their ability to fill in the data gaps identified during year 1. Methodological insights from a social science perspective have been reported in a research note. The results informed the development of fieldwork. Following results of mapping Cultural Heritage and modifications in CICES work on the creation of indicators based on other secondary data (**Jun 2019**) is in progress (audience: agencies, local authorities; inge.aalders@hutton.ac.uk).

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 has been produced and will be presented at the Ecosystem Services Partnership Conference, Hannover (**Oct 2019**) and submitted for journal publication. The urban greenspace accounts should be completed by March 2020 (**Mar 2020**; intended audience: SG and agencies Alistair.McVittie@sruc.ac.uk). Year 5 plans include developing marine natural capital accounts.

Based on ESS maps a zonation of areas that have low delivery for multiple services was identified (1.4.2ci and cii). These areas have relatively high intensity of use /management and could benefit from restoration e.g. through targeting of incentives (**Oct 2019).** This zonation will be combined with one based on Biodiversity (e.g. priority species). (alessandro.gimona@hutton.ac.uk).

Research into the use of **Social Innovation** (1.4.2biii) to deliver multiple benefits is continuing. Barriers and opportunities for woodland expansion and green energy development 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 include 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 to be also presented at the workshop of **Oct 2019** at Hutton. (Intended audience: SG and wider stakeholders; maria.nijnik@hutton.ac.uk).

Assessing economic impacts of changes in Ecosystem Services (1.4.2ciii). Following the augmentation of the CGE model with the inclusion of ecosystem services. The work has been presented to Keith McWhinnie, Richard Haw and Helen Duncan (**June 2018**) and is available as a working paper. Results from CGE modelling work including the potential impacts of the Beef Efficiency Scheme were presented to RESAS staff (**Feb 2019;** intended audience: SG and agencies; alastair.mcvittie@sruc.ac.uk). This project finished in March 2019, a paper on the environmental and economic impacts of healthy eating was published in Food Policy (**Jul 2019**), further scientific papers are in preparation by the Fraser of Allander Institute.

Opportunities to increase multiple benefits through policy and industry delivery mechanisms (1.4.2bi) We have 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) with data collection completed by **Dec 2019** and an interim report due in **Mar 2020.** Feedback on this report will shape further analysis during Spring 2020 leading to further outputs in **July 2020** (audience: SG, agencies and NGOs; kirsty.blackstock@hutton.ac.uk).

The findings from 1.4.2bi referred to in the preceding paragraph helped to frame the research on **Using Monitoring and Evaluation to deliver multiple benefits** (1.4.2bi). The key findings and recommendations were presented to the ALTERNET-EKLIPSE conference discussing the EU Biodiversity Strategy beyond 2020 (**Jun** 2019; audience: SG and agencies; kerry.waylen@hutton.ac.uk). We are now responding to requests for evidence to **support Post-EU environmental and agricultural policy (Mar 2020;** audience: SG and agencies; kirsty.blackstock@hutton.ac.uk).

The review of **biodiversity governance mechanisms** developed in 2016/17 was used as the basis to explore with stakeholders the potential for using different governance mechanisms (including market, non-market and hybrid mechanisms) and the role of values and perceptions for biodiversity governance in Scotland (O1.4.2dii). We have conducted interviews and a workshop with key stakeholders involved on biodiversity governance, including representatives from government agencies, land manager and environmental organisations. Current research uses Q-methodology and semi-structured interviews to explore further the role of social values, place and identity on land and biodiversity management practices. Findings from this work will be summarised as a case study on the SEFARI website and discussed directly with key stakeholders (**Jan 2020**; audience: SG and agencies, land managers, environmental organisations; Paula.Novo@sruc.ac.uk).

CLIMATE CHANGE PLAN & CLIMATE CHANGE 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 sue change results for these 2 narratives are will be produced by **October 2019.** We will use models developed so far to assess the consequences of changes on key ecosystem services. (alessandro.gimona@hutton.ac.uk).

Work to understand the **range shifts and resilience of key pest species to climate change** analysed data on tick altitudinal and latitudinal limits during 2016-17 (1.3.3, O2.2a). In 2018-2019 we completed models to predict range shifts in ticks and Lyme disease (the most prevalent vector-borne disease in the northern hemisphere) due to climate and land use change at the European scale, published in the journal *Environmental Health Perspectives* in 2019. We are now accumulating data from the literature to investigate tick's response to temperature (**Nov 2019**) which will parameterise models of resilience to climate change (**Mar 2020**). SG, agencies, SNH, NHS, land managers, public; Lucy.Gilbert@glasgow.ac.uk).

