A report on work undertaken in year 2 (2017-2018) of the Scottish Government's Strategic Research Programme in support of the Natural Capital Asset Index

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Introduction

The Natural Capital Asset Index aims to assess the potential of Scotland's Natural Capital – its environmental resources – to continue to provide the benefits that Scottish people obtain from the environment[1].

Within the Scottish Government Strategic Research Programme (SRP) 2016-2021 we are tasked with undertaking work to help support the continued development of the NCAI. This follows on from a previous large-scale review of the index (Albon et al. 2014).

In year 1 of the SRP (2016-2017) we undertook a review of new indicators that it had been proposed could be included within the NCAI (Brooker et al. 2017). Our work in support of the NCAI in year 2 of the SRP (2017-2018), which is reported here, focussed on two topics:

1. Identifying gaps within the datasets underpinning the NCAI and putting forward proposals to address these.

2. Examining how cultural ecosystem services are currently handled within the NCAI and how this might be improved.

These two topics are covered by the two main parts of this report.

[1] Full descriptions of Natural Capital and the NCAI can be found at https://www.nature.scot/professional-advice/planning-and-development/industries-reliant-nature/valuing-our-environment and http://www.snh.gov.uk/docs/B814140.pdf.

Part 1 – NCAI Data Gaps Analysis

Aim

The overall aim of this work was to identify clear gaps in the datasets underpinning the NCAI and, if possible, to suggest routes by which gaps might be addressed, e.g. through alternative or additional data sources.

Approach

Understanding the existing data

The data underpinning the NCAI are set out within an Excel file. Multiple data types go in to making up the final NCAI score for any given habitat, and data from across multiple habitats are then used to produce the final overall NCAI score. Many of these underpinning datasets might provide opportunities for identifying improvements. The following list details the key data sheets within the NCAI and provides a brief assessment of whether data gap identification and improvement might be possible:

Ecosystem Area – estimated area (ha) of each of the 31 EUNIS level 2 habitats found in Scotland, 2000-2015 (for the model released in 2017). Substantial effort has already gone into the habitat classification of Scotland and so this dataset is less of a priority for consideration in terms of an assessment of data gaps.

ES Potential (weighting) – user-defined weightings for the importance of a particular ecosystem in delivering ecosystem services. Values for ES Potential Weighting have already been determined through a survey of scientists and the public. Although the technical guidance for the index states that the authors do not "claim to have reached a single correct answer", to revise these data would be a very considerable job. In addition it is not obviously necessary: the technical guidance for the 2017 version of the NCAI notes support for the current weightings from other peer-reviewed sources.

ES Potential per SPU – the ecosystem service potential on a scale of 0 to 5 for each combination of CICES ecosystem service type and level 2 EUNIS habitat categories. The data here are based upon the work of Burkhard et al. (2014) with some adaptation to the Scottish context, and so again might be considered relatively fixed.

ES Potential Base and *Well-Being Base*. These sheets do not require input; they update automatically to reflect changes in the three preceding input sheets. Consequently any data gaps in these sheets simply reflect data gaps in the preceding three input sheets.

Indicator sheets. These worksheets show combinations of habitats and ecosystem services that particular indicators measure. For each combination, the sheet shows whether the indicator is applicable (i.e. can this indicator be used as an indicator of ES potential for this habitat x service combination?); where it is applicable, a weighting is shown based on data in the *Indicator Directory* which reflects the perceived quality of that indicator for that service type (based on the 3 main service categories, with a weighting of 1 being an ideal indicator). They also contain raw data for the indicator between 2000 and 2015.

Gaps sheet. This aims to "provide a flavour of the strength of evidence for each combination of ecosystem service and habitat, and hence gaps in our knowledge". The assessment of whether a habitat is relevant for producing a particular ecosystem service is done in the sheet ES Potential per SPU, and this data arises from Burkhard et al. (2014); if a particular habitat is considered irrelevant for delivery of a particular service then this is indicated in the *GAPS* sheet by NA. For all situations where an ecosystem is considered relevant to service delivery, the *GAPS* sheet indicates the sum value of the weightings of the contributing indicators (as shown in the multiple *Indicator* sheets).

