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Joint Nature Conservation Committee

Terrestrial evidence review part 1: The value of JNCC's terrestrial evidence programme

Cover Note by Anna Robinson, Niki Newton, Chris Cheffings

Executive Summary

1. Key issues

1.1 The Joint Committee is asked to:

i. **note** the breadth and nature of the applications of, and value from, the current terrestrial surveillance portfolio;

ii. **note** the advantages and limitations of the current surveillance methods, and the implications of changes to the existing portfolio;

iii. **note** that the second part of the JNCC Terrestrial Evidence Review is now underway.

2. Background

2.1. JNCC's Terrestrial Evidence Programme supports a suite of biodiversity surveillance schemes for a range of taxonomic groups, which collect data by working with partner organisations and volunteer recorders.

2.2. The Joint Committee was consulted in June 2017 about the proposed Terrestrial Evidence Review, the aims of which are to evaluate the surveillance portfolio and generate an updated terrestrial surveillance strategy, taking into account changing statutory needs, technological opportunities and budget reductions.

2.3. The annexes to this paper form part 1 of the Review. They outline the value of JNCC terrestrial surveillance; evaluate the advantages and limitations of the current monitoring approach, and possible alternative approaches; and discuss how the investment from the Terrestrial Evidence Programme to the schemes has shifted over the past decade, and what further changes could be made in the future.

i. Annex 1 is an infographic summary of the value of JNCC terrestrial surveillance. Committee members are encouraged to use this as a resource to promote JNCC surveillance.

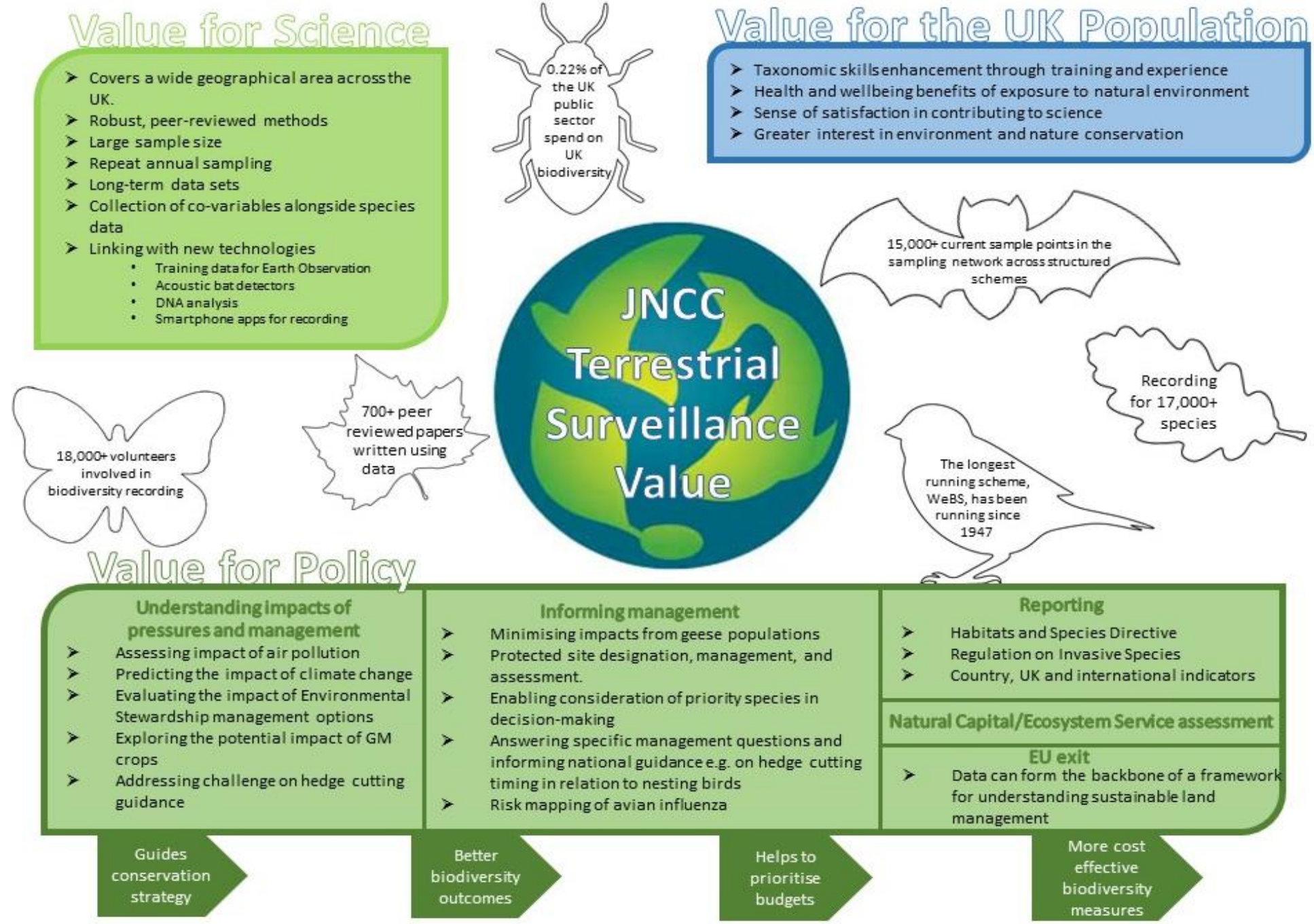
ii. Annex 2 describes the surveillance portfolio, its value, advantages, limitations and budgets.

iii. More details can be provided on request on the detailed calculations underlying estimates of volunteer time contributed to surveillance schemes; how the surveillance could contribute to natural capital and ecosystem

service assessments; and the key reporting requirements that use data from JNCC's suite of terrestrial surveillance schemes.

