Ecosystems and Land Use Policy Exchange Group (ELPEG) Bulletin

Issue 6, January 2018

What is this document?

The ELPEG Bulletin provides updates for policy stakeholders on research activities being undertaken in the Scottish Government Strategic Research Programme, in particular in the areas of Biodiversity and Ecosystems, and Integrated Natural Assets. 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 Bulletin does not try to cover all of the research being undertaken in the Biodiversity and Ecosystems and the Integrated Natural Assets work packages. We are currently in the process of reviewing and revising the work planned for the period April 2018 - March 2019 (year three of the Strategic Research Programme). Consequently this edition of the ELPEG Bulletin focuses on the work where there will be policy-related outputs and stakeholder engagement during the period January to March 2018, and gives an indication of related work planned from April 2018 onwards (although this may be subject to change).

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 March 2018; note this includes some work with end dates beyond March 2018 but where activity will be underway this year. 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.

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). We are undertaking further analysis of data from our 2016 experimental study of barley-weed interactions, assessing how barley diversity effects propagate across trophic levels and impact on ecosystem

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

function (initial results from which are now available[2] here); we have also been exploring experimentally the effects of barley genetic diversity on **resilience of ecosystem functions** (**February 2018**). Work in 2018-2019 will focus in particular on the relationship between arable vascular plant diversity and crop productivity, and analysing the results of previous studies of the role of crop genetic diversity in ecosystem resilience (intended audience: SG, academics, land managers; Alison.Karley@hutton.ac.uk).

- Detailed studies are examining the **genetic resource available within traditional bere barley landraces**, including assessing the growth of different landraces under a range of environmental conditions. Understanding the adaptation of bere's to stressful environments might help in breeding crop lines able to cope with reduced inputs and so deliver more sustainable cropping systems (**March 2018)**. Work in 2018-2019 will continue to focus on multi-site trials established in 2017, and will assess the ability of bere barleys to grow on nutrient deficient and marginal soils (intended audience: SG, academics, land managers; Tim.George@hutton.ac.uk).
- Understanding the **impacts of genetic factors on reintroduction success** is critical for the conservation of threatened plants and animals. Building on foundation fieldwork undertaken in 2016, we have completed - for the threatened alpine plant species *Cicerbita alpina* - controlled long-term cross-pollination experiments at a RBGE nursery (1.3.1, O1.2a). Site visits have been undertaken to assess the species' ecological requirements, and information is being used to choose appropriate reintroduction sites (**D1.2i, due March 2018**). In 2018-2019 we will continue to monitor the survival of germinating plants, undertake staged reintroductions of *C. alpine*, and develop further studies targeted on a wider range of priority species (intended 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) is being examined in upland ecosystems. Field survey data from 2017 have been integrated into a long-term dataset prior to final analysis. This will focus on the vegetation dynamics across the first fifteen years of a controlled grazing experiment at Glen Finglas, identifying the functional impacts of removing or intensifying grazing (**March 2018)**. In 2018-2019 we will again undertake monitoring of experimental plots, and data analyses will focus on the impacts of management regimes on plant traits and invertebrate species composition (intended audience: SG, SNH, academics; Robin.Pakeman@hutton.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; data gathering have included workshops with farmers and their advisors to assess their attitudes to biodiversity management (e.g. peatland restoration, deer and livestock grazing controls, moorland management etc.) and woodland management and creation on farms. This includes interviews with stakeholders to collect data on ES benefits, disbenefits and their linkages, which will enable the development of example maps of ecosystem services (and their uncertainties) for discussion with stakeholders (**March 2018)**. Work in 2018-2019 will involve a workshop with local experts to elicit their views on land use change scenarios and the likely impact on ecosystem service delivery (Sept 2018). It will also involve draft example maps of ES and uncertainties at a farm/estate level being disseminated and discussed with a small group of wider science and policy audience to allow the co-construction inform the development of final draft versions (Aug 2018; Davy.McCracken@sruc.ac.uk).
- The development of **Ecosystem Health Indicators** (EHI) (1.3.1, O2.1) continues to be supported through work in the Strategic Research Programme (SRP), and collaboration between SRP researchers and key stakeholders (e.g. SNH staff). In particular we have

[2] http://www.hutton.ac.uk/sites/default/files/files/projects/Brooker%20et%20al__Barley%20mixtures%20poster_BES%202016.pdf

provided information notes on the possibility of developing new EHIs focussing on urban greenspace[3] and previously-unused species diversity data[4], and we are currently developing the species diversity indicator (**March 2018)**; (intended audience: agencies, SG). Likewise we are undertaking further work on refinements of the **Natural Capital Asset Index** (NCAI) (1.4.1, biii), including an assessment of data gaps in the NCAI and an assessment of the NCAI's treatment of cultural ecosystem services (**March 2018**). Work in 2018-2019 on the EHIs and NCAI will continue this collaborative approach through initial discussion with key staff in SNH to determine research priorities for the year (intended audience: agencies, SG, SRP researchers; Rob.Brooker@hutton.ac.uk).