Gap prioritisation

On the basis of the above checks on the various data types, and our assessment of where there might be worthwhile opportunities for data gap analysis, we decided to focus in particular on data gaps in the *Indicator* sets, and how this was summarised and assessed in the *GAPS* sheet.

Although the *GAPS* sheet starts to identify data gaps in the indicator set, it is hard to identify from the *GAPS* sheet which gaps might be considered most important. This is a problem if the list of identified gaps is very large because there is then no obvious way of prioritising which should be addressed first.

There are in fact 108 situations where the ecosystem service x habitat combination is considered relevant, but where there are also no data available in the *Indicator* sheets (i.e. the score in the *GAPS* sheet is 0). Not all of these 108 combinations might be considered equally important and hence might not all be priorities for seeking new datasets. However, for many of these there is a relatively low associated *Well-Being Base* score; this indicates that the service x ecosystem combination is not considered important for human well-being in Scotland.

In contrast, important data gaps are those where there is no data available in the indicators sheets and where the Well-Being Base score is high. In this case it is the ratio of *GAPS* score to *Well-being score* which can help identify priority data gaps.

In addition, a high score in the *GAPS* sheet does not indicate that for the particular habitat x service combination there are any ideal datasets. A high score in the *GAPS* sheet might result from multiple imperfect datasets. Any combinations which only have highly imperfect data in the indicators sheets would also be important data gaps.

To aid with this work we created the file *NCAI_Gaps assessment 2018 V1.xlsx*. In this we:

1. Compiled additional data on the number of indicators contributing to the final scores in the *GAPS* sheet (see the sheet *Count data*).

2. Combined this with data provided by Tom McKenna (SNH) on the ratio of *GAPS*:*Well-being scores* (see the sheet *Relative gaps*).

3. For top ranking gaps identified using either of the two above processes (filtered using the *Ranking sheet*), examined the nature of the underlying data and whether these identified data gaps are genuinely important, and if so whether additional datasets might be available to help plug the gaps.

Results

GAP score:Well-being ratio

When ranking by the *GAP score: Well-being* ratio (relative gaps) the process was relatively straightforward. The top 10 identified data gaps are shown in the table below.

Habitat	Service	GAPS	Well-being	Count	(GAPS+0.1)/(Count+0.1)	Relative gaps
F4 Temperate shrub heathland	Reared animals and their outputs	0	80	0	1	800.6
G3 Coniferous woodland	Materials from animals, plants and algae (for direct use or processing)	0	77	0	1	766.5
G3 Coniferous woodland	Plant-based energy sources	0	66	0	1	659.0
D1 Raised and blanket bogs	Plant-based energy sources	0	47	0	1	473.9
F4 Temperate shrub heathland	Materials from animals, plants and algae (for agricultural use)	0	44	0	1	436.8
D1 Raised and blanket bogs	Global, regional and micro climate regulation	1	457	1	1	415.9
F4 Temperate shrub heathland	Materials from animals, plants and algae (for direct use or processing)	0	38	0	1	376.8
F4 Temperate shrub heathland	Plant-based energy sources	0	32	0	1	323.9
G3 Coniferous woodland	Wild animals, plants and algae (and their outputs)	0	30	0	1	299.5
G3 Coniferous woodland	Genetic material from all biota	0	29	0	1	288.3

Obviously, given that the *GAP* score is zero for all of these, none of these combinations are underpinned by any indicator data, and so all might be considered priority data gaps.

Number of indicators contributing to final GAPS score

The process for selecting priority data gaps based on the quality of indicators contributing to a final *GAPS* score was more complex.

As noted, many ecosystem service x habitat combinations have 0 scores in the *GAPS* sheet. There then needs to be a process of identifying which low scoring combinations might represent important data gaps. The combinations were therefore sorted by their *Well-being* score, and then selection was made of those combinations where the GAPS score was < 2.4 (50% of the maximum gaps score).

A process was then undertaken to work through the *Indicators* sheets to identify which of these potential priority combinations did not have at least 1 perfect indicator (i.e. an indicator getting a score of 1 in the indicator sheets).