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 are currently testing further for a wider 100 km2 regional areas (due **Nov 2019**). A research note with our interim findings will be prepared (audience: SG and agencies/NGOs with an interest in peatland systems; **Mar 2020**), rebekka.artz@hutton.ac.uk).

Many projects listed under other headings include an aspect of climate change adaptation including: **understanding the role of biodiversity in delivering ecosystem resilience** (1.3.1, O1.1a)**; woodland supply of ecosystem services** (1.3.2a)**; adaptive 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 schemes** (1.3.4, O2). An experiment was established in spring 2018 to assess the long-term 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).

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 and crane flies (Tipulidae)) for breeding and over wintering waders. Over 2019-20 we will continue to monitor the effects of lime addition on soil characteristics, earthworms and vegetation to add to the baseline data already collected (**Mar 2020**; audience: SG, agencies, land managers; scott.newey@hutton.ac.uk).

Research into the **implementation of agri-environment schemes at a landscape scale to deliver multiple benefits and protect natural assets** (1.4.3b) has now focussed on the study of a specific option, 'magic-margins', an innovative, award-winning agri-environment management option developed at the James Hutton Institute, as a measure to deliver multiple benefits associated 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). After baseline measures of ecosystem services, magic margins will be implemented at the catchment scale on volunteering farmer's fields (**Dec 2019**, audience: land managers). The environmental performance of the magic margins' measure at Balruddery will be assessed in **Dec 2020**. In parallel, an investigation of the design of potential Agri-Environmental Scheme and related payment to support the coordination of farmers' adoption of magic margins to deliver multiple benefits at the landscape scale will be investigated through a participatory economic experiment approach (**Mar 2020**; 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) is now finalising work on the Lunan catchment, with additional work on the use of watercress to reduce diffuse pollution loads. Results from the hydraulic model for scenarios of water level management in the Lunan Water were presented at the Land Use and Water Quality conference in Denmark (**Jun 2019**) and will be presented to the Lunan catchment management group (**Oct 2019**). A paper presenting the result of the interdisciplinary work on the Lunan Water catchment was published **(Sep 2019**). The project is now moving on to the analysis of Loch Leven catchment for a comparative analysis. Building on the Lunan experience and methods, the work will explore alternative governance strategies to accompany innovative water management in the Loch Leven catchment area, alongside the development of hydraulic and hydrological models (**Mar 2020**; 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 the results were published in Frontiers in Sustainable Food Systems (**Apr 2019**). A summary of the results will also be published in SAC Consulting Sheep & Beef News (**Nov 2019**). A manuscript exploring scenarios of production of environmentally sustainable high-quality protein in Scotland, and trade-offs related to protein supply has been submitted to a scientific journal (**Aug 19**). Forthcoming work will include expanding the framework for modelling the 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 relationship between people and the environment, can alter the **supply of ecosystem services**. Work in 2019 will complete the local stakeholder panel workshops to assess changes in ecosystem services in response to changes in land management, as well as presentation of interim findings to stakeholder and policy audiences (intended audience: land managers) (1.3.2, O1.3-1.4). We plan to hold expert panel workshops in two other case-study areas, Cumbernauld and in the Cairngorms in 2019. In addition, the qualitative data collected on the role of humans in, and their perceptions of, ES production in 2018 will be analysed and developed into a manuscript. We have completed our data collection on the potential of participatory video as a monitoring and evaluation tool to assess management interventions in Cumbernauld's greenspace. This will be written up as reports for the Creating Natural Connections project, with a scientific paper to follow. The participatory videos created (four in total) by pupils of St Maurice's High School 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 of management interventions has been completed and submitted for publication as scientific paper (**Jan 2020**; audience: land managers; antonia.eastwood@hutton.ac.uk).

A novel approach to the collection of biodiversity and other ecosystem services (**O1.4.2cii D9**) has been implemented through a combination of ODK (Open Data Kit) and Google Earth. For use in mobile devices, the

visualisation tool will enable data collected on the ground to be viewed in Google Maps with their locations by combining Questionnaire/Survey information, mobile data collection, data aggregation, and geospatial data display. We have tested the mobile application at Tyrebagger and Countesswells forests which contain different woodland types. Useful data related to tree species has been collected. Geo-reference ground photographs have been taken which are used to help validate land-cover and soil maps. Filled electronic forms have been sent to ODK server for analysis and aggregation. Geographic data has been presented on a custom map using Google MyMaps, visualized through bar graph and pie chart, annotating by Google Earth. This work has been presented at the ELSEG workshop. Useful feedback has been provided by engaging with stakeholders and this has identified this tool as being useful for local community groups, people reporting problems such as pathways, broken gates, fungal infections. *Vice versa*, land owners could communicate management plans for the forest, e.g. clear-fell. Other uses identified: estate agents (3D scanning of buildings), botanic gardens to spot plant health problems and to collect data over time (**Mar 2019**; audience: agencies); We have designed and implemented an integrated platform for forest landscape visualization. Results have been published in 10th IALE WORLD CONGRESS Conference (**Jul 2019**) chen.wang@hutton.ac.uk).