- One central element of ecosystem health is **habitat connectivity** (1.4.2cii). The results of this analysis will be mapped and a report detailing results will be produced and discussed with key stakeholders (**January 2018)**, intended audience: SG and agencies; Alessandro.Gimona@hutton.ac.uk). Future plans for 2018-19 include refining the modelling work for a scientific output, and then consulting stakeholders (particularly SNH in relation to the National Ecological Network) in order to apply the approach to further habitat types (intended audience: SG and agencies, scientists, land managers; Alison.hester@hutton.ac.uk).
- At a more detailed scale, and again building on work undertaken in 16-17, **connectivity metrics for temperate rainforest systems** (1.3.1, O3.3) are being used to identify areas that make a disproportionately high contribution to spatial connectivity for key (or a wide range of) species in that they (a) already harbour many species with large-scale isolation problems and function as spatial "bridges", or (b) the restoration of their natural vegetation would result in large overall connectivity gains (**January 2018**). Future work in 2018-2019 will focus in particular on the identification of sites for practical habitat restoration efforts (intended audience: SG and agencies, land managers; C.Ellis@rbge.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. SRP researchers provide blood testing as required by SWT and other landowners to track the incidence of squirrelpox virus and 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 direct to appropriate stakeholders (**March 2018**) and a similar plan of work will be adopted in 2018-2019 (intended audience: SG, NGOs, agencies; Colin.Mcinnes@moredun.ac.uk). Field studies (1.3.3; 1.4.3) will also investigate the risk of liver fluke disease to livestock associated with animals grazing as part of agri-environment schemes aimed at promoting biodiversity, specifically around newly-established wader scrapes and on designated natterjack toad habitat[5]. We will keep relevant stakeholders – e.g. RSPB, SNH, Soil Association, ARC-Trust – regularly informed on progress and will communicate best practice advice to farmers and land managers in a timely manner (**March 2018**). Work in 2018-2019 will involve in particular monitoring of livestock use of toad habitat and associated liver fluke infection risk (intended audience: SG, agencies, NGOs, land managers, farmers; Philip.Skuce@moredun.ac.uk).
- We have developed a novel statistical modelling approach to characterise **invasive non-native species (INNS)** in terms of habit preferences and dispersal using species atlas data. Application to **non-native trees and woody shrubs** is informing a meta-analysis designed to address questions such as which groups of introduced species are more invasive and which

[3] http://www.hutton.ac.uk/sites/default/files/files/Information%20Note%20EHI%20Green%20Space.pdf

[4] http://www.hutton.ac.uk/sites/default/files/files/Information%20Note%20EHI%20Complex%20diversity%20indicators.pdf

[5] http://www.hutton.ac.uk/sites/default/files/files/Solway%20fluke%20%20NJTs_abridged_Skuce%20August%202017.pdf

habitats are at higher risk of invasion (1.3.3, O3.1a; **March 2018**). Work in 2018-2019 will involve extension of analytical approaches for handling INNS spread data, as well as consideration of the extension of modelling techniques to the spread of plant pests/pathogens (intended audience: SG, agencies; Stephen.Catterall@Bioss.ac.uk).

- **System – including ecosystem – resilience** (1.3.3, O1) is an emerging focus for research and policy. To enable the development and targeting of management actions to enhance resilience we will build on foundation work undertaken in 2016-17. Through a focussed workshop - run jointly with SNH - we have undertaken consultation with a range of stakeholders to identify main gaps in knowledge of ecological resilience in Scotland's biodiversity and ecosystems. The workshop report identified knowledge gaps and a UK-level forum run by JNCC has emerged (**January 2018**). In 2018-2019 we will continue to work closely with SNH on these issues, in particular helping to develop a resilience assessment framework and to "road-test" this framework at a number of sites (intended audience: SG, agencies, NGOs, land managers; Glenn.Iason@hutton.ac.uk).
- Understanding the **relationships between biodiversity and cultural ecosystem services** is a key current research priority. We are in the process of publishing our rapid evidence assessment literature review on the effects of biodiversity enhancement on the delivery of cultural ES (1.3.2, O1.1), focussing on "does the ecology of a place matter in terms of cultural ecosystem services being delivered". A research note will be produced summarising the findings from the rapid evidence assessment (**March 2018);** intended audience: SG, SNH, researchers; Katherine.Irvine@hutton.ac.uk).
- 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. Work during 2016-17 on developing a participatory GIS (PGIS) has been continued to assess the impact of human disturbance and mitigation measures on resilience of Capercaillie within a study area in the Cairngorms National Park. The PGIS will be extended to a second policy-relevant case study system, which will be chosen through consultation with stakeholders (**February 2018).** Work in 2018-2019 will focus on gathering the data needed to extend the PGIS to a new study species (intended audience: National Park Authorities, NGOs, agencies Scott.Newey@hutton.ac.uk).
- The extent to which **biodiversity of insects associated with Ecosystem foundation tree species** depends upon the provenance of the tree and the effect of climate change (1.3.3, O2.1) is being investigated using native Scots pine trees in a long-term experiment. Initial assessments have been made in July 2017. Results from the work will be the focus of a scientific publication and will also be communicated directly to key stakeholders (**March 2018**). Work in 2018-2019 will focus on the susceptibility of native Scots pine provenances to pests and fungal pathogens (intended audience: agencies; Glenn.Iason@hutton.ac.uk).
- The review of **biodiversity management mechanisms** developed in 2016/17 is being used as the basis to explore with stakeholders the potential for using different governance mechanisms (including market, non-market and hybrid mechanisms) for biodiversity management in Scotland (1.3.4, O1.2). Using different qualitative research methods, this research will assess Scottish stakeholders' attitudes to and support for different types of mechanisms, and their design, implementation, and metrics for measuring the 'value' of biodiversity and ecosystem services. Findings from qualitative work will be summarised as reports and also discussed directly with key stakeholders (**March 2018**; intended audience: SG and agencies, land managers; Anja.Byg@hutton.ac.uk).
- Modelling approaches will explore the **consequences of habitat loss**. A metapopulation model (1.4.2cii) is being developed to investigate the theoretical consequences of loss and gain of habitat in a spatially explicit and dynamic manner (beta version completed and being tested). The results will be discussed with stakeholders in **March 2018**, (intended audience:

SG and agencies, land managers; Alessandro.Gimona@hutton.ac.uk). The focus in 2018-19 will be to develop the results for a scientific publication.