Of the top 15 of these prioritised combinations, only one had no perfect indicator, specifically:

Habitat	Service	GAPS	Well-being	Count	(GAPS+0.1)/(Count+0.1)	Relative gaps
I1 Arable land and market gardens	Cultivated crops	1.5	373	3	0.52	233.0

In all other cases there was at least 1 "perfect" indicator, and this was generally SCM data. After having worked through the first 15 cases we stopped this process because the same habitats were being repeatedly brought up in the list, and hence would all have "perfect" indicators based on SCM data.

Discussion

The initial aim of this part of our work was to identify gaps in the NCAI that might be plugged with new data, so have we been able to do this? Although we have identified some clear data gaps, filling these gaps with additional datasets may be less straightforward. With respect to the type of gaps being identified, the NCAI aims to indicate the potential of ecosystems to deliver services. The earlier data reviews (Albon et al. 2014, Brooker et al. 2017) recommended removing some data, or flagged it as being less useful, if it only told us about offtake and not about long-term sustainable potential. For example "Deer available for watching/ shooting: no. of deer shot" was scored red in the 2014 assessment as offtake can be decoupled from the underlying state of the environment and long term potential. Following this logic we can't plug the gaps identified in the tables above – which seem largely to be about provisioning services - with obvious datasets like deer shooting numbers or commercial timber production.

For these same habitats, but for other services, SCM (site condition monitoring) data are used as the primary indicator of potential ES delivery, and are often given a score of 1 in the indicators sheet, indicating a "perfect" indicator. The use of SCM data is problematic because it represents an assessment of the state of only a subset of a particular habitat, and a subset which may not be fully representative of that habitat type in Scotland. However, given its use elsewhere in the NCAI, and working on the assumption that SCM data is acceptable based on its current usage in the NCAI, then it might be argued that the same data indicates potential to deliver provisioning services as well as regulation and maintenance services.

The only identified situation where it may not be possible to extend the use of SCM data to plug some of the identified gaps is the production of cultivated crops from arable land and market gardens. Such habitats are not covered by the SCM process, so alternative data on the health of these habitats, rather than simply service delivery, would need to be found. Note that this lack of data from habitats not well covered by the SCM dataset is also flagged below with respect to assessing cultural ES delivery.

Conclusions and recommendations

In conclusion, this simple analysis has indicated in which parts of the NCAI process data improvements could most readily be made, specifically in the *Indicators* sheets. It has also highlighted particular habitats where there are clear data gaps: Temperate shrub heathland (F4), Coniferous woodland (G3), Raised and blanket bogs (D1), and Arable land and market gardens (I1).

On the basis of our assessment we recommend the following:

1. **Extend the use of Site Condition Monitoring data** in the *Indicators* sheets so that it can also act as an indicator of potential service delivery for provisioning as well as cultural and regulating services for the identified habitats.
2. When considering the future of the Site Condition Monitoring programme, **include locations away from protected areas** so that the data become more representative of the health of these ecosystem (and their potential to provide ecosystem services) in Scotland overall.
3. **For habitats such as arable land and market gardens which are not currently captured by the SCM process**, either include them in future, or **find alternative data** providing an indication of the state of these ecosystems. Some suggestions given below in Part 2 of this report - with respect to the assessment of cultural ecosystem services – may also be of relevance here.

Part 2 – Cultural Ecosystem Services

Aim

The overall aim of this work was to examine how cultural ecosystem services are currently handled within the NCAI and how this might be improved.

Background: the NCAI and Cultural Services

Scotland's natural assets encompass its geology, soil, air, water and all living things, including ecosystems and biodiversity. A country's natural capital is the stock of its natural assets which yield a flow of ecosystem services into the future. To ensure a continued and sustainable flow of ecosystem services we need to be able to assess and monitor the state of our natural assets in terms of their quantity and quality. For example, the ability of a nation's peatland to sequester carbon will not only depend on peatland area, but most importantly its condition i.e. whether it is degraded or not. The Natural Capital Asset Index attempts to analyse and track the quality and quantity of Scotland's terrestrial habitats according to their potential to deliver ecosystem services now and in the future. It is an index based on a composite indicator of currently 38 habitat quality indicators across 10 EUNIS level 2 habitat categories (Coastal, Inland surface waters, Raised and blanket bogs, Grasslands, Heathland, Woodland and forest, Un-vegetated or sparsely vegetated, Cultivated agricultural, Montane, Artificial habitats) broken down into 31 terrestrial habitats. The index is calculated annually and is measured relative to the year 2000.

A simple definition of cultural ecosystem services is provided by the MEA (2005) as the "non-material benefits people obtain from ecosystems through spiritual enrichments, cognitive development, reflection, recreation and aesthetic experiences". Measuring the quality of Scotland's terrestrial habitats and taking into consideration cultural services poses a challenge for the NCAI. This is due to the complex process by which cultural ecosystem services are produced.

Recent studies have demonstrated that the majority of ecosystem services, and in particular, cultural services, are co-produced through human-nature interactions (see Fischer and Eastwood, 2016) and involve inputs from other types of capital, in addition to natural capital. The interaction of people, through different activities such as playing or working the land, with an environmental space or setting can by physical, intellectual, spiritual or symbolic. The cultural services, goods and benefits that are co-produced from this interaction will be dependent on many things, including the perceived 'quality' of the ecosystem or setting, which will be dependent on cultural norms, identities, beliefs and values. Thus the perceived 'quality' of a particular ecosystem or environmental setting, in terms of the delivery of cultural services, will be different between different groups of people (with different identities) and in different places, and will be subject to change over time. For example, an open grouse moorland managed for driven shooting may be viewed as high quality in terms of providing cultural services to the local game-keepers association (skills and traditional knowledge, aesthetics, recreation), but seen as poor quality to the local wildlife conservation group who wish to create more wild cat habitat (aesthetics, conservation skills and knowledge).

Indeed our understanding and knowledge of which aspects of ecosystems and biodiversity (often measured to ascertain quality) underpin the delivery of cultural ecosystem services, including mental

and physical health, is still very limited (Fuller et al. 2007, Cardinale et al. 2012, Clark et al. 2014). For example, studies which have examined the relationship between the objective (biophysical) metrics of biodiversity and self-reported health are inconsistent and inconclusive, and have lead authors to coin the term the "people-biodiversity paradox" (Pett et al. 2016). This people-biodiversity paradox is thought to have emerged as a result of the multidimensionality of both biodiversity and human well-being, making it difficult to account for and measure the complex social and ecological characteristics that may influence the outcome of interactions (Hartig et al. 2014, Lovell et al. 2014). This is supported by a recent review by Irvine and Herrett (Subm.) which asked whether the ecological quality of woodlands matters for cultural services. It found that ecological health was not the main factor underpinning cultural services in urban woodlands, and that there was very little evidence to suggest that biodiverse native woodlands were more beneficial than mixed woodlands with regards to cultural service delivery.

Given the complexity of the relationship between biodiversity and the state of habitats and the delivery of cultural ES, it is worth considering whether the NCAI should even attempt to measure the quality of natural assets for their potential to deliver cultural services. However, in not doing so we risk excluding the consideration of one of the major factors that contribute to how and why land is managed.

What does new knowledge on cultural services mean for the NCAI?

If the relationship between the condition of habitats and ecosystems in terms of biodiversity and cultural ecosystem services is complex and difficult to measure, what does this mean for the NCAI, its current indicators, and the way in which it handles cultural ecosystem services?

And if ecosystem services are co-produced by the interaction of people with nature, then does it make sense to assess the potential of our natural assets to deliver ecosystem services by looking at only their state (quantity and quality)?

Table 1 lists the current indicators in the NCAI which have been assigned to represent assets that contribute towards cultural services. From the list of indicators there are a few immediate noteworthy points:

• Nine of the twenty six indicators are a Scottish species or diversity indicator, seven of which are based on bird diversity or abundance.

• Seven of the indicators are based on the condition of features from designated sites.

• Four of the indicators are based on water quality

• Four of the indicators are based on perceived greenspace quality

Table 1. Current Natural Asset indicators for cultural services

Woodland bird index	Montane site condition	Visual influence of the built environment
Wintering water bird index	Grassland site condition	Use of marked coastal paths
Farmland bird index	Temperate shrub heathland site condition	Greenspace – provides a place to relax

Urban birds	Woodland Site Condition	Greenspace – attractive green areas
Upland bird index	Mires/bogs/fens site condition	Greenspace – strongly agree quality reduced in last 5 years (inverse)
Total number of different bird species counted	Coastal Site Condition	Greenspace – a place for children to play
Butterflies – generalists	Freshwater Site Condition	
Wild Salmon and grilse	Pollution: orthophosphate at safe level	
Adult red grouse density	Coastal bathing water quality	
	Raw water quality – nitrates in rivers at safe level	
	River water quality (% unpolluted sites)	

From these four points we can clearly see that the indicators of quality for the potential of natural capital to deliver cultural services are heavily reliant on national biodiversity indicators, which are also limited in scope (type of taxa and area of land covered). The lack of suitable quality indicators measured annually for land outwith designated sites is a key generic gap in the NCAI (and is not only a problem for cultural ecosystem services).

New indicators for cultural services

Given the heavy reliance of the current dataset on standard biodiversity indicators, and a bias in these data towards less intensively managed land, there may be opportunities for other national indicators which look more at people's engagement with - and the overall sustainable management of - Scotland's land.

Sustainable management and ownership

Examples of sustainable management indicators can be found for woodland and, perhaps more importantly, for farmland which is probably underrepresented within site condition monitoring data. The following are examples of the type of 'working landscape' indicators that might be considered for integration into the NCAI:

- Area of FSC or UKWAS certified woodland
- Agri-environment area or land classified as high nature value
- Area of land under organic farming

This by no means suggests that a non-organic arable farmer in North-East Scotland does not co-produce cultural services from his or her land. It just means that we have made the assumption - on the basis that less intensive farming practise are, in the long term, more sustainable (Brooker et al. 2016) - that by managing arable farms organically the natural assets (soils, water) are being managed in a more sustainable manner. Including land such as farmland that has the potential to co-produce cultural services beyond just those based on recreational activities is important, as working and managing the land is a key way that humans interact and engage with our natural assets.

In addition, whilst the NCAI is fundamentally about measuring the country's asset, i.e. the stock of natural capital, one cannot ignore, with respect to cultural services, the ownership or governance of

these assets. i.e. community woodlands vs publically owned vs investment owner. The type of land ownership, governance, and management objectives will have an impact of the types and distribution of ecosystem services co-produced. Although at present there is very little research in this area, it is possible that local ownership and management of – for example - woodlands for community benefit through social enterprises or community ownership will enhance local cultural services compared to those managed by a commercial investor or individual land owner. However, until there is more evidence concerning the relationship between cultural services, land ownership, governance and management we do not recommend the NCAI incorporates land ownership indicators.

Interaction with the environment

In order to generate cultural service benefits it is necessary for people to interact in some way with the environment. On this basis it may be worthwhile incorporating into the NCAI more indicators that measure people's potential to interact with Scotland's natural assets. This may be more straightforward to assess for natural assets in urban environments, for example by assessing percentage greenspace in cities and towns and distances to local greenspace, or using SPAN indicators for the number of visits to the outdoors. A capability indicator for greenspace is currently being tested by Kate Irvine and Kathryn Colley at the James Hutton Institute.

In the wider environment, interactions with the landscape could be assessed through, for example, numbers of people spending time outdoors, employed/volunteering outdoors, or attending guided walks/forest schools/camps. These 'use' or 'interaction' indicators would have to be balanced out with measures that monitor the ecological integrity of the ecosystems, in and outside protected areas.

Work is currently underway at the James Hutton Institute to develop algorithmic relationships between landscape characteristics (the environmental setting for people's experiences), EUNIS habitats, and people's experience of landscapes.

Conclusions and recommendations

This short discussion note on cultural services and the NCAI illustrates that there are gaps in the way the NCAI handles cultural ecosystem services, but that these reflect to some extent the many gaps in our knowledge of the relationship between the state of natural assets, their management and governance, and cultural service provision. Although raising a number of questions, we have also put forward some new ideas and options for how to tackle these gaps. These include:

1. Incorporating **more indicators of sustainable management** of habitats outwith protected areas, such as the area of FSC certified woodland or area of land under agri-environment schemes.
2. Consider adding **more ecosystem interaction indicators** such as those collected by SPAN or annual household surveys.

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