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Something to grouse about? The cost-effectiveness of biodiversity measures in Scotland

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Abstract

The development of environment measures in the reformed CAP can be informed by the evaluation of existing policies. We undertook a cost-effectiveness analysis of biodiversity measures in Scotland to determine whether current biodiversity objectives have been achieved. We assessed measures targeting 13 species and 5 habitats under the Scottish Rural Development Programme (SRDP) and similar schemes.

Expert interviews were used to determine the extent to which published conservation objectives for species and habitats have been achieved. Effectiveness scores for multiple objectives were then weighted and combined to produce overall effectiveness for each species or habitat. Cost data for relevant SRDP and other scheme measures were apportioned to our study species and habitats.

There was a wide variation in cost per unit of effectiveness both across and within species and habitats, e.g. Hazel gloves fungus cost-effectiveness was £3,286 per unit whilst Black grouse ranged between £112k and £4m. These results reflected both levels of funding and effectiveness; also the often wide variation in assessment of effectiveness can be linked to vague objectives and lack of monitoring. We also considered impacts on wider ecosystem services which found that there are often broader benefits from biodiversity measures that should be considered.

Introduction

Careful design and evaluation, in both ecological and economic terms, should be a key component of biodiversity conservation programmes, since it underpins the efficient allocation of conservation resources (OECD, 2010 & 2012). Globally most biodiversity conservation programmes are not currently assessed in terms of their costs and benefits, or any notional rate of return on investment that they provide. Despite their benefits, interdisciplinary evaluations of conservation programmes are still relatively rare (Haddock et al., 2007), though there have been some notable exceptions (e.g. Moran et al., 1996; Metrick and Weitzman, 1998; Cullen et al., 1999; Cullen et al., 2001; Finn et al. 2009; Laycock et al. 2009, 2011, 2012; Perkins et al. 2011; Baker et al. 2012).

In response to dramatic biodiversity loss during the 20th century, the UK Government launched the UK Biodiversity Action Plan in 1994. While Biodiversity Action Plans were a central focus of species and habitat action, significant biodiversity and ecosystem gains are also sought via agri-

environmental and rural policy under the Rural Development Programmes of the Common Agricultural Policy. Since devolution across the UK, the UK BAP has been superseded by distinct policy approaches, including the implementation of the RDP and CAP. In Scotland, the Scottish Biodiversity Strategy published in 2004 (currently under review) outlined the government's long-term commitment to biodiversity, and the Species Action Framework[1] (SAF) sets out a strategic approach to species management. The SAF contains a 'Species Action List' of 32 species, which were the focus of new, targeted management action for five years from 2007.

There is considerable ecological evidence, but limited economic evidence about the returns on spending on UK biodiversity programmes. Notable exceptions are Laycock et al (2009, 2011, 2012) and Christie et al (2011). These studies are specific to species and habitat action plans. A few other studies including Wynn (2002) and Macmillan et al (1998) targeted the cost-effectiveness of broader agri-environmental measures. Christie et al (2011) and other studies have focussed on the monetary valuation of biodiversity and ecosystem services as a class of non-market goods. These studies can provide the basis for cost-benefit analysis although they are not necessary for cost-effectiveness analysis.

Overall these studies are somewhat incommensurate in terms of the biodiversity metrics used, and they provide a piecemeal evidence base on returns on investment. Aside from the Laycock et al (2009, 2011, 2012) studies, it is currently not possible to make a systematic comparison of the returns (either qualitative or quantitative) across target species or habitat types. This is not ideal for target setting and efficient resource allocation.

Cost-effectiveness analysis (CEA) allows alternative programmes to be compared on the basis of present value cost and effectiveness at meeting pre-determined targets (Macmillan et al., 1998). It is more routinely applied in health economics (Gold et al., 1996), and has so far only been applied to the evaluation of conservation programmes on a handful of occasions (e.g. Laycock et al, 2009, 2011, 2012; Montgomery et al., 1994; Macmillan et al., 1998; Fairburn et al., 2004).The main challenge in CEA is that investment comparisons and choices need to be based on a constant outcome metric. In other words, species and landscape scale outcomes need to be scaled using a comparable scale. In health assessment this metric has been developed in the form of a Quality Adjusted Life Year, which collapses many otherwise incommensurate health states to a common metric or scoring system. To date the only attempt to apply this to biodiversity in a UK context is the work of Laycock et al. (2009). That work focused on Biodiversity Action Plans.

The purpose of this study was to evaluate the cost effectiveness of a selection of species and habitat measures applied through the Natural Care Scheme (SNH), the Species Action Framework (SNH), and the Rural Priorities agri-environment scheme within the Scottish Rural Development Programme (SRDP). Our interpretation of efficiency is initially in terms of CEA, which means that for the policies (or conservation targets) of interest our methodology needs to establish a consistent method for identifying and allocating associated costs, define a metric of conservation outcome, and then estimate the cost per unit of conservation outcome. The study also considers how the measures associated with our selected species and habitats provide wider ecosystem service benefits.

[1] http://www.snh.gov.uk/protecting-scotlands-nature/species-action-framework/ [Last accessed 27/5/2013]

Ideally a standard methodology would be developed to accommodate relatively discrete species and habitat action plans, with an easily identifiable outcome and associated costs that can be clearly allocated. However, this is not the case for the costs and outcomes associated with a wide range of biodiversity measures, where the outcomes are more difficult to assess in terms of their environmental impact and where costs are less easily identified and allocated. In addition, the effectiveness of any set of measures can be dependent on many factors, including suitability of the measures themselves, how the spending has been targeted/implemented and the ecology of the species/habitats under consideration. Qualitative information can therefore be important in providing a background context to the quantitative data for each species/habitat and thereby help explain the cost-effectiveness calculations obtained.

Selection of species and habitats

An initial scoping suggested a suite of both highly targeted and broader species and habitats to consider. Species measures are more specific and it should be clearer how to allocate costs and determine outcomes. In contrast, for habitats a range of measures have been highlighted as being potentially beneficial. There are greater challenges in allocating spending and attributing returns (i.e. conservation outcomes) to these broader ranges of measure than to specifically targeted spending.

Table 1 presents our short list of species, together with a rationale for selection and an indication of whether they were covered by either the Species Action Framework (SAF) or the former Natural Care programme. This list of species also contains a mix of species which it is desirable to encourage and conserve, and invasive species which action aims to reduce. Our intention was to consider all 14 of these species although recognised the possibility that adequate data may not be available for all species for the final analysis. A number of other species were ruled out of further consideration commonly because there were no actions being taken with respect to biodiversity targets. Instead survey work may be undertaken to establish presence or numbers rather than trends; monitoring to establish trends in some cases may only apply to limited, specific, locations rather than across the range of the species.

Our short list of candidate packages[2] for specific and broad habitats is presented in Table 2 together with our rationale for inclusion. Hedgerows and arable fields are the only ones that contain specific SRDP measures. The broad habitats packages contain a mixture of different habitat focused measures and so these are best looked at individually. Note also that many of these broad habitats potentially have a range of more specific habitats associated with them.

[2] Under Rural Priorities packages of individual measures have been identified as relevant for particular species and habitats

Table 1 Short listed species

Species	SAF†	Natural Care	Rationale for suggesting focusing on this
Black grouse	Y	N	SRDP package of Rural Priorities measures targeted at this species. Active groups conducting and coordinating action on the ground
Capercaillie	Y	Y	SRDP package of Rural Priorities measures targeted at this species. Active groups conducting and coordinating action on the ground
Hen harrier	Y	Y	SRDP package of Rural Priorities measures targeted at this species. Active groups conducting and coordinating action on the ground
Sea eagle	Y	Y	Measures largely focused on protection and reintroduction but with a specific option (now closed) in SRDP Rural Priorities and a SNH Management Scheme available
Corncrake	N	Y	Species targeted for Action within SRDP Rural Priorities with some very specific measures for it
Red squirrel	Y	N	Targeted species with active SNH and Forestry Commission Scotland action on the ground. Type of measures of benefit have been highlighted in documents
Grey squirrel	Y	N	Invasive with targeted action being coordinated with active SNH and Forestry Commission Scotland action on the ground for red squirrel. Control measures supported under SRDP Rural Priorities
Great crested newt	Y	Y	Guide available highlighting Rural Priorities and LMOs of potential benefit to newts. Species Lead at SNH will (hopefully) be able to point in direction of relevant people/groups doing action for this species
Marsh fritillary butterfly	Y	N	Measures in SRDP Rural Priorities which can be used to help with habitat management for this species and Butterfly Conservation trying to actively target people to take up such measures
Slender Scotch burnet moth	Y	N	Limited distribution but some targeted action for known colonies being undertaken under SRDP Rural Priorities measures
Hazel gloves fungus	Y	N	Targeted action being directed at hazel woods and a small amount of habitat management being supported under SRDP Rural Priorities
Rhododendron ponticum	Y	N	Targeted action happening on the ground. Control measures being funded via SRDP Rural Priorities and Highland have a control strategy
Water vole ‡	Y	N	Species where measures are more in the form of re-introductions and mink eradication to help this species
American mink ‡	Y	N	Invasive species with targeted action and new Scottish Mink Initiative recently launched – action focused more on eradication programmes as opposed to making measures available to farmers etc.

† Species Action Framework

‡Not included in the SRDP

Table 2 Short list of habitats

Habitat	Specific/ broad	Rationale
Hedgerows	Specific	- Habitat that is targeted within SRDP Rural Priorities with a suite of specific measures highlighted as being of relevance and generally specific to the habitat and also with relevant options within Land Managers Options. - This habitat has been subject to a large amount of SRDP spending.
Arable Fields	Specific	- Habitat that is targeted within SRDP Rural Priorities with a suite of specific measures highlighted as being of relevance and generally specific to the habitat and also with relevant options within Land Managers Options.
Wetland	Broad	- Broad habitat with specific targeted option within SRDP Rural Priorities. - Although there is not a large amount of SRDP spending associated with this habitat it does have clear links to a wide range co-benefits, i.e. multiple ecosystem services.
Native Woodland	Broad	- Broad Habitat with specific targeted option within SRDP Rural Priorities at management and at creation, and also with relevant options within Land Managers Options. - There is a large amount of SRDP spending associated with this habitat. - This habitat has also been covered by the Natural Care Scheme
Upland heaths and moorland	Broad	- Broad Habitat with specific targeted options within SRDP Rural Priorities at management by grazing and management of livestock, by addition measures specific to peatlands, measures for red deer and red grouse management, and also with relevant options within Land Managers Options. - This is a very extensive habitat within Scotland and delivers a range of ecosystem services including carbon storage. - Some elements of this habitat have also been covered by the Natural Care scheme.

Methodology

Data collection

Data were collected at interview using a structured survey design. The questions were developed in order to extract information on:

1. Relevant options and schemes (specific to the species/habitat)
2. Apportionment of expenditure data (how much has been spent on each species/habitat per option and over what timeframe)[3].
3. Change in conservation status of species (or proportion of habitat in good condition for habitats)
4. Effectiveness of schemes (in terms of extent to which species/habitat objectives have been met)
5. Impacts for ecosystem services (of species/habitat relevant schemes)
6. Impacts on species/habitat of changes in funding allocation

In addition to specific questions relating to the above data, a number of more 'open' questions were asked in order to gain further information surrounding the species/habitat. A total of 28 interviews were conducted between October and December 2012. This included participants from a range of

[3] Data on the actual expenditure on relevant options and schemes were obtained from RPID and SNH prior to the interviews. Interviewees were presented with this data and asked to apportion the spending to specific species/habitats

organisations including SNH, RSPB, Forestry Commission and the Game and Wildlife Conservation Trust. These participants were either key stakeholders in relation to the species/habitats or they were the lead species/habitat partners.