2.4. Part 2 of the Review will consider how fit-for-purpose JNCC's Terrestrial Evidence Programme is for delivering the evidence needs of country nature conservation bodies and government administrations. Steer for the review will be from a Programme Board, which will include representatives from the country conservation bodies and devolved administrations, alongside two independent members.

Annex 1. Summary of JNCC Terrestrial Surveillance Value



Annex 2. Terrestrial Evidence Review Part 1: The value of JNCC's Terrestrial Evidence Programme

Contents

List of Acronyms:

ADS: Avian Demographics Scheme (comprising ringing and nest record scheme)
BBS: Breeding Birds Survey
BC: Butterfly Conservation
BCT: Bat Conservation Trust
BRC: Biological Records Centre
BRAIn: Biological Recording Analysis and Interpretation (a contract delivered by CEH)
BSBI: Botanical Society of Britain and Ireland
BTO: British Trust for Ornithology
CEH: Centre for Ecology and Hydrology
CES: Constant Effort Survey (bird ringing)
GSMP: Goose and Swan Monitoring Programme
GWCT: Game and Wildlife Conservation Trust
NBMP: National Bat Monitoring Programme
NGC: National Gamebag Census
NGO: Non-Governmental Organisation
NPMS: National Plant Monitoring Scheme
NRS: Nest Record Scheme
RAS: Re-trapping for Adult Survival (bird ringing)
PMRP: Pollinator Monitoring and Research Partnership
RBBP: Rare Breeding Birds Panel
RSPB: Royal Society for the Protection of Birds
TEP: Terrestrial Evidence Programme
TEPoP: Terrestrial Evidence Partnership of Partnerships (a declaration of intent)
TSDA: Terrestrial Surveillance, Development and Analysis (contract delivered by CEH/BTO)
UKBMS: UK Butterfly Monitoring Scheme
UKPMRP: UK Pollinator Monitoring and Research Partnership
WCBS: Wider Countryside Butterfly Survey (a component of UKBMS)
WeBS: Wetland Birds Survey
WWT: Wildfowl and Wetlands Trust

1.Overview of the Terrestrial Evidence Programme

1.1 Programme scope

The TEP supports the following structured biodiversity surveillance schemes, in partnerships with NGOs and research organisations:

- **Avian Demographics Scheme**
- **Breeding Birds Survey**
- **Goose and Swan Monitoring Programme**
- **National Bat Monitoring Programme**
- **National Plant Monitoring Scheme**
- **UK Butterfly Monitoring Scheme**
- **Wetland Birds Survey**

Collection of both unstructured and semi-structured records is supported in partnership through:

- **Biological Records Centre**
- **Rare Breeding Birds Panel**

Volunteers undertake the majority of the monitoring funded by JNCC and its partners, whilst the partnership organisations provide scheme support, resources, training, data collation and analysis.

To support and develop the schemes and biological recording, the TEP also includes:

- **Terrestrial Surveillance, Development and Analysis contract:** Cross-cutting work to develop the analytical applications of the surveillance activity and investigate opportunities for scheme improvement
- **Terrestrial Evidence Partnership of Partnerships:** a non-contractual declaration of intent across surveillance scheme partners to support the TSDA and cross-scheme collaboration.

The TEP also includes involvement in:

- **Pollinator Monitoring and Research Partnership:** steering group input to this Defra-led contract.
- Work in new opportunities such as DNA technologies, spatial modelling, Earth Observation and Plant Health, some of which has brought a significant amount of new funding into the organisation.

JNCC employs 11.5 FTE staff in the area of terrestrial research, monitoring and data, 8.5 of whom are funded from grant-in-aid. It invests approximately £1M annually in the TEP: 0.22% of the UK public sector spend on UK biodiversity (£453M in 2015/16, from UK Biodiversity Indicator E2a[1]). The majority of the grant-in-aid supports structured surveillance schemes in partnership with NGOs and research institutes.

1.2 Country context

The surveillance schemes and support of unstructured biological records funded through JNCC's TEP cover the UK, and, where there are sufficient data, schemes analyse species trends at country level. A series of bilateral meetings with the four countries of the UK in 2015/16 indicated support for this work, particularly in relation to the efficiency of monitoring at a UK scale, provision of a contextual baseline for species monitoring, and combined analysis of the schemes by JNCC to deliver information on natural capital/ecosystem health.

1.3 Link to JNCC Strategy

The surveillance portfolio closely aligns with JNCC's new strategy, contributing to high level outcomes 1, 3 and 5: evidence quality, cost-effectiveness and customer service (table 1). The JNCC Strategy also contains further detail on how the strategic plan will be delivered over the next three years. This includes explicit references to strengthening and building on JNCC's work with both 'government and public bodies' and with 'NGOs and the nature conservation community', the key stakeholder groups with whom TEP engage through the surveillance portfolio.

[1] http://jncc.defra.gov.uk/page-4251

Table 1. Surveillance portfolio alignment to JNCC's strategy (first two columns are extracts from the strategy).