- Assessments of **habitat/species distributions and impacts of habitat loss and gain** in the context of planning are being developed (1.3.4, O3). ES maps developed during 16-17, and refined through stakeholder consultation, are being used to prepare a research paper on biodiversity and ES impacts from proposed development. This considers both habitats at risk from different types of development (identified at local and national levels) and where habitats might be created (e.g. green infrastructure investments such as in the Central Scotland Green Network). This will inform the integration of valuation data (from RD1.4.1) for the development of offsetting assessment tools in years 3 to 5 (**March 2018**). Work in 2018-2019 will focus on communicating the work to a range of stakeholder groups (intended 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** (1.3.4, O3). The focus habitat is upland birch woodland, and whether recently regenerated wood can be substituted for more ancient woodland. The initial phase of this work is the identification of chronosequence sites enabling contrasts between stands of different age (**March 2018**). 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 (intended audience: SG and agencies, land managers; c.ellis@rbge.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.

- A draft prototype **Natural Asset Register** (NAR) (1.4.1a) has been developed and the consultation report will be available here[6] shortly with work continuing towards the launch of the NAR as a publicly accessible and spatially explicit collection of data on natural assets **in late spring 2018.** (David.Donnelly@hutton.ac.uk). Future work includes updating the NAR with data as it becomes available; developing a user group and a tool to help data providers ensure the data are in a suitable format for sharing with end-users.
- **Cultural Ecosystem Services (CES) indicators and mapping** (1.4.1bvi) is evaluating participatory research methods for their ability to fill in the data gaps identified during year 1. Data generated by these methods are combined with existing data to generate draft maps for CES (particularly landscape, spiritual and experiential services) in Scotland to be discussed with stakeholders and initial prototype CES maps will be finalised in **January 2018**, supplemented by a research note on methodological insights from a social science perspective. The original 'gap analysis' deliverable will be updated in **March 2018** (Inge.Aalders@hutton.ac.uk). Future work will concentrate on disseminating the findings from the first two years as well as continuing to advance the methods and indicators.
- Following on from draft maps presented at ELPEG in May 2017 showing **current status and associated with delivery of ecosystem services** (1.4.2a), future work is focussing on trade-offs between provisioning, regulating and cultural ecosystem services; providing further maps and research brief (**January 2018,** Alessandro.gimona@hutton.ac.uk)**.**
- **Policy option appraisal for delivery of multiple benefits** (1.4.2ci) aims to take the trade-off analysis further to extend it beyond ecosystem services by combining bio-physical data with farm data (farm type, farm payments etc.) and/or socio-demographic data to generate maps

[6] http://www.hutton.ac.uk/research/srp2016-21/wp141-natural-asset-inventory-and-accounts

illustrating ES delivery from policy scenarios (**January 2018**, audience: SG and agency staff working on agri-environment measures including woodland expansion). Based on results from these maps, and premised on availability and engagement of these policy stakeholders, we plan to develop a policy briefing on impacts of land use change on ES by **March 2018** (Alessandro.gimona@hutton.ac.uk). Feedback on the maps and briefing will be used to guide further analysis and outputs in 2018-19.

- Knowledge of **social innovation**, including its definition in the context of rural development, is being improved (Maria.Nijnik@hutton.ac.uk). We are now drafting a systematic framework for categorising and understanding social innovation (1.4.2 biii linked to 1.4.3), and to test the conceptualization and promote operationalization of social innovation in rural areas of Scotland, a science-policy-practice workshop is planned (by **March 2018**) (Intended audience: SG and EU policy makers, land-use planners and managers in Scotland). Future work includes developing a deliberative support tool in 2018-19.
- Initial case studies of **Natural Capital Accounting** (1.4.1c) will be agriculture and forests and woodland. To support these, primary valuation studies are underway 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 short summary[7] of survey rationale, methods, preliminary results and planned future analysis is available and further results shared seminar in **March 2018,** (intended audience OCEA, (Alistair.McVittie@sruc.ac.uk). Further research briefings and KE events will be held in 2018, whilst a third case-study (peri-urban green space) will be started.
- Research **assessing economic impacts of changes in Ecosystem Services** (1.4.2ciii) was presented to a meeting of OCEA economists (Office of the Chief Economic Adviser – SG) in **September 2017** (Alistair.McVittie@sruc.ac.uk). Using the methodology agreed December 2016 and published in two briefing papers by Fraser of Allander Institute available on request, the results from a case study will be presented in **March 2018**. An internal proposal paper was produced on the incorporation of agricultural biomass into the CGE model **November 2017,** this will be followed by selection of a further case study (the case study results will be shared in year 3).
- **Opportunities to increase multiple benefits through policy and industry delivery mechanisms** (1.4.2bi) will continue to focus on the alignment of existing policy mechanisms governing soil, water and biodiversity. We are analysing 10 policy instruments with final summary reporting due **March 2018**. (Kirsty.Blackstock@hutton.ac.uk). Using these insights, we plan to consider what is needed to fill any gaps or deal with any conflicts during 2018-19. This work will also help to frame the research on **Using Monitoring and Evaluation to deliver multiple benefits** (1.4.2bii). We have analysed monitoring associated with Water Framework Directive, Natura 2000 directives and Agri-environment schemes in Scotland and 9 other member states and preliminary findings can be found here[8] (Kirsty.blackstock@hutton.ac.uk). During the next year, we will be discussing these findings with the main policy leads to refine our recommendations.
- The **adaptive management approach to facilitate the evaluation and coordination of measures to deliver multiple benefits** (kit.macleod@hutton.ac.uk) (1.4.3a) will be applied to evaluate our agri-environment (O1.4.3b); woodland expansion (O1.4.3c) and catchment (O1.4.3d) case studies. A research briefing on the cases will be developed for November 2018.

[7] http://www.hutton.ac.uk/research/srp2016-21/wp141-natural-asset-inventory-and-accounts
[8] http://www.hutton.ac.uk/research/projects/monitoring-and-evaluation-ecosystem-management-meem-comparing-theory-and-practice

ELPEG SPOTLIGHT: SOCIAL INNOVATION IN RURAL AREAS

Sustainable use of ecosystem services (ES) provides contribution to the well-being of rural communities and helps them to tackle the challenges they face. Social innovation, as a product of the policy discourse, has led to the promotion of civic values as a means of delivering support to local communities and enhancing sustainable use of ES, especially where markets and existing institutions fail. Attention to social innovation (SI) has been rising but knowledge of SI pertaining to rural areas is lacking. Our research, therefore, aims to drive innovative solutions through reconfiguring social practices and implementing civil society actions. We will provide innovative solutions potentially useful for policy makers and practice communities of different levels, with ultimate aims of increasing the well-being of communities and building the resilience to global changes in rural areas of Scotland.

The research specifically includes defining of SI as *"the reconfiguring of social practices, in response to societal challenges, which seeks to enhance outcomes on societal well-being and necessarily includes the engagement of civil society actors".* The criteria of SI, as identified in this research, include: i) evidence of reconfiguration of social practices in response to societal challenges; ii) the active involvement of civil society or grassroots organisations; iii) the novelty or reconfiguration taking place in new geographical settings or in relation to previously disengaged social groups; iv) improvement of societal wellbeing through addressing social, environmental or economic aims.

We have developed a systematic framework for categorising and understanding SI, advancing knowledge of how in remote rural areas, where people have disadvantages and are highly dependent on natural assets, SI can deliver value and make a difference. We explain that this would entail new practices targeting new products, services, models and new social relationships, collaborations, as well as new fields of activity, e.g. social entrepreneurship and social enterprises.

In the context of case studies in Scotland, with forestry in the centre (e.g. Laggan Forest Trust, Lochcarron Community, Braemar Community Hydro or Huntly initiatives) we consider the mechanics behind the success of trialled and tested examples of innovation that improve people's lives, add value to the local economy, enhance the circular economy and encourage people to reinforce their "roots". We look for answers of how to best integrate local knowledge in the decision-making processes, seeking to come up with innovative instruments, relevant incentives and diverse entities as catalysts to enhancing territorial governance.

Our work on SI in Scotland has been co-constructed with stakeholders. Our knowledge was shared at a number of events, including the Royal Palace Symposium[9] in Amsterdam and the 125 Anniversary Congress[10] of IUFRO. We will host a workshop inviting representatives from the Scottish Government, Forestry Commission, and other relevant stakeholder groups at the James Hutton Institute, Aberdeen, in March, 2018.

We seek to contribute to capacity building and the development of social capital for supporting the creation of successful SIs, with the overall goal of advancing sustainable development in rural areas of Scotland. We trust that joint societal initiatives and innovative actions, involving scientific and practice communities, policy and third-sector actors and representatives of local communities, along with a proper combination of top-down and bottom up governance approaches, supported by adequate policy instruments and incentives, will help in the development of capabilities to tackle the challenges that remote rural areas currently face.

For further information contact Maria.Nijnik@hutton.ac.uk; More information on the sister H2020 project SIMRA can be found here[11]

[9] http://www.hutton.ac.uk/news/dutch-royal-palace-hears-about-social-innovation-scotland-europe-and-beyond

[10] https://www.iufro.org/media/iufro-spotlights/iufro-spotlight-47/

[11] http://www.simra-h2020.eu/

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.

- Research **assessing multiple land use options** (1.4.2cii) is focussing on climate adaptation and mitigation impacts when trading off agriculture against woodland expansion. National-scale multi-criteria models of trade-offs focussed on forest expansion for the present time, and initial results based on the exploration of intensification and extensification scenarios (for 2050) will lead to maps of potential trade-offs. Further scenarios will be run to look at national-scale multi-criteria models of potential future trade-offs based on the exploration of scenarios of afforestation and peatland restoration. Mapped results will be available by **January 2018** generating, if requested, policy briefings summarising opportunity mapping results by **March 2018** (Alessandro.Gimona@hutton.ac.uk). These results will be the basis for discussion of further investigation. Most of the planned work for year 3 is based on model refinement, with a presentation of the main trade-off results planned for Spring 2019.
- Further research on new methods to improve our understanding of **ecosystem service flows and our inventory of natural assets** (1.4.1bii) is focussing on whether new satellite sensors are able to produce improved habitat maps based in the EUNIS classification. These habitat maps will be consulted on (intended audience: SG and agencies with an interest in modelling ES delivery) and a report on the potential of the methodology will be published **March 2018**, (Alessandro.gimona@hutton.ac.uk). This complements **analysis of Earth Observation (EO) data in biodiversity modelling** (1.4.1bi) that will help generate experimental results at a finer resolution (Alessandro.Gimona@hutton.ac.uk), leading to a collated data set (**January 2018**) and draft maps to be shared with selected stakeholders for evaluation (**March 2018**). Intended audience: SG and agencies, particularly SNH.
- Work to understand the **range shifts and resilience of key pest species to climate change** will focus on analysing data collated from existing databases and the literature during 2016-17 (1.3.3, O2.2a). Specifically a database on altitudinal and latitudinal limits of ticks are being combined with climate data to build models to predict current altitudinal and latitudinal tick distribution over the UK and Europe (**February 2018**). In 2018-2019 this work will be extended to model tick range shifts due to climate at both a Scottish and European scale (intended audience: SG and agencies with an interest in tick distributions, Lucy.Gilbert@hutton.ac.uk).
- Peatland systems are a key component of the natural environments contribution to climate change mitigation. We will produce a national model of **peatland condition** for Scotland based on MODIS satellite images (1.3.3, O2.2c). The results of this modelling exercise will be written up as a research paper along with associated targeted summary material (**March 2018**). Work in 2018-2019 will involve further improvements to this national-scale model, as well as developing a local high resolution model of peatland restoration success for the area surrounding RSPB Forsinard (intended audience: SG and agencies/NGOs with an interest in peatland systems, Rebekka.Artz@hutton.ac.uk). This will complement improvements in the way we model peat depth and condition (1.4.1biv) leading to maps and a report in **March 2018**; intended audience: SG and agencies/NGOs with an interest in peatland systems (Matt.Aitkenhead@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). Work within year 2 of the Programme will establish the experiment 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 (**March 2018**). This work will continue through 2018-2019 and we will continue our stakeholder outreach through a farm demonstration day (intended audience: SG and agencies involved in Agri-Environmental Climate Scheme (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 (earth worms and tipulidae) for breeding and over wintering waders. We are monitoring the effects of lime on soil characteristics, earthworms and vegetation to investigate the effects of lime addition on soils processes and how these affect the availability of key invertebrate prey for upland waders, and habitat characteristics. Data on sward diversity, invertebrate data, and soil characteristics (pH, bulk density and water regime) will be combined to assess the effects of liming on farmland waders. Liming trials are being established during the summer of 2017 (**March 2018**). In 2018-2019 these liming trials will continue to be monitored (intended audience: SG, agencies, land managers; Scott.Newey@hutton.ac.uk).
- An associated activity is the development of methods for **targeting SRDP payments for biodiversity** (1.4.1bv). A consultation on how to refine SRDP AECs targeting has been carried out (intended audience: SG and agencies involved in AECs implementation post 2021, Robin.Pakeman@hutton.ac.uk), leading to recommendations on a potential new scoring system outlined in a paper (**October 2018**).
- Research is **assessing the potential for Environmental Focus Areas (EFAs), Agri-Environmental Climate Schemes (AECS) and the Environmental Cooperation Action Fund (ECAF) to deliver multiple benefits at a landscape scale** (1.4.3b) within case study catchments based around i) the arable Balruddery Centre for Sustainable Cropping and ii) the three MRP grassland research farms (Glensaugh, Hartwood and Kirkton/Auchentyre) and the Game and Conservation Wildlife Trust farm at Auchnerran. Initial results from year one will be shared at an annual demonstration day at Glensaugh, looking at soil liming and woodland expansion issues (**September 2017**) (intended audience: local farmers, NFUS, Scottish Land & Estates). (Justin.Irvine@hutton.ac.uk). An evaluation of ECAF applications led to a report which reflects on the need for, and challenges associated with, policy to facilitate collaborative approaches to environmental management in Scotland. (freddy.vanHulst@hutton.ac.uk). Draft maps of catchment scale delivery of ecosystem services are now available for the upland grass catchments and maps of predicted natural pest control services are available for the arable catchment. These maps will be used as a baseline for scenarios illustrating gains in ecosystem service delivery given the landscape scale adoption of EFA or AECS measures, generating simulations by **March 2018**.

- The delivery of **multiple benefits from innovative and collective approaches to water management**[12] (Andy.Vinten@hutton.ac.uk). This work has reported on options for water quality and water quantity management (see report online; intended audience: policy, agencies, land managers) and will report on the changes in monitored parameters by **March 2018**.
- Work on **improving the environmental performance of beef supply chains** (1.4.2biv) has analysed the environmental burdens and benefits (in terms of GHG emissions) of using distillery by-products in both livestock production and renewable energy production. A research briefing presenting the findings has been published at the SRUC website[13]. A herd level supply chain model has been developed and applied to the beef supply chain to identify geographical, sectoral and supply chain hotspots (in terms of GHG emissions and nutrient balance) resulting in a corresponding database of material flows of beef production **(March 2018)** (Ilkka.Leinonen@sruc.ac.uk). The model will be applied for other agricultural supply chains, and a stakeholder workshop will be organised to identify relevant topics for new supply chain case studies **(August 2018).**

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 will continue to be the focus of work considering how management interventions, and their effect on the relationship between people and the environment, can alter the **supply of ecosystem services**. Using case studies of woodland management in the Cairngorms National Park, Glen Creran and the Central Scotland Green Network (Cumbernauld Living Landscape), initial activities included developing a conceptual framework for assessing the production of woodland ecosystem services and the outcomes of management interventions (e.g. ecosystem restoration). We have built on this work in year 2 of the SRP, collecting data on the human role in, and perceptions of, ES production, as well as working towards assessments of service delivery at three points in time (past, present and future) and across study sites, in close interaction with stakeholders in these areas (1.3.2, O1.1-O1.9). Scenarios reflecting contrasting future woodland management priorities have been developed in collaboration with stakeholders, and a first set of qualitative data on the role of humans in, and their perceptions of, ES production has been collected and is currently being processed (**March 2018**). Work in 2018-2019 will include further fieldwork and 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; Anke.Fischer@hutton.ac.uk).
- Building on data analysis undertaken in 16-17 and our connectivity scoping workshop with stakeholders (see above under SBS), a paper on **drivers of change in woodland diversity** at different scales (local, regional, national), and the implications of these drivers for land management planning will be produced (1.4.2cii). Findings will be discussed directly with relevant SG and agency staff (in particular, Pete Rawcliffe at SNH) to feed into their ongoing

[12] http://www.hutton.ac.uk/research/projects/payments-ecosystem-services-lessons
[13] https://www.sruc.ac.uk/downloads/download/1299/distillery_by-product_use_and_greenhouse_gas_emissions_from_scottish_malt_whisky_production

NEN work) (**February 2018**; intended audience: SG and agencies, land managers; Alison.Hester@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 in particular 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). Currently a draft protocol to assess environmental risks from tree diseases is being discussed with stakeholders and summarised in a short research note (**February 2018**). Work in 2018-2019 will experimentally test the suitability of alternative tree species to replace those threatened by new emerging plant pests and pathogens (intended audience: SG and agencies, land managers; Ruth.Mitchell@hutton.ac.uk).
- **Detailed studies of key pathogens** are also being undertaken. These include (1.3.3, O3.1b) establishing a monitoring programme for detecting and managing the spread of *Phytophthora ramorum* particularly in conservation nurseries and botanic gardens (**March 2018**); these monitoring approaches will be continued in 2018-2019 and will be linked to the development of best practice management guidelines for managing disease transmission risk during conservation translocations (intended audience: land managers; K.Hayden@rbge.ac.uk). Other studies (1.3.3, O3.1c) are assessing techniques for detecting the presence of the pathogenic *Phytophthora* fungi in landscapes via water sampling, as well as the impact of environmental factors in regulating *Phytophthora* species diversity (**February 2018**). In 2018-2019 this work will be continued and analysed to understand the drivers of *Phytophthora* distribution and dispersal (intended audience: SG and agencies, land managers; David.Cooke@hutton.ac.uk).
- Related work to develop **approaches that reconcile woodland expansion with other land use priorities** (1.4.3c) will address processes of adaptive management i) in Cumbernauld (Central Scotland Green Network) and ii) the Cairngorms National Park. Maps of woodland expansion options and consequences for ecosystem services and biodiversity are being developed (alessandro.gimona@hutton.ac.uk). Work will begin on planning the digital storymapping exercise with communities of interest in the Cairngorms National Park (katrina.brown@hutton.ac.uk). Participatory mapping workshops with key stakeholders **(February 2018)** will identify and clarify the social and ecological criteria needed for the woodland expansion model to aid to land-use change decisions. Using insights from this discussion, the results of woodland expansion options will be published thereafter. (Proposed audience: SG agency staff; justin.irvine@hutton.ac.uk).

Please check the following webpages for more information and links to publicly available outputs:

- RD1.3.1: Biodiversity and ecosystem function[14]
- RD1.3.2: Ecosystem services supply[15]
- RD1.3.3: Resilience of ecosystems and biodiversity[16]
- RD1.3.4: Biodiversity management[17]
- RD1.4.1: Natural asset inventory and accounts[18]
- RD 1.4.2: Multiple Benefits and trade-offs[19]
- RD1.4.3: Practical Interventions[20]

[14] http://www.hutton.ac.uk/research/srp2016-21/wp131-biodiversity-and-ecosystem-function
[15] http://www.hutton.ac.uk/research/srp2016-21/wp132-ecosystem-services-supply
[16] http://www.hutton.ac.uk/research/srp2016-21/wp133-resilience-ecosystems-and-biodiversity
[17] http://www.hutton.ac.uk/research/srp2016-21/wp134-biodiversity-management
[18] http://www.hutton.ac.uk/research/srp2016-21/wp141-natural-asset-inventory-and-accounts
[19] http://www.hutton.ac.uk/research/srp2016-21/wp142-identifying-and-understanding-multiple-benefits-and-trade-offs

Please contact the named researcher if you would like more information or an output not posted on the website (as there may be some that are not appropriate for dissemination via a webpage).

Summary of activities

Topic	Contact	Activities and Due dates
Scottish Biodiversity Strategy		
Resilience of ecosystem functions (1.3.1, O1.1a)	Alison.Karley@hutton.ac.uk	Explore in more detail the effects of genetic diversity in service delivery - **February 2018**
Genetic resource available within traditional bere barley landraces (1.3.1, O1.2b)	tim.george@hutton.ac.uk	Results of nutrient deficiency tolerance studies – **March 2018**
Impacts of genetic factors on reintroduction success (1.3.1, O1.2a).	a.finger@rbge.ac.uk	Visits to and selection of field sites (**March 2018**).
Impact of management regimes on biodiversity, ecosystem function and ecosystem service delivery (1.3.1, O1.3a)	robin.pakeman@hutton.ac.uk	Analysis of long-term dataset to explore vegetation dynamics – **March 2018**
Impacts of management regime on ecosystem service supply in upland ecosystems (1.3.1, O1.3a)	Davy.McCracken@sruc.ac.uk	Example maps of ecosystem service delivery – **March 2018**
Ecosystem Health Indicators (1.3.1, O2.1) **& Natural Capital Asset Index** (1.4.1, biii)	Rob.Brooker@hutton.ac.uk	Development of species diversity indicator – **March 2018;** Identifying data gaps and exploring handling of cultural ecosystem services - **March 2018**.
Habitat connectivity mapping (1.4.2cii)	Alessandro.Gimona@hutton.ac.uk	Habitat connectivity results discussed with key stakeholders - **January 2018**
Connectivity metrics for temperate rainforest systems (1.3.3, O3.3)	C.Ellis@rbge.ac.uk	Identify areas that make a disproportionately high contribution to spatial connectivity for key species - **January 2018**
Animal diseases – squirrel pox virus (1.3.3, O3.2b)	Colin.Mcinnes@moredun.ac.uk	Data and advice on the general problem of SQPV provided direct to appropriate stakeholders - **March 2018**
Animal diseases – liver fluke (1.3.3, O3.2b)	Philip.Skuce@moredun.ac.uk	Field studies of liver fluke risk to livestock - **March 2018**

[20] http://www.hutton.ac.uk/research/srp2016-21/wp143-practical-interventions-realise-multiple-benefits-and-manage-trade-offs

Meta-analysis of the invasive behaviour of non-native trees and woody shrubs. (1.3.3, O3.1a)	Stephen.Catterall@Bioss.ac.uk	Meta-analysis – **March 2018**
System – including ecosystem – resilience: identifying gaps in knowledge for Scotland's biodiversity and ecosystems (1.3.3, O1.1)	Glenn.Iason@hutton.ac.uk	Summarising identified knowledge gaps from stakeholder workshop in short report – **January 2018**
Relationships between biodiversity and cultural ecosystem services (1.3.2, O1.1),	Katherine.Irvine@hutton.ac.uk	Rapid evidence assessment literature review on effects of biodiversity enhancement on cultural ES – **March 2018**
Consequences of environmental and climate change for ecosystem resilience (1.3.3, O2.2b)	Scott.Newey@hutton.ac.uk	Stakeholder consultation on 2nd case study choice – **February 2018**
Biodiversity of insects associated with Ecosystem foundation tree species (1.3.3, O2.1)	Glenn.Iason@hutton.ac.uk	Results from experimental work communicated to stakeholders – **March 2018**
Biodiversity management mechanisms: (RD 1.3.4, O1.2)	Anja.Byg@hutton.ac.uk	Report on attitudes and perceptions of different ways of designing and implementing biodiversity management mechanisms in Scotland – **March 2018**
Consequences of habitat loss (1.4.2cii)	Alessandro.Gimona@hutton.ac.uk	Develop a meta-population model - **March 2018**
Assessment of habitat/species distributions and impacts of habitat loss and gain (1.3.4, O3)	Alistair.Mcvittie@sruc.ac.uk	Research paper on biodiversity and ES impacts from development - **March 2018**
Test cases to examine feasibility of offsetting for woodlands (1.3.4, O3)	C.Ellis@rbge.ac.uk	Chronosequence of sites identified and first phase of field sampling – **March 2018**
Land Use Strategy for Scotland		
Natural Asset Register (1.4.1a)	David.Donnelly@hutton.ac.uk	Consultation report – **January 2018**
Cultural Ecosystem Services indicators and mapping (1.4.1bvi)	Inge.aalders@hutton.ac.uk	Research note - **January 2018**. Updated Gap Analysis Report – **March 2018**
Current status and associated with delivery of ecosystem services (1.4.2a)	Alessandro.gimona@hutton.ac.uk	Maps and research brief – **January 2018**
Policy option appraisal for delivery of multiple benefits (1.4.2ci)	Alessandro.gimona@hutton.ac.uk	Maps illustrating ESS delivery from policy scenarios – **January 2018**

		Policy brief – **March 2018**
Using social innovation to deliver multiple benefits in forestry (1.4.2biii)	Maria.Nijnik@hutton.ac.uk	Framework for categorising and understanding SI - **March 2018**
Natural Capital Accounting (1.4.1c)	Alistair.McVittie@sruc.ac.uk	Natural capital valuation seminar - **March 2018**
Assessing economic impacts of changes in Ecosystem Services (1.4.2ciii)	Alistair.McVittie@sruc.ac.uk	Journal paper – **March 2018**
Opportunities to increase multiple benefits through policy and industry delivery mechanisms (1.4.2bi)	Kirsty.blackstock@hutton.ac.uk	Final summary reporting - **March 2018**.
Using Monitoring and Evaluation to deliver multiple benefits (1.4.2bii)	Kirsty.blackstock@hutton.ac.uk	Report available now
Adaptive management approach to facilitate the evaluation and coordination of measures to deliver multiple benefits (1.4.3a).	kit.macleod@hutton.ac.uk	Research Briefing – **November 2018**
Climate Change Plan & Climate Change Adaptation Programme		
Assessing multiple land use options (1.4.2cii)	Alessandro.Gimona@hutton.ac.uk	Maps of scenarios - **January 2018** Policy briefings (if requested) - **March 2018**
Ecosystem service flows and our inventory of natural assets (1.4.1bii)	Alessandro.Gimona@hutton.ac.uk	Published report on the potential of the methodology - **March 2018**
Analysis of Earth Observatory (EO) data in biodiversity modelling (1.4.1bi)	Alessandro.Gimona@hutton.ac.uk	Collated data set (**January 2018**) Draft maps to be shared with stakeholders (**March 2018**).
Response of key pest species to climate change (1.3.3, O2.2a)	Lucy.Gilbert@hutton.ac.uk	Models to predict current altitudinal and latitudinal tick distribution over UK and Europe – **February 2018**
Model of peatland condition (1.3.3, O2.2c).	Rebekka.Artz@hutton.ac.uk	Research paper and associated targeted summary material - **March 2018**
Methodology to model peat depth and condition (1.4.1biv	Matt.Aitkenhead@hutton.ac.uk	Maps and a report - **March 2018**
SRDP and CAP greening		
New management options for agri-environment schemes (1.3.4, O1.1 & O1.2)	Robin.Pakeman@hutton.ac.uk	Stakeholder consultation on novel measures and associated policy brief – **March 2018** The establishment of new

		experimental investigation(s) - **March 2018**
Impact of liming (1.3.1, O1.3b)	Scott.Newey@hutton.ac.uk	Liming trials established – **March 2018**
Targeting SRDP payments for biodiversity (1.4.1bv)	Robin.Pakeman@hutton.ac.uk	Potential new scoring system outlined in a paper – **October 2018**
Assessing the potential for Environmental Focus Areas (EFAs), Agri-Environmental Climate Schemes (AECS) and the Environmental Cooperation Action Fund (ECAF) to deliver multiple benefits at a landscape scale (1.4.3b)	Justin.Irvine@hutton.ac.uk	Simulations of catchment scale delivery of ES -**March 2018.**
Innovative and collective approaches to water management (1.4.3d)	Andy.Vinten@hutton.ac.uk	Reports on changes in parameters – **March 2018**
Improving the environmental performance of beef supply chains (1.4.2biv)	Ilkka.Leinonen@sruc.ac.uk	Spatial database – **March 2018** Stakeholder workshop to identify new supply chain case studies – **August 2018**
Scottish Forestry Strategy		
Human-environment interactions in the supply of ecosystem services (1.3.2, O1.1-O1.9)	Antonia.Eastwood@hutton.ac.uk ; Anke.Fischer@hutton.ac.uk	Attain first set of qualitative data from collaborative working with stakeholders – **March 2018**
Drivers of change in woodland diversity (1.4.2cii)	Alison.Hester@hutton.ac.uk	Research paper and discussion of findings with key stakeholders – **February 2018**).
Impacts of tree pests and diseases - risk assessment for service provision (1.3.3, O3.1a).	Ruth.Mitchell@hutton.ac.uk	Draft protocol discussed with stakeholders - **February 2018**
Detailed studies of key pathogens – *Phytopthora* monitoring programme (1.3.3, O3.1c).	K.Hayden@rbge.ac.uk	Detailed studies completed – **March 2018**
Detailed studies of key pathogens – *Phytopthora* detection and diversity (1.3.3, O3.1c).	David.Cooke@hutton.ac.uk	Detailed studies completed - **February 2018**
Approaches that reconcile woodland expansion with other land use priorities (1.4.3c)	Justin.Irvine@hutton.ac.uk	Participatory workshops completed **– February 2018** Woodland expansion options – **April 2018**

Table of Acronyms

AECS	Agri-Environmental Climate Scheme
ARC-Trust	Amphibian and Reptile Conservation Trust
CAP	Common Agricultural Policy
CCAP	Climate Change Adaptation Programme
CCP	Climate Change Plan
CES	Cultural Ecosystem Services
ECAF	Environmental Cooperation Action Fund
EFA	Environmental Focus Area
EHI	Ecosystem Health Indicators
ELPEG	Ecosystems & Land Use Policy Exchange Group
ELSEG	Ecosystems and Land Use Stakeholders Engagement Group
ES	Ecosystem Services
EU	European Union
EUNIS	European Nature Information System
GHG	Greenhouse Gas
GIS	Geographical Information System
H2020 PROVIDE	EU project on public goods and bads from agriculture and forestry in Scotland
INNS	Invasive Non-Native Species
MODIS	Moderate Resolution Imaging Spectroradiometer
NAR	Natural Asset Register
NCAI	Natural Capital Asset Index
NEN	National Ecological Network
NFUS	National Farmers Union Scotland
NGO	Non-Government Organisation
OCEA	Office of the Chief Economic Advisor
PGIS	Participatory GIS
RBGE	Royal Botanic Gardens Edinburgh
RSPB	Royal Society for the Protection of Birds
SBS	Scottish Biodiversity Strategy
SFS	Scottish Forestry Strategy
SG	Scottish Government
SI	Social Innovation
SNH	Scottish Natural Heritage
SQPV	Squirrel pox virus
SRDP	Scottish Rural Development Programme
SRP	Strategic Research Programme
SWT	Scottish Wildlife Trust