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 for Glen Geldie and Glen Quoich in the Cairngorms National Park. The Future woodland scenario has been presented in 3D Environment in Mar Lodge within preferred area (Cairngorms National Park Forest Strategy 2018). Afforestation animation has been attached in Google My Maps. Stereopanorama images of woodland expansion scenarios have been created. They are available to be viewed from PC, Mobile Devices and VR equipment. Invited presentation has been given at the Imaging the Environment Workshop in Queen Mary University of London (**Sep 2019**) chen.wang@hutton.ac.uk)

Woodland management and digital story-telling (1.4.3c)**:** Digital storytelling is being used to gain a deeper understanding of the social issues associated with natural asset management, including reconciling competing interests, strengthening collaboration between stakeholders, and reducing environmental conflict. Visualisation of potential future states are being developed using methods such as 3D visualisations, 360-degree videos and digital storytelling. Static visualisations of Forest Wood (Cumbernauld) are at an advanced stage and will be used in the expert panel workshop in Cumbernauld (**Jul 2019**; audience: land managers, industry; scott.herrett@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 oak-associated biodiversity in the face of a decline in the health of oak trees https://www.hutton.ac.uk/oak-decline. 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 (**Dec 2019**; audience: SG, agencies, land managers; ruth.mitchell@hutton.ac.uk).

Work on **social innovation to deliver multiple benefits in forestry** (1.4.2biii) lead to a publication in Chartered Forester (**Jan. 2019**). The development of pan-European network activities and publications under the EFI facility "from Science to Policy" (**Dec 2019).** This collaborative product was discussed in Bonn, Prague and at the EFI conference, Hutton **(Sept 2019)** to be launched for 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).

Multiple benefits from woodland expansion (O1.4.2ciiD5). A multicriteria analysis approach has been developed to highlight areas that would provide multiple benefits (in terms of ecosystem services) from woodland expansion. The approach has been piloted for the Cairngorms National Park (see Web Story) and is being extended to the whole of Scotland **(Dec 2019;** audience: policy makers, decision-makers, politicians, wider stakeholders alessandro.gimona@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 **(May 2019**) and a journal paper on stakeholder roles and relationships in AM for realising multiple land use benefits **(Jul 2019**; audience: NGOs; antonia.eastwood@hutton.ac.uk).

ACRONYMS

AECS	Agri-Environmental Climate Scheme
BOT	British Trust for Ornithology
CCAP	Climate Change Adaptation Programme
CCP	Climate Change Plan
CES	Cultural Ecosystem Services
CGE	Computable General Equilibrium
CICES	Common International Classification of Ecosystem Services
CIEEM	Chartered Institute of Ecology and Environmental Management
CKAN	Comprehensive Knowledge Archive Network
CNPA	Cairngorms National Park Authority
CREW	Scotland's Centre of Expertise for Waters
EHI	Ecosystem Health Indicators
ELPEG	Ecosystem and Land Use Policy Engagement Group
ELSEG	Ecosystem and Land Use stakeholders Engagement Group
ES	Ecosystem Services
ESCOM	Ecosystem Services Community Scotland
FCS	Forestry Commission Scotland
GIS	Geographical Information System
GWCT	Game & Wildlife Conservation Trust
H2020 PROVIDE	EU project on public goods and bads from agriculture and forestry in Scotland
IPCC	Intergovernmental Panel on Climate Change
JNCC	Joint Nature Conservation Committee
LLTNPA	Loch Lomond and The Trossachs National Park Authority
NAR	Natural Asset Register
NGO	Non-Government Organisation
NHS	National Health Service
NNR	National Nature Reserves
RESAS	Scottish Government Rural and Environment Science and Analytical Services
RSPB	Royal Society for the Protection of Birds
SAC	Scottish Agricultural College
SASA	Science and Advice for Scottish Agriculture
SBS	Scottish Biodiversity Strategy
SEPA	Scottish Environment Protection Agency
SFS	Scottish Forestry Strategy
SG	Scottish Government
SLE	Scottish Land and Estates
SNH	Scottish Natural Heritage
SQPV	Squirrel pox virus
SRDP	Scottish Rural Development Programme
SRP	Strategic Research Programme
SWT	Scottish Wildlife Trust