High Level Outcome	JNCC will…	Surveillance portfolio alignment
1. High-quality evidence on biodiversity and ecosystems to inform decisions affecting the environment	• Produce robust and cost-effective evidence of environmental status and change across the UK	• Robust evidence on environmental status and change is collected through UK-wide schemes, many of which have long time-series of data enabling study of long term change across a range of taxa. • Methods, data and findings are regularly published in peer-reviewed journals. • Partner co-funding and volunteer input increases cost-effectiveness of schemes.
3. Cost-effective delivery of devolved environmental priorities through shared solutions and joint working	• Produce scientifically robust standards and methods for use across the UK, that enable governments to meet international obligations consistently and efficiently, and that provide consistency and certainty for industry and regulators • Convene partners from across the UK and internationally to identify and solve emerging challenges and exploit shared opportunities	• Schemes undergo Quality Assurance and are based on scientifically robust standards. • Data enables government to meet international obligations (see section 2.4) • Schemes are run as partnerships with NGOs, and CEH. Country Agencies feed into steering groups. This combined capability can be convened to share experiences, and jointly work to identify and make steps in solving emerging challenges, e.g. through the new TEPoP initiative.
5. Excellent, customer-focused delivery	• Provide a high-quality and cost-effective service to all our customers	• UK based schemes provide a cost-effective way for countries to obtain high quality biodiversity evidence.

2. Value of JNCC-supported surveillance schemes and their outputs

JNCC's terrestrial surveillance schemes produce cost-effective evidence that has had demonstrable value in different applications. In the context of shifting policy in the face of EU exit, and alongside development of new technologies and analyses, it is foreseen that the schemes will also have value in other new applications.

2.1 Value for science through robust scheme design/methodology

JNCC's structured surveillance schemes are well suited to determining **trends in species (at UK and country/regional level**) and for **analyses against pressures, or conservation management action** that vary across the UK and/or over time. Scheme attributes that support this include:

- Coverage of a very **wide geographical area** across the UK.

- Many of the scheme sample points have a **stratified random location basis** (i.e. BBS, NPMS, UKBMS:WCBS, NBMP:Field Survey), which reduces bias in analyses.
- A **large sample size** (over 15,000 current sample points in the network across all schemes), with the same sites being revisited year on year. For most schemes, the sample size is sufficient for basic national trend analysis. In addition, it also provides sufficient statistical power to provide robust outputs when data are analysed against a range of other variables.
- **Long-term data sets** which are particularly valuable for identifying and interpreting temporal changes. e.g. precursors of UKBMS and WeBS have been running since 1976 and 1947 respectively.
- **Robust quality assurance** procedures, including verification procedures and appropriate levels of peer review. Survey methods are well established and peer reviewed and techniques developed by schemes to analyse data are published in peer-reviewed journals, ensuring acceptance in the scientific community. This results in robust evidence that can feed into policy decision making.
- **Collection of co-variables** alongside the species data. For example, the UKBMS includes collection of temperature, cloud cover and wind speed data, and these are accounted for in the trend analyses, resulting in more robust population trends.
- Collection of many observations of habitats and management activities, providing **training data for Earth Observation**, unlocking its power to detect habitat, structural and management changes.

Box 1. Scientific value

A measure of the scientific value can be seen by considering the number of peer-reviewed papers produced using data from the schemes:

Scheme	Approx. number of peer reviewed papers published
NBMP	11
UKBMS	110
BBS	73
WeBS	82
ADS	486
GSMP	17 (at least)
NPMS	6 (including those in prep)

There are also numerous other reports and articles that are of high scientific value but are not published through a peer reviewed journal, for example reports in the BTO and the JNCC report series. These can be of use in informing policy, e.g. see some of the outputs from studies in table 2.2.

2.2 Value for understanding impact of pressures and conservation action

Table 2. Examples of policy impacts from understanding pressures or conservation actions.

Issue	Data used	Findings	Policy Impact
Investigation of the effect of nitrogen deposition on vegetation communities (Stevens *et al* 2011)[2]	Data from schemes and societies that have received JNCC support (e.g. BSBI Local Change Survey (1987-1988 and 2003-2004), British Bryological Society, and British Lichen Society). (Note, this study predated the NPMS, hence this was not	Demonstrated how N deposition levels impacted plant species occurrence and vegetation community structure (shown through the specific leaf area, canopy height and Ellenburg N values associated with species).	Work increased awareness of the issue and resulted in an updating of the national critical load values used in pollution assessments (Hall *et al* 2015)[3]. It also informed Natural England's IPENS Atmospheric nitrogen theme plan (NE 2015)[4], which has in

[2] http://jncc.defra.gov.uk/pdf/jncc447_web.pdf
[3] http://www.cldm.ceh.ac.uk/sites/cldm.ceh.ac.uk/files/MethodsReport_Updated_July2015_WEB.pdf
[4] http://publications.naturalengland.org.uk/file/5688662740172800