All participants were asked the same questions regarding the species/habitat as detailed above. Each interview typically lasted between 1 and 2 hours depending on the number of species/habitats that the participant was being interviewed about. The interviews were conducted during face-to-face meetings, but when this was not possible, they were conducted via telephone or video conference. The interviews were recorded with the permission of the participants to support the extensive notes that were taken at the time of interview.

Cost-effectiveness calculation

Where cost data and effectiveness data were obtained by interview for a given species/habitat, a cost-effectiveness ratio could be calculated. This ratio uses a 'present value' cost as well as the data regarding the extent to which objectives have been met and the relative importance of each objective. The resulting ratio is a measure of the 'cost per unit of effectiveness', therefore, the higher the value, the higher the cost of each unit of effectiveness gained.

We used the following equation to calculate the Total Effectiveness of SRDP spending on each species or habitat (after Laycock et al., 2009):

$$E_i = \sum_{n=1}^{N} \left[M_n \left(I_n / 100 \right) \right] \quad (1)$$

where E_i is the Total Effectiveness *i*; each species or habitat has a total of N objectives; M_n is the percentage by which objective n has been met; and In is the percentage importance of objective n to the overall effectiveness of spending on that species or habitat. We then calculated the efficiency of spending on each species or habitat using Eq. (2), where C_i/E_i is the Present Value (PV) Cost-Effectiveness Ratio, i.e. the discounted cost per percent effectiveness, of species *i* or habitat *i*; the spend on species *i* or habitat *i* has been implemented for a total of *T* years; C_{it} is the spend on species or habitat *i* in year *t*; and *d* is the discount rate.

$$C_i / E_i = \frac{\sum_{t=0}^{T} \left[C_{it} (1+d)^t \right]}{E_i} \quad (2)$$

Discounting is a commonly used process that collapses cost/benefit streams over time to present value equivalents (HM Treasury, 2003). Here, the process allows different SRDP spend profiles to be compared on a consistent basis. In cases where participants had estimated the percentage of the total amount that was spent over blocks of several years rather than single years, when discounting we assumed that the cost was distributed evenly across the individual years within these blocks. In addition, because the different species and habitat programmes were not all implemented at the same time, the only time point common to all programmes is the end of the approved spending (2015). Thus, this was be taken as the reference date for discounting, which means that we actually compounded rather than discounted, taking 2015 as Year 0 and the first year that any programmes were implemented (2005, if some Natural Care Schemes applied) as Year 10.

Cost-effectiveness results

We present the objectives and effectiveness assessments for each species in Table 3 for those species for which effectiveness could be estimated. For each species the relevant conservation objectives were identified from the Species Action Framework. These objectives can be broadly categorised as: (1) maintaining current populations and ranges; or (2) extending populations and ranges. There is variation in the extent to which their objectives are quantified. For some species the objectives are less well defined in terms of an outcome that could be quantified, for example for hen harriers: *to develop our understanding of the constraints on hen harrier numbers and breeding success, and the land use and management measures needed to sustain hen harriers across Scotland*. And for red and grey squirrels: *to reduce the threat from grey squirrels*.

Estimated effectiveness ranges from 0 (lower estimate, black grouse and capercaillie) to 100 (upper estimate, sea eagle). There were five species for which we were unable to estimate effectiveness due to participants being unable to supply this information; these are listed in Table 4. Reasons given by participants included: lack of monitoring data; the participant' feeling that associated SRDP measures were not actually being applied to those species; or simply that the participant did not know how effective the measures were being.

The effectiveness estimates for habitats are presented in Table 5. The objectives for habitats also typically relate to maintaining or expanding the extent, or improving condition. Unlike species, these objectives are associated with specified quantities (in hectares or kilometres) for expansion or improved condition. However, there has in some instances been a mismatch between objectives and measures (e.g. new hedgerow planting versus management of existing hedgerows).

In terms of the habitats, effectiveness ranges from 28 (lower estimate, hedgerows) to 95 (upper estimate arable fields). Participants were unable to give complete estimates of effectiveness in relation to all objectives for two habitats (upland heath and moorland and native woodland); see Table 6.

Table 3 Species objectives and effectiveness estimates

Species	Number of interviews	SAF objectives for species*	Effectiveness (percentage range given)	Summary of species information, based on participant interviews
Black grouse	5	- Maintain the population (1996 level) and work towards longer term increase. - To restore range to its 1991 extent by 2011 and work towards longer term increase. - To promote re-colonisation of formerly occupied areas between currently isolated populations.	0 – 72	- Funding often spent in areas where populations are too low - Weather and neighbouring land-uses have a large impact on breeding success - More accurate geographical targeting needed
Capercaillie	4	- Increase population to 5,000 birds by 2010. - Stabilize and where possible increase the range of capercaillie.	0 – 30	- Deer fence removal and predator control has been beneficial - Weather impacts on breeding success - More geographical targeting and advice for landowners
Hen harrier	1	- Develop understanding of the constraints on numbers and breeding success, and the land use and management measures needed. - Devise and put in place management and conservation measures to improve conservation status.	40	- Increases in populations recorded at some sites but not seen throughout Scotland. - A balanced wildlife management strategy that considers the needs of sporting interests and the conditions needed for successful Hen Harrier populations
Sea eagle	2	- To translocate white-tailed eagles to an east coast Scottish site. - To ensure the current west coast population is viable and self-sustaining.	75 - 100	- Natural Care schemes have enabled conflict reduction via positive management of livestock for both Sea Eagle populations. - Broader habitat improvement will be needed in the future in line with conflict reduction schemes.
Corncrake	2	- Maintain or increase population within its current range. - Encourage expansion of range into suitable areas.	27.5 - 79	- Many options are specific to Corncrakes as they require very specific conservation management. - Numbers increased or maintained in certain areas, although range expansion has been limited. - Need to ensure continued targeting, more advisory support and better collaboration with neighbouring land owners.
Red squirrel and grey squirrel	1	- Maintain populations of red squirrels across their current range in Scotland. - Reduce the threat from grey squirrels.	90	- Good uptake of the RP scheme and a coordinated programme of Grey Squirrel control. Project involvement has enabled measures to be effective.
Hazel gloves fungus	1	- Maintain populations of this species at all current sites. - Increase the extent of known populations where feasible.	21	- LEADER funding has been especially beneficial for raising awareness of the Hazel Gloves using conservation advice.

* All species objectives are taken from the Species Action Framework (Scottish Natural Heritage, 2007) apart from the Corncrake objectives which were taken from the Rural Priorities package website: http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Packages/Corncrakes [Last accessed 27/5/2013]

Table 4 Species for which effectiveness could not be estimated

Species	Number of interviews	SAF objectives for species	Summary of species information
Great crested newt	1	- Increase the number of occupied recorded breeding ponds from 100 to 150, and ensure new ponds are created as components of pond clusters. - Improve/restore the quality of 20 current breeding ponds and surrounding habitat to ensure medium-long term viability for great crested newt populations.	- Effectiveness has not been calculated as funding from SRDP sources has not been used for this species. - SRDP is not considered useful as it does not contribute to pond creation. - Future SRDP measures will need to include an option for pond creation to be considered beneficial for this species.
Marsh fritillary butterfly	1	- Maintain the core range of the species in Scotland. - Maintain viable networks (meta-populations) within this core range, aiming at occupancy within 107 1km squares (work to increase this figure to 117 by 2015).	- SRDP funding has been successful in delivering for this species as funding rates have been suitable and farmers have been keen to take up the schemes. - Effectiveness is difficult to determine as no monitoring has taken place as part of the SRDP. - Site-specific advice is particularly important for the effectiveness of the schemes for this species and needs to continue. More monitoring is needed in order to improve future management recommendations.
Slender Scotch burnet moth	1	- Ensure the populations are maintained on all extant sites. - Increase the amount of potentially suitable habitat. - Maintain and enhance current meta-population links between colonies.	- As above – species have very similar requirements in terms of funding and management
Rhododendron ponticum	1	- Eradicate it from certain Natura sites designated for EC Habitats Directive Annex I habitat 'Old sessile oakwoods with Ilex and Blechnum in the British Isles' and from adjacent land to prevent re-infestation. - Raise awareness and undertake promotional work to dissuade use of this species and its hybrids in horticulture.	- The participant was unable to give a response regarding the extent to which objectives have been met so far. - The grant rates were considered appropriate for this species but the application process was thought to be discouraging landowners from applying.
Water vole and American mink	1	- Maintain the current range of the water vole (79 occupied 10km squares in Scotland in 2005). - Achieve an increase in range by 16 new occupied 10km squares in Scotland by 2010. - Improve connectivity between populations by favourable habitat management (in 95 occupied 10km squares in Scotland) by 2010.	- Effectiveness has not been calculated for this species as SRDP funding has not been used for management. - SAF and SNH funding sources have largely been used for mink control. Mink control requires management on a large scale and current SRDP funding is aimed at individuals.

Table 5 Habitats objectives and effectiveness estimates

Habitat	Number of interviews	Habitat objectives *	Effectiveness (percentage range given)	Summary of habitat information, based on participant interviews
Hedgerows	4	- Between 2005 and 2010 hedgerows remain at least as rich in native woody species - Favourable condition of 35% of hedgerows in Scotland by 2010 and of 50% by 2015 - Halt decline in the condition of herbaceous hedgerow flora in Scotland by 2010 - Net increase of 560 km in the length of hedgerows in Scotland between 2010 and 2015	28 - 80	- Much of the funding allocated for this habitat has been spent on the creation of new hedges not the management of existing ones. - Future schemes may be more effective if the management of existing hedgerows is included along with planting new ones. - Needs better geographical targeting of where new hedges are planted, so that they have the most biodiversity benefit.
Arable fields	3	- Expand the area of cultivated, low-input field margins from 1,800 ha in 2005 to 2,000 ha by 2010 and 2,500 ha by 2015 - Expand the area of margins providing wild bird seed to from 1,200 ha in 2005 to 1,500 ha by 2010 and 2,000 ha by 2015 - Expand the area of permanent grass margins to from 1,200 ha in 2005 to 1,500 ha by 2010	48.5 - 95	- Schemes have had impacts but there are still lots of areas where intensification is continuing. - The scheme needs to be continued in order for the benefits to be secured. - Needs better geographical targeting of the schemes so that they have the most biodiversity benefit.
Wetlands	4	- Blanket bog: area within SSSIs in favourable or recovering condition to be 168,000 ha by 2010 and 218,500 ha by 2015. - Wet woodland: total area in favourable condition to be 7,100 ha by 2010 and 8,900 ha by 2015. - Lowland Raised Bog: 4,333 ha in or approaching favourable condition by 2010, 8,666 ha by 2015 and 13,000 ha by 2020 - Coastal floodplain and grazing marsh: ensure that 375 ha is in favourable or recovering condition by 2010, 675 ha by 2015 and 1,350 ha by 2020 - Lowland Fens: ensure that 400 ha is in favourable or recovering condition by 2010, 600 ha by 2015 and 850 ha by 2020 - Lowland Fens: Establish 1 new landscape scale wetland complex by 2020, in which fen is a major component	53	- Many of the RP options are important for wetlands but uptake has been low in some cases enhancing payments and training available to landowners may improve this. - Natural care schemes thought to be more effective than RP options as they are better targeted, more accessible and easier to apply for. - Improvements in effectiveness could be made by not having targets but by training landowners so that skills are there to continue management. - Targeting, advice, support and monitoring will also enhance effectiveness of schemes.

* All habitat objectives are taken from Scotland's Targets (drawn from Biodiversity Action Reporting System – version which holds target information: http://ukbars.defra.gov.uk/archive/default.asp). Where more than six objectives were given for a habitat, we chose to focus on those most important for biodiversity.

Table 6 Habitats for which effectiveness could not be calculated

Habitat	Number of interviews	Habitat objectives *	Summary of habitat information, based on participant interviews
Upland heath and moorland	3	- Maintain at least 623,000 ha of upland heathland in Scotland through to 2010 and 2015 - A total of 144,000 ha of upland heathland, within SSSIs, in Scotland to be in favourable or unfavourable recovering condition by 2010.	- Moorland grazing options have been particularly influential for this habitat but the availability of places to store stock is a barrier to some landowners. - Advice and geographical targeting is needed in the future management of this habitat as well as adequate monitoring of designated sites. - Effectiveness may be improved by enabling fewer specific options and focusing on the delivery of management plans.
Native woodland	2	- Maintain the net extent of native woodland in Scotland, (no net loss of 391,000 ha). [shared target for all priority woodlands] - Maintain the current extent and distribution of ancient semi-natural woodland, which qualifies as native woodland in Scotland, (no change in the existing area of 118,000 ha). [shared target for all priority woodlands] - Achieve favourable or recovering condition of 120,000 ha of native woodland resource in Scotland by 2010 and 150,000 ha by 2015. [shared target for all priority woodlands] - Restore at total of 4,000 ha of non-native plantations on ancient woodland sites (PAWS) to native woodland in Scotland by 2011 and a total of 9,000 ha by 2015. - Expand the current native woodland resource in Scotland by 53,955 ha by 2010	- The payment rates for this habitat have increased which has attracted people to native woodland planting. - However, further checks and aftercare is needed to ensure that this planting is maintained and biodiversity benefits are gained. - Furthermore, effectiveness could be improved by targeting payments, enabling greater deer management at the landscape, ensuring that disease resistant planting stock is available.

* All habitat objectives are taken from Scotland's Targets (drawn from Biodiversity Action Reporting System – version which holds target information: http://ukbars.defra.gov.uk/archive/default.asp). Where more than six objectives were given for a habitat, we chose to focus on those most important for biodiversity.

The aggregated scheme costs (over the 2005 to 2015 time period) and cost-effectiveness ratios are presented for species and habitats in Table 7 and Table 8 respectively. For species present value costs (d=3.5) range from £79,000 (hazel gloves fungus) to £10,603,600 (corncrake). The cost-effectiveness estimates range from £3,500 (lower estimate, sea eagle) to £4,564,800 (upper estimate, black grouse), see Table 7.

For habitats present value costs (d=3.5) range from £12,516,000 (arable fields) to £50,403,000 (hedgerows). Cost-effectiveness estimates range from £131,700 (lower estimate, arable fields) to £1,800,100 (upper estimate, hedgerows), see Table 8.

Along with these quantitative results we must add some caveats. The cost-effectiveness ratios in particular cannot be considered in isolation without examination of the further qualitative data and specific context of the species background. In addition, the species objectives used for this study were mostly taken from the Species Action Framework (Scottish Natural Heritage, 2007). There is considerable variation in the substance and detail of these objectives between species. Hence, values of cost-effectiveness should be considered solely in relation to the objectives of the species or habitat concerned and should not be treated as equivalent measures for comparison across species or habitats.

Table 7 Cost estimates for species

Species	PV Cost (£'000, d=0)[a]	PV Cost (£'000, d=3.5)[b]	Cost per unit effectiveness (£'000, d=0)	Cost per unit effectiveness (£'000, d=3.5)
Black Grouse	8,068.9	9,129.6	112.1 - 4,034.5	126.8 - 4,564.8
Capercaillie	3,850.3	4,356.5	128.3	145.2
Hen Harrier	424.5	537.9	10.6	13.4
Sea Eagle	314.5	351.2	3.1 - 4.2	3.5 - 4.7
Corncrake	9,300.9	10,603.6	117.7 - 338.2	134.2 - 385.6
Red squirrel and Grey squirrel	3,573.5	4,043.2	39.7	44.9
Great Crested Newt	NA	NA	NA	NA
Marsh fritillary butterfly	NA	NA	NA	NA
Slender Scotch Burnet moth	NA	NA	NA	NA
Hazel Gloves Fungus	69.0	79.7	3.3	3.8
Rhododendron ponticum	2,363.2		NA	NA
Water vole and American Mink	NA	NA	NA	NA

[a] This is the cost in nominal cash terms (i.e. discount rate = 0%)

[b] These values have been compounded forward to 2015 values (discount rate = 3.5%)

Table 8 Cost estimates for habitats

Habitat	PV Cost (£'000, d=0)[a]	PV Cost (£'000, d=3.5)[b]	Cost per unit effectiveness (£'000, d=0)	Cost per unit effectiveness (£'000, d=3.5)
Hedgerows	44,133.4	50,403.4	551.7 - 1,576.2	630.0 - 1,800.1
Arable fields	10,556.9	12,516.0	111.1 - 217.7	131.7 - 258.1
Upland heath and moorland	29,220.2	33,817.4		
Native woodland	110,143.5	124,706.5		
Wetlands	19,880.9	22,494.4	375.1	424.4

[a] This is the cost in nominal cash terms (i.e. discount rate = 0%)

[b] These values have been compounded forward to 2015 values (discount rate = 3.5%)

Impacts on wider ecosystem services

Ecosystem services are a key integrating concept across different strands of environmental and land use policy. Categorisations of ecosystem services have been developed by a number of studies (e.g. de Groot et al, 2002; Millennium Ecosystem Assessment, 2005) and recently in the UK context by the National Ecosystem Assessment (UK NEA, 2011). These frameworks highlight the potential trade-offs and synergies between different services particularly where pursuit of specific services (e.g. agricultural production) has consequences for other services such as biodiversity, water resources (quality and quantity) and climate change. In order to assess the potential co-benefits of species and habitat measures on a wider range of ecosystem services we presented participants with the broad list of ecosystem service categories used by the UK National Ecosystem Assessment together with their definitions (see Figure 1)

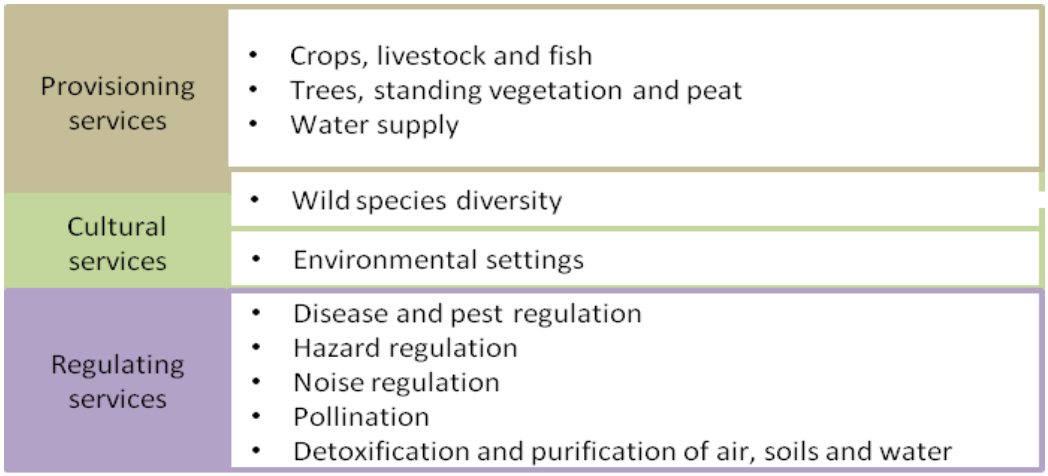

Figure 1 Classification of ecosystem services (adapted from UK NEA, 2011)

In this section we outline the assessment of the impact of species and habitat related measures on a wider set of ecosystem services. Interview participants were asked to qualitatively assess whether the measures (to their knowledge) had either slight or large impacts on the provision of ecosystem services and whether those impacts were positive or negative. These responses were then scored as either ±1 or ±2 respectively for slight or large impacts. We stress that this assessment relates to the impact of the measures not the abundance or condition of the target species and habitats, i.e. we are assessing the co-benefits arising from the measures targeting specific species and habitats. The assessment also does not take account of the scale of measure implementation; therefore strongly positive or negative impacts may not be widely applicable.

Figures 2 and 3 present the summary assessment for each species and habitat for three broad ecosystem service categories (provisioning, cultural and regulating). For species the majority of measures were considered to have positive impacts across the categories of ecosystem services. The exceptions to this are for provisioning services in the case of hen harriers, sea eagles and great crested newts. In the case of hen harriers and great crested newts the reduction in agricultural production either due to reduction in livestock number for the former or creation of pond habitats for the latter. Sea eagles have negative impacts due to increased predation of livestock (provisioning services) or wild species (cultural services). Figure 2 does not illustrate a negative impact of hen

harrier measures on the specific regulating service of 'disease and pest regulation' which arises due to the difficulty in controlling tick numbers due to reduced stocking densities.

The impacts of habitats measures were positive across the aggregate ecosystem services groups. These are largely reflected at the level of individual ecosystem services with the exception of 'crops, livestock and fish' in the case of upland heath and moorland, and 'disease and pest regulation' in the case of native woodland.

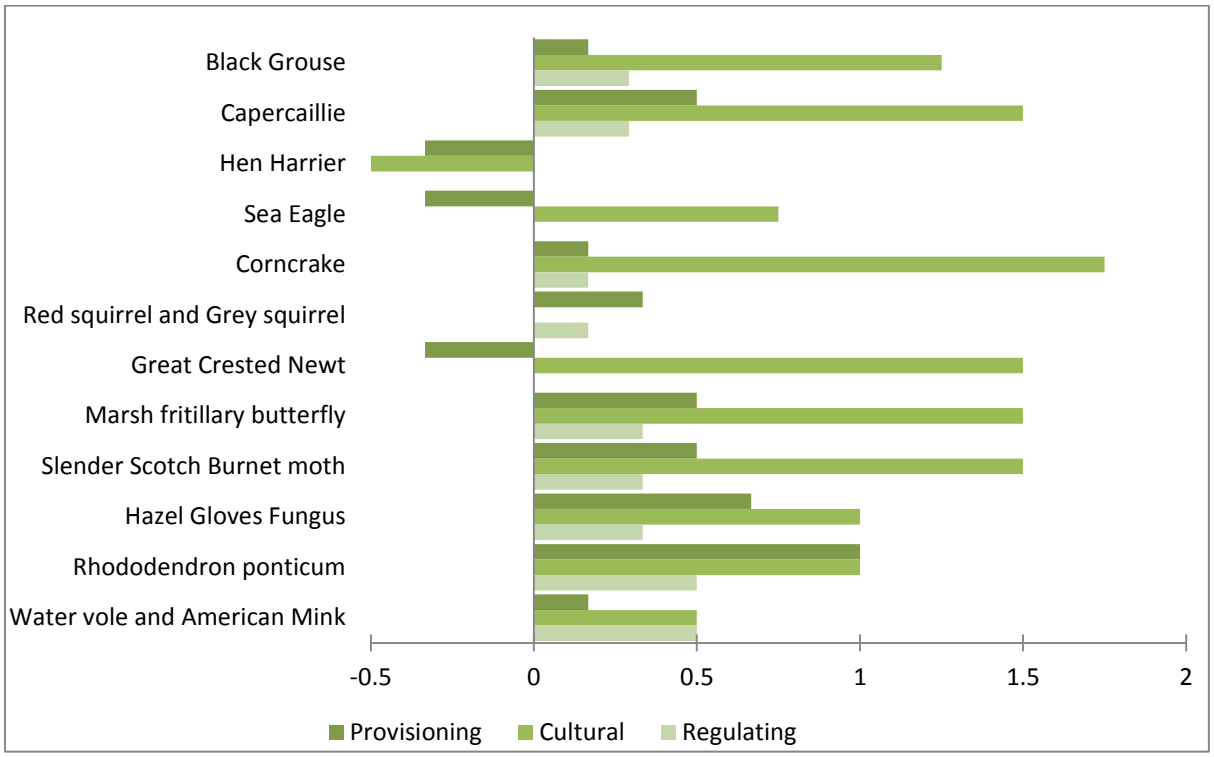

Figure 2 Ecosystem services impacts of species measures

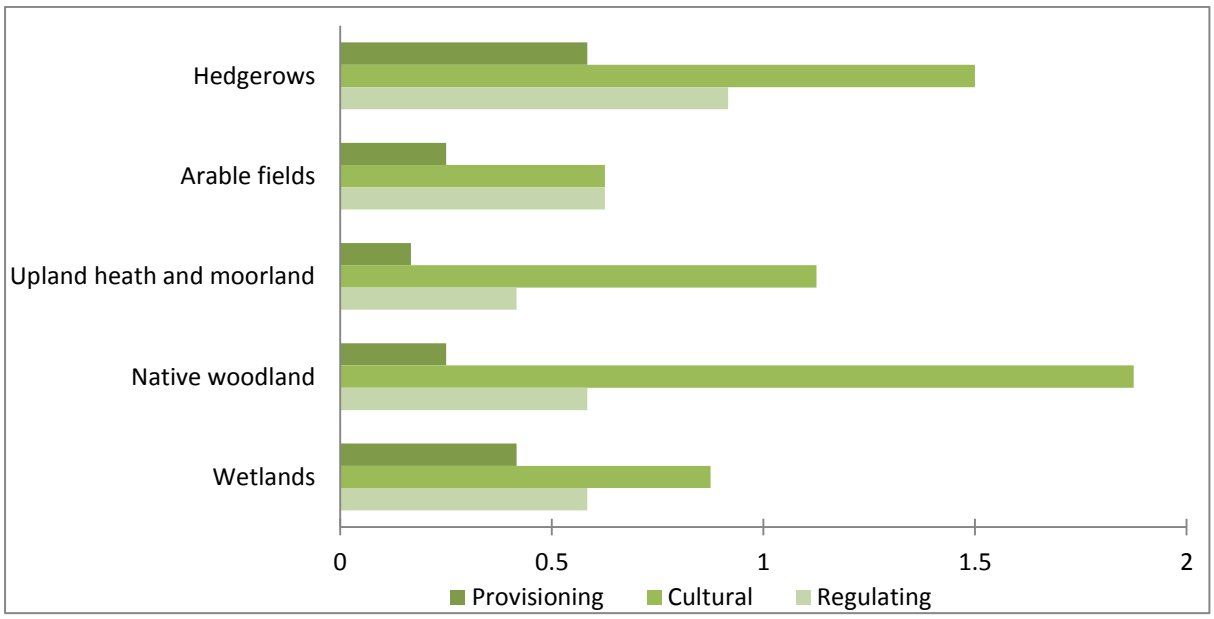

Figure 3 Ecosystem services impacts of habitats measures

Discussion and recommendations

In this section we reflect on the issues that have arisen in our efforts to empirically quantify the costs and effectiveness of species and habitat conservation resulting from the SRDP and related measures. We then propose recommendations for design of future schemes and objectives.

Empirical issues

Although conceptualisation of the cost-effectiveness of management actions/policy measures in protecting and enhancing biodiversity is possible, estimation of actual cost-effectiveness is hindered by a number of empirical difficulties.

First, the complex inter-connectedness of ecosystems means that identifying a discrete set of relevant measures is not necessarily easy. Directly relevant measures may be relatively obvious, but their effectiveness may be conditional upon a number of other, less directly relevant but nonetheless supporting measures. Hence, although constructed using the best available information and expert advice, the range of measures specified here may be too narrow or too wide.

Second, even if a set of relevant measures can be identified, attaching a cost to them is not straightforward. This partly reflects unexpected difficulties in accessing funding data, but also that funding does not necessarily equate to expenditure (the latter is often less, and lags behind, the former) and that any given measure may support more than one species or habitat and thus funding needs to be apportioned between them. This apportionment was further reliant on the perceptions of our survey participants; although this may be the best approach to determining where broadly categories of funding have been targeted.

In addition, it is worth noting that funding projections for future years will alter over time as the number of farms enrolled in schemes changes - different snapshots of a live funding database give different pictures. For example, a data extract in (say) 2011 will show less funding for (say) 2016 than a later extract in (say) 2012 when more farms have entered into relevant schemes. Hence care needs to be exercised in comparisons over time in terms of the funding allocated to future years and the interpretation of future effectiveness.

Third, ideally, effectiveness would be measured against some standard metric (e.g. conservation status) for all species and habitats. This would avoid interpretation difficulties across different metrics and would allow comparisons across species and habitats. However, as confirmed by the survey, a lack of monitoring means that it is impossible to estimate such a metric. Our survey attempted to apply such a metric by asking participants to rate species conservation against categories in the IUCN conservation status index[4]. However, this proved a difficult task for respondents and arguably this metric was fairly blunt and substantial changes in conservation status are required to move a species across categories. Further, such a metric would require an assessment of status relative to pre-scheme levels or a counterfactual trend.

Consequently, recourse has to be made to stated policy objectives which vary across individual species and habitats in terms of their ambition, clarity and initial conditions. This makes it impossible to compare effectiveness across species and habitats and also makes it difficult to

[4] See IUCN (2013) http://www.iucnredlist.org/documents/RedListGuidelines.pdf

interpret whether effectiveness is attributable to easily attainable objectives and/or to well-designed/implemented measures or, equivalently, whether poor effectiveness is attributable to unrealistic objectives and/or to poorly designed/implemented measures. Best practice guidance suggests that objectives should be "SMARTER".[5]

Fourth, again reflecting an almost complete lack of routine monitoring of either baseline conditions prior to adoption of a management action/measure and of subsequent changes, all estimates of effectiveness against stated policy objectives reflect the subjective judgements of survey interviewees. Although interviewees were selected for their expert knowledge, many acknowledged information gaps and limits to the accuracy of their quantitative estimates. Notably, there were several instances where even those identified as being best placed to comment felt unable to do so. Again this emphasises the need for monitoring to be set in place, and that monitoring is matched with the objectives, so that if there is a change (negative or positive) in status, this can be related to the specific objectives and that the data are sufficient for it to be detectable. Objectives should be set such that it is possible that data being collected will be able to determine whether it has been met or not. The issues due to lack of monitoring and inability to ascribe outcomes to schemes is not unique to SRDP measures and have been noted in similar contexts elsewhere (see for example Welsh Assembly Government, 2008; OECD, 2012).

These empirical problems mean that cost denominators and effectiveness numerators are subject to a high degree of uncertainty and hence any cost-effectiveness estimate is subject to a number of caveats. Nonetheless, the quantitative findings serve as an "exercise in paying attention" to the factors affecting cost-effectiveness and the accompanying qualitative findings offer some valuable insights into how effectiveness could be improved. For example, recurrent themes included the need for improved targeting of measures; improved advice and a meaningful monitoring programme. Few interviewees queried technical prescriptions per se, more the manner of their targeting and supported implementation – sentiments that echo findings in other recent studies (e.g. Hart et al., 2011; Perkins et al., 2011; Armsworth et al., 2012).

Recommendations

Species

Collaborative schemes: The assessment of success in meeting objectives highlighted the sensitivity of outcomes to external factors such as weather and neighbouring land uses (e.g. Black grouse and Capercaillie); although the former is difficult to mitigate the latter illustrates the need for a collaborative approach to species measures. Collaborative applications are not always possible with the current SRDP system and yet this would improve the effectiveness of biodiversity measures for a number of species, particularly regarding potentially controversial species (e.g. Hen harrier and Sea eagle) and invasive species (e.g. Rhododendron and mink control). Such Joint species initiatives should also be linked to the delivery of a broader set of ecosystem services.

[5] Specific, Measurable, Attainable, Relevant, Time-sensitive, Evaluated and Re-evaluated. Policy guidance includes: http://archive.treasury.gov.uk/performance_info/fabric.pdf
http://www.civilservant.org.uk/betterpolicymaking.pdf

Geographical targeting: Schemes should be geographically targeted where there are sufficient local species populations to benefit from measures. Species objectives would need to be adapted to recognise this. For example, maintaining or increasing populations should be given greater short term emphasis before objectives such as increasing species extent which would be a longer term aspiration.

Tailored and timely advice: Greater geographical targeting should be combined with tailored advice on appropriate management and on-farm implications. This reflects the fact that scheme impact is dependent on voluntary adoption by land managers and uptake behaviour is inevitably conditioned by social and cultural factors as much as technical aspects of prescribed measures (e.g. Pannell & Vanclay, 2011). The range of measures linked to particular species need not be simplified or reduced as current measures offer flexibility of action when matched with locally relevant advice. Such advice should also be available during the application process as well as during delivery to ensure selection of the correct measures.

Linking objectives and monitoring: Local successes are occurring but this does not always translate to changes nationally, which is ultimately harder to achieve. Objectives for some species need to be altered in order to be more achievable and these should be more in line with monitoring which does not currently occur with the SRDP. Further attempts to fully assess the impact of conservation spend should not be restricted to locations where schemes are applied since counterfactual evidence of species status in the absence of management measures is also important for determining trends and to provide some indication of the true effectiveness of measures..

Habitats

Restoration before creation: The effectiveness of measures for habitats such as hedgerows would be improved if these focused on restoration of existing habitat stocks rather than new planting. This is analogous to the recommendation made for species to support current populations rather than expanding ranges. Objectives should be adjusted to reflect this.

Geographical targeting: The effectiveness of measures could be enhanced by targeting areas where biodiversity benefits would be highest. This might include targeting at a landscape level to improve connectivity and delivery of wider ecosystem services.

For some habitats such as upland heath and moorland there has been a conflict with agricultural management, specifically the lack of alternative grazing land has been a barrier to uptake of some measures. Measures may need to be more reactive to local circumstances.

These issues indicate that an ecosystem approach should be adopted to guide scheme implementation at landscape scale. This would require collaboration and coordination by landowners/managers. Current Rural Priorities regions might need to be reviewed to determine whether these can be more appropriately defined. This should be in conjunction with broader initiatives such as the Land Use Strategy.

Advice and aftercare: The effectiveness of all the studied habitat schemes could be improved with greater advice and particularly aftercare to assist in the delivery of management plans. In contrast to species measures, having fewer specific options might improve effectiveness (e.g. upland heath and

moorland). For wetlands the importance of training in skills for habitat management was emphasised over having targets.

Streamlined applications: For landowners managing smaller areas a more streamlined or 'fast track' scheme application process may be appropriate.

Ongoing financial support: The need for ongoing funding of management was highlighted for arable fields and wetlands.

Monitoring: Linked to advice and aftercare there should be sufficient monitoring of outcomes, ideally with ongoing review of objectives and counterfactual assessment of non-targeted areas.

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