	used as a source of vegetation data). Met Office climate data. Land Cover Map 2000. NEGTAP N deposition data.		turn prompted further work and action in England, e.g. inclusion of ammonia measures within RDPE incentive schemes.
BICCONet project[5] (Biodiversity Impacts of Climate Change Observation Network)	BBS, UKBMS, NBMP	Study looked at the impact of climate change and made predictions for changes in the future	Report presents potential future scenarios available to inform adaptive management.
Analysis of the effect of fragmentation on butterfly population response to drought. (Oliver *et al* 2013)[6]	Data from the UKBMS – ringlet butterfly used as a model species. Land Cover Map 2000.	This determined that larger, more connected patches of woodland habitat were less sensitive to the effects of drought.	This contributed to the stock of evidence demonstrating the importance of large areas of joined up habitat. Improving connectivity features in country biodiversity strategies.
Evaluating impact of management options in Environmental Stewardship in England on farmland bird populations (Baker *et al* 2012)[7]	Data from Breeding Bird Survey. Environmental Stewardship options uptake data.	There was a positive effect of winter food provision options (winter stubble, and wild bird seed). Mixed results for options designed to provide breeding season benefits.	Evidence that can be used to promote options in future agri-environment schemes.
Analysis to explore whether we would be able to detect any impacts of GM crops were they to be introduced, as part of 'Post Marketing Environmental Monitoring' that would be required under the EU Deliberate Release Directive.[8]	BBS and UKBMS data Countryside Survey data	Concluded that the sample network was sufficient to be able to detect changes to subsets of the data. Hence if there were differences in areas planted with GM (or indeed subject to any other type of land management change or pressure) then JNCC schemes should be sufficient to detect this.	PMEM has not been implemented yet because to date GM crops have not been introduced to the UK. However, the findings have wider relevance for environmental monitoring of agro-ecosystems by making use of UK environmental surveillance networks to investigate causes of change.

[5] http://randd.defra.gov.uk/Document.aspx?Document=13404_Appendix5_Fine-scalepopulationresponsestoweatherandclimate.pdf
[6] http://onlinelibrary.wiley.com/doi/10.1111/j.1600-0587.2012.07665.x/abstract
[7] http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2012.02161.x/full
[8] http://jncc.defra.gov.uk/page-6869

2.3 Value for informing management

Table 3. Scheme outputs (e.g. species presence records, population estimates and trends) have also been used directly to inform management at a variety of scales and across several sectors.

Minimising the negative impacts of internationally important goose populations in agricultural areas of Scotland.	Data from the GSMP on population sizes, breeding success, and adult survival allowed the Scottish Government to set evidence-based quotas for shooting geese in the close season, in order to mitigate human-wildlife conflict without compromising conservation objectives, farm production, or the revenue stream from the sale of hunting licenses.
Protected site designation, management, and assessment.	Site-specific data, particularly from WeBS, are integral to the identification and monitoring of many protected areas – e.g. WeBS provided data for 54% of the UK's SPA interest features and was the sole data source for 50 waterbird species.
Helping public bodies take biodiversity into account while carrying out their functions.	Across the whole range of schemes (including those supported by BRC), there are many records collected of priority species (NERC 41/Section 7/Scottish biodiversity list species) which public bodies are legally obliged to take into consideration when carrying out their functions. The collection of such data by volunteers enables better consideration of conservation priorities.
Answering specific management questions and informing national guidance.	BBS data were used to address a challenge to official guidance on hedge cutting times. Analysis of nest record data showed that a significant proportion of birds were still nesting during the challenged dates. The data provided sufficient evidence to indicate that the hedge cutting guidance was appropriate to prevent nest disturbance and destruction and so contribute to conserving bird populations.
Risk-mapping avian influenza.	Data on waterbird numbers and movements collated by BTO (with WWT) and owned also by JNCC and RSPB have been instrumental in developing risk-based approaches to target the surveillance of avian influenza viruses (AIV), especially of those of potentially highly pathogenic H5 or H7 subtypes. WeBS data identifying areas of waterbird abundance were combined with information on poultry densities to identify areas of higher risk for the transmission of AIV to poultry. The DEFRA-funded analysis (Snow *et al* 2007) transformed the approach to UK AIV surveillance, with significant cost-savings, and has been used internationally as a model of evidence-based disease-risk assessment. UK waterbird movements shown from ringing, have also been used to develop an interactive Migration Mapping Tool[9] to visualise the monthly 'flows' of migratory waterbirds across Europe. This has been an influential support tool to explore scenario-setting and other risk-scenarios in developing responses to outbreaks of highly pathogenic avian influenza.

[9] https://app.bto.org/ai-eu/main/data-home.jsp

2.4 Value for reporting biodiversity status and meeting legislative requirements

Birds and bats are examples of two taxon groups that are particularly reliant on JNCC schemes for European reporting purposes. The **Birds Directive** requires reporting on status and trends for *all* wild bird species, and has a strong reliance on BBS, WeBS, GSMP, and RBBP. All bat species are included on Annex IV of the **Habitats and Species Directive**, and Article 17 reporting for these species is heavily reliant on NBMP data. The NPMS, whilst too new to have had trends analysed yet, is likely to feed into reports for habitats assessments, and assessments of 'habitat for species' across a range of taxa.

The UK is also subject to the **EU Regulation on Invasive Species**. Since detection of new invasive species starts off small scale and with considerable uncertainty of where records will arise, JNCC's support of general recording, through the BRC support of schemes and societies, is of particular value in supporting this Regulation; for an example of this see box 2.

For national scale reporting, trends from schemes feed into **UK Biodiversity Indicators**. The UK Biodiversity Indicators also form the UK's reporting response to the **Convention on Biological Diversity**. Reporting into international forums is an important part of the UK's approach to the role it plays in global governance to find shared solutions to global and inter-generational challenges.

Box 2. Detecting Asian Hornet

The Asian Hornet, which arrived in France in 2005, was identified as high risk through a horizon scanning exercise, and included in the 'Alert System' of the GB-NNSIP. Consequently, and enabled by JNCC investment in BRC, an online recording facility using iRecord was set up, as well as a dedicated email address. The first record in the UK was received on the 19th September 2016, and in the 4 weeks following, ecologists from CEH, alongside the Bees Wasps Ants Recording Society, managed >2000 reports. Reports received have been important in informing the rapid response team from Defra's National Bee Unit. Early detection of problematic invasive non-natives leads makes eradication of the species considerably easier and cheaper, and with a higher chance of success. Once species have established, the costs to control them (which is a legal requirement for species covered under the regulation) tend to increase exponentially. These costs are likely to be considerably higher than the costs required to support recording activity. For example, the National Trust has estimated that the cost of eradication across the UK of Japanese knotweed, a now-established Asian plant introduced in the 1800s, would be £1.5bn. Recording activity also monitors spread of invasives, enabling more effective targeting of management efforts.

UK and **country-level indicators** influence country biodiversity strategies. For example, in Wales, new indicators, which are likely to include data from JNCC schemes, are being developed in response to the Well-being of Future Generations (Wales) Act 2015. In addition, the Natural Resources Policy (Welsh Gov. 2017) [10] recently published by Welsh Government under the Environment (Wales) Act 2016 states that "We will develop an evaluation framework to demonstrate the extent to which we deliver our priorities in the NRP, supported by performance measures aligned to those in the suite of 'National Indicators for Wales'". It is possible that data from JNCC schemes will inform these performance measures.

[10] http://gov.wales/docs/desh/publications/170821-natural-resources-policy-en.PDF

2.5 Value for natural capital/ecosystem service assessments

Assessing natural capital and related measures of ecosystem health is a key aspirations for all countries in the UK. Biodiversity is a central component of natural capital (Mace *et al* 2015) and so biodiversity monitoring can contribute directly to this understanding. Data on trends in specific taxa can also potentially indicate ecosystem services associated with these taxa (e.g. pollinators and pollination, cultural values for charismatic taxa such as birds and butterflies). Recent work by Oliver *et al* (2016) develops this idea to illustrate how combining data across JNCC-supported monitoring schemes (and monitoring by other organisations) allows the resilience of ecosystem services to be investigated. Habitat information collected as co-variables alongside biodiversity data in some TEP schemes might also contribute to assessments of other aspects of natural capital, either directly or by ground-truthing habitat maps produced by Earth Observation.

2.6 Value for EU Exit

The TEP is designed to be flexible to legislative and policy change, and to remain informative on the state of the UK environment. TEP can provide relevant input to environmental decision-making in relation to EU exit.

For example, going forwards, there is demand for development of a robust framework for understanding sustainable land management. This would capture the impacts of different pressures on the UK environment, for example the relationship between nitrogen deposition in sensitive habitats and waterways, as different crops and management techniques on farms are favoured. This understanding would allow better prediction of how changing pressures will influence natural capital, aiding the development of effective policy. JNCC has plans to develop such a framework, working alongside other current initiatives. The data from the TEP would form the backbone of the framework, helping to understand the impacts of different types of pressure on species over time.

2.7 Added value through linking with new technologies

In recent years, there has been rapid development in many technological areas that could interact with the surveillance that JNCC and the country agencies carry out. JNCC has invested time in exploring these areas to determine how they can be used to meet requirements more effectively or in a more cost-effective manner. These technologies complement the existing surveillance as many could be incorporated into volunteer-based recording schemes. In these examples, the technology is more efficiently collecting a better product (e.g. better recorder experience, better species identification, higher species coverage). Examples are shown in table 4.

Table 4. New technologies and their application and benefits alongside JNCC schemes.

New technology	Application in JNCC schemes	Benefit
Acoustic monitoring	NBMP is currently exploring changing its methods to include volunteer deployment of multi-spectral bat detectors.	Enhanced recording allows better species ID to improve quantity and accuracy of data.
DNA analysis	The Pollinator Monitoring Research Partnership is investigating pan trapping where recorders send in samples for DNA analysis	Enables recorders who are unskilled in invertebrate ID to collect data.
Development of smartphone apps for data capture	NPMS has seen development of a smartphone recording app for recorders, and iRecord has a series of associated apps focussing on different taxa.	Allows more efficient data capture whilst recorder is in the field, saving time and potentially improving data accuracy.
Earth Observation (EO)	EO is currently undergoing rapid analytical advances and increased data availability following the launch of the European Space Agency	Country Agencies could save funding for monitoring of protected sites or parcels

	Sentinel satellites, with Sentinel 1 (radar) and Sentinel 2 (multi-spectral reflectance) being particularly valuable for biodiversity monitoring. JNCC has been working in partnership with the Country Agencies to develop methods for using EO data to assess factors that will impact habitat condition. The most rapid progress in exploiting EO is being made where large consistent time series of field observations exist, as these can be used to train models for interpreting the EO data. Whilst the Country Agencies have extensive field data, it is temporally and spatially quite patchy, and can be hard to access. The JNCC biodiversity surveillance schemes collect many observations of habitats and management activities. The NPMS is particularly valuable as it collects direct measurement of plant species composition and vegetation structure in habitats. The schemes have a large spatial coverage and can provide annual, or in some cases multiple observations within a year. This is likely to be a valuable data source to complement the more detailed but less temporally and spatially consistent country sources.	of land under land management. EO could be used to provide a risk-based alert system of where appropriate management is not being followed and where a targeted field visit would be shrewd. With further development, the kinds of condition change that may be able to be picked up by EO include: identification of coppicing, scrubbing up, bracken encroachment, moorland burns and grassland management

2.8 Value for skills enhancement and public engagement

Schemes actively develop the skills of volunteers through training workshops and published guidance, as well as some one-to-one support. Benefits to volunteers from such training are reported e.g. an NPMS questionnaire in 2016 revealed that 76% of respondents felt that they had gained new skills or knowledge through participation in the scheme. Many schemes also encourage more experienced volunteers to pass on skills to newer volunteers. For example, the NBMP are piloting the 'volunteer mentor scheme' and 'baton passing scheme', and NPMS have introduced volunteer mentor and trainer roles in 2016. Similarly, UKBMS, BBS and WeBS have a large network of volunteer Regional Officers/Local Coordinators who provide guidance to less experienced people wanting to participate in the schemes.

Whilst some scheme participants may be involved in biological recording regardless of JNCC's suite of schemes (particularly bird recorders), for other participants, these schemes are the reason for developing natural history skills and represent their gateway to wider biological recording. Indeed, 186 out of 581 respondents (32%) to an NPMS questionnaire had not participated in biological recording prior to entering the scheme. Involvement in biological recording helps the public to engage with and understand the natural environment to a greater extent.

2.9 Value to public health

Volunteer involvement in survey work in the natural environment can also bring health benefits, a sense of satisfaction in contributing to science, and spark a greater interest in the environment and nature conservation. The benefits to volunteers have been acknowledged by the Country Agencies, and volunteer participation in nature conservation has been included as one of the UK Biodiversity Indicators (A2 Taking action for nature: volunteer time spent in conservation[11]). A systematic review of evidence for the added benefits to health of exposure to natural environments was carried out by Bowler *et al* in 2010[12], covering 25 studies. The meta-analysis results suggested that activity in natural environments led to

[11] http://jncc.defra.gov.uk/page-4253
[12] https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-10-456

improved outcomes in areas such as attention, energy levels, and levels of anger and sadness/depression.

3. Advantages of the current monitoring approach

JNCC's suite of surveillance schemes and support for unstructured monitoring are run in partnership with NGOs and the nature conservation community (including: CEH, BTO, BC, BCT, WWT, RSPB, Plantlife, and BSBI). The success of this partnership monitoring relies on volunteer participation in data collection. The partners contribute expertise in volunteer management, taxonomic knowledge, surveillance scheme design, and data management and analysis. JNCC also contributes expertise in some of these areas, as well as knowledge of policy linkages and priorities across the UK. This partnership and volunteer-led approach has many advantages over alternative data collection approaches such as professional contractors including:

- increasing the value for money for JNCC's investment (e.g. through co-funding by partners)
- enabling simultaneous recording in a number of sites across the UK without the need to fund travel costs
- collecting many unstructured records for species for which there is no structured scheme supported
- strengthening the UK's natural history recording skills capacity and public interest in the environment
- physical and mental health benefits to volunteers from interacting with the natural environment.

The first three of these advantages are discussed below; the latter two were discussed in section 2.8 and 2.9.

3.1 Value for money

JNCC surveillance schemes have attracted considerable co-funding; for some schemes, more than 50% of total funding is contributed by partners. In addition, running the schemes as partnership research projects means that partners have judged them to be VAT exempt. As a result, the whole of JNCC's investment goes towards the scheme, and hence 20% more goes to survey than if it was contracted to professional ecologists to carry out the sampling as a service.

The value of time contributed by volunteers also contributes to the portfolio's value for money, and is valued at over 20 times the programme budget for structured surveillance schemes. The value of volunteer time for unstructured surveillance is extremely difficult to estimate accurately due to the variation in time invested to collect each record; however, the value is high due to the large numbers of records being generated.

Figure 1 shows the value of the annual contributions that JNCC, partners and volunteers[13] make to structured surveillance schemes. The value of volunteer time was calculated using Heritage Lottery Fund rate guidelines[14], and comes to £20.5M[15] per year across the TEP.

[14] https://www.hlf.org.uk/community/general-discussions/our-most-frequently-asked-questions-and-answers. Typical rate used is for 'skilled labour', which is valued at £20/h.

[15] Note, figure includes ADS, which contains structured survey components, but is not completely a structured surveillance scheme as it also includes some ad-hoc bird ringing. Figure excludes volunteer value from the RBBP and from recording schemes supported by the BRAIn contract, due to high uncertainty in these estimates.

Note, the volunteer time input has increased over the last decade as the number of survey sites and volunteer participants have increased (see figure 4 in section 6.2).

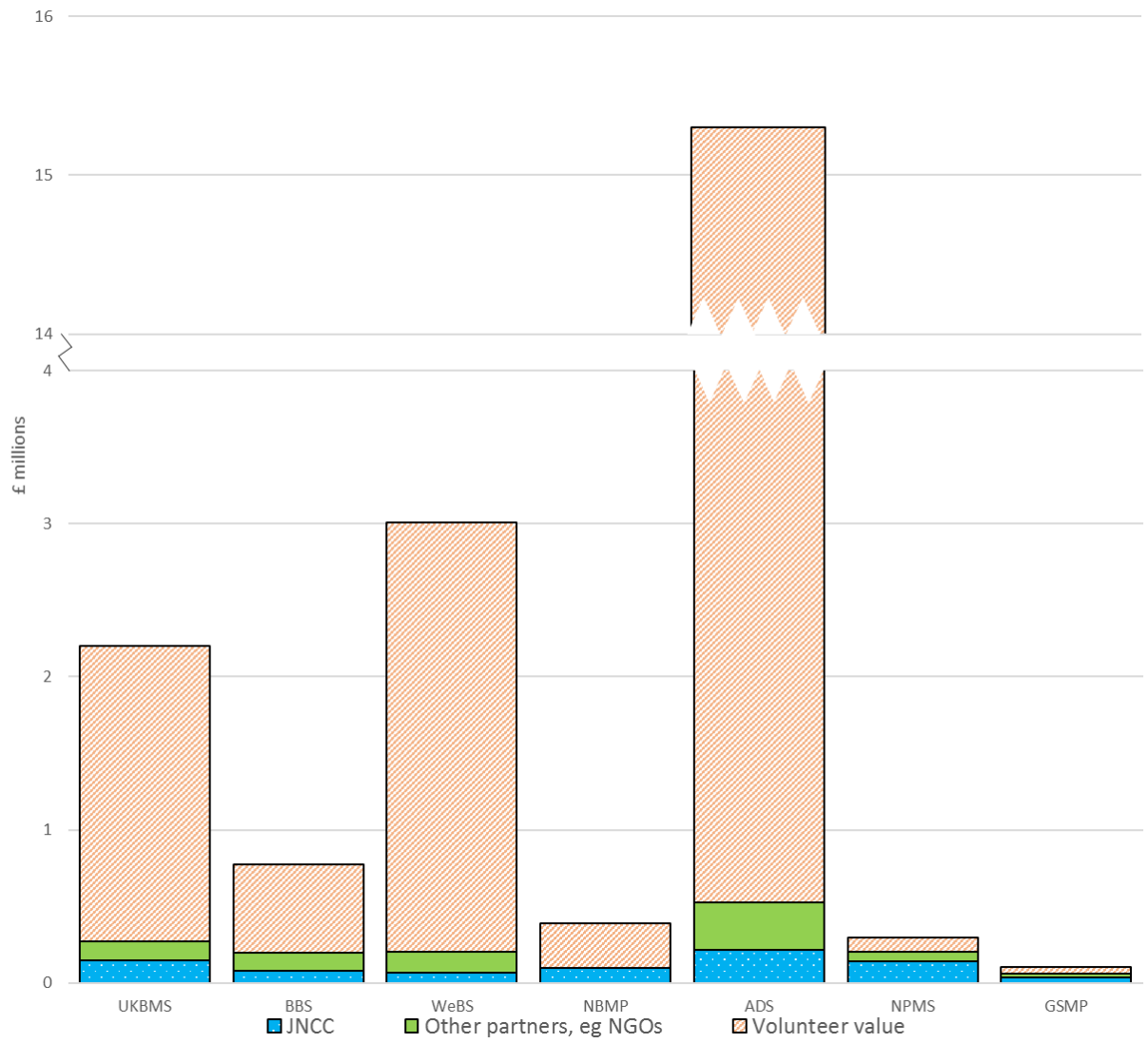


Figure 1. Financial inputs and value of volunteer time across structured surveillance schemes. Volunteer time includes survey time, data entry time, and travel time. It does not include travel costs to volunteers.

3.2 Dispersed UK volunteer recorder network

The TEP's structured surveillance schemes rely on thousands of sample locations dispersed throughout the UK being sampled regularly and, for some schemes, simultaneously, throughout the year. For example, there are 1492 UKBMS pollard walk sites that are sampled weekly throughout the summer, and a further 774 WCBS squares that are sampled twice in the summer. The 2017 BBS has a sample size of 3731 squares that were each recorded twice a year, and the GSMP (whilst having smaller number of sites) requires sampling simultaneously over specific weekends each year. It is possible to achieve this with volunteers because of the large number of dedicated volunteers, and stratification of the schemes to allow volunteers to select sites within a reasonable distance of their homes or

preferred holiday locations. In addition, volunteers fund their own travel to sample locations, removing the need for a scheme travel budget.

3.3 Ability to provide measures for taxa with fewer taxonomic specialists

JNCC structured schemes have been designed specifically so they are sensitive to detecting trends. However, budgetary limitations, as well as more limited interest/taxonomic expertise in some taxa, prohibit such structured schemes for all species. However, more unstructured records are collected for many of these species through the schemes and societies supported by JNCC through the BRC. BRC have been making analytical developments to enable trends to be established from unstructured records, and account for recording bias. For example, Isaac *et al* 2013[16] sets out some approaches BRC have trialled to help overcome such limitations, e.g. 'list length', 'mixed model' and 'Frescalo'. Methods such as these have resulted in data being more widely used, for example the 'State of Nature report' produced by a consortium of NGOs in 2016 successfully used a considerable amount of this type of data. This enables trends to be established for species not covered by structured surveillance schemes, providing greater understanding of ecosystem changes across trophic levels.

4. Limitations of the current monitoring approach

The aspirations and views of partners in running surveillance schemes largely align with JNCC's. For example, all are concerned with scientific rigour in methodology, and obtaining sufficient volunteer coverage. However, the partnership approach means compromises must be reached in relation to certain aspects of the schemes. To date, solutions have been found that all are prepared to accept, including in more contentious areas such as data access policies. Similarly, where schemes experience budget cuts, different partners' views must be accommodated when it comes to priorities over areas to target.

The fact that schemes are run in partnership means that JNCC cannot make changes to the schemes without partnership agreement. However, since partners have expertise both in the taxonomic groups involved and in managing volunteers, this can be seen as a useful control mechanism that ensures that only ideas deemed likely to succeed will occur. In addition, all partners have agreed to sign up to the TEPoP, highlighting their willingness to work together to share best practice and consider any developments/improvements to schemes that could be put in place.

One risk of relying on partner organisations is whether partners have the financial stability/ability to continue investment. Currently almost all partners co-invest in the schemes (as well as leveraging considerable volunteer time). However, NGOs are facing increasing financial pressures, finding it harder to win grants, which are becoming increasingly limited in availability, and facing cuts from other conservation agencies. Partnerships are excellent value for money (section 3.1), though if a partner was struggling financially and had to withdraw their funding, there would be a risk to JNCC of having to cover the full costs of the scheme administration.

There are also limitations to relying on volunteer recorders for monitoring. Schemes must be designed to be engaging to and achievable by volunteers, which can limit the taxonomic groups that can be covered and the extent to which representative samples can be collected across the country. For example, across all JNCC schemes, remote regions of the UK further

[16] http://jncc.defra.gov.uk/pdf/488_Webv2.pdf

from populated areas are typically less sampled. It is much more challenging to encourage volunteers to survey these areas where access is difficult.

5. Possible alternative monitoring approaches

Given that the current partnership monitoring has limitations, this section considers different possible monitoring approaches and evaluates their main strengths and weaknesses compared to the existing approach.

5.1 Use of professional surveyors

5.1.1 Value for money

Although there is an estimated return of >20 times JNCC's investment from volunteer recorder time contributions, this does not mean that the current approach is 20 times lower in cost than employing professional surveyors. For example, professional surveyors may be able to work with less support, more efficiently, and potentially return higher quality data.

However, it should be noted that whilst using professional surveyors may enable savings in aspects such as training courses and some coordination costs, there are many scheme running costs that would still be required (in addition to surveyor salaries), for example, maintaining online recording systems, central analysis of data etc. Also, travel costs for professional surveyors would require additional funding. Hence, the potential ability of professionals to work with less support would only result in limited savings to the support function which would not likely make up the cost of their salary.

As a comparative example, for the UKBMS, Workstream 1 'Support of Recorder Network' has been allocated £68K of JNCC funding in 2017/18, out of a total of £150k (which also covers data management, routine data analysis, interpretation and communication of results, and involvement in the TEPoP). The value of time contributed by volunteers to the UKBMS amounts to £1.9M. Professionals are likely to work more efficiently than volunteers to some extent, although time investment cannot be hugely reduced for many schemes as time taken to walk a sample transect is fixed. Therefore, to fund an equivalent sample size recorded by professional surveyors would require a greater investment than the current UKBMS, particularly as their rate may be higher than the £20/h used in the volunteer calculations.

Were professional surveyors used, the sample size for schemes could be reduced to that required for analysis. This would involve decreasing the samples in south-east England (schemes are typically oversampled here due to high volunteer population), and increasing the sampling in the areas that currently have less sampling. However, based on the example above, the number of UKBMS samples would need to be reduced to a twentieth of its current levels to be the same cost to JNCC as volunteer recorders, and it is unlikely this will yield a sufficiently robust sample.

5.1.2 Taxonomic identification skills

Quality and consistency of records collected by volunteers are occasionally questioned, as recorder skill levels are variable and cannot be guaranteed. However, many volunteers are just as skilled, if not more skilled than professionals at taxonomic identification (pers. com Stroud 2017, and see also Lewandowski *et al* 2015[17]). Many professional ecologists participate as volunteers in these schemes in their free time. Even if, on average, professionals gave higher quality records than volunteers, this is unlikely to have too big an impact on scheme outputs, since the very large sample size achieved, and scheme in-built

[17] http://onlinelibrary.wiley.com/doi/10.1111/cobi.12481/full

record validation rules, help to minimise the impact of any mis-identifications. In addition, species identification training and resources for volunteers provided by schemes contribute towards increasing data quality through developing recorder skill.

Professional surveyors could be employed to collect structured samples for taxonomic groups for which there are insufficient volunteers interested in a structured scheme. However, a likely bottleneck will be getting samples identified, for example for taxonomic groups for which specimens are collected in sampling and are not identified during the survey.

Relying on professional recorders instead of volunteers would result in a minimal increase in the UK's natural history skills capacity at most (compared to not running the schemes at all). The increase in recording jobs could potentially result in a slight increase in people training in taxonomic skills, and may lead to the development of the skills of the professionals employed. However, this will impact a lower number of people than are involved as volunteers, given there are currently approximately 18,700 volunteers involved across the suite of structured surveillance schemes[18].

5.1.3 Number and location of surveyors

Whereas volunteer schemes can mobilise volunteers simultaneously across the country, it would be more expensive to cover such a large range of sites using professional surveyors, across the whole of the UK, in the specific time periods required. There would be particular challenges associated with schemes with more specific recording time restrictions, e.g. GSMP, UKBMS pollard walks. This approach would also require considerable additional investment in travel and accommodation costs for surveyors.

A more pragmatic approach could be to use self-employed professionals stationed regionally around the country. However, attracting and retaining a large cohort of suitably skilled professionals in part-time work throughout the monitoring season would be challenging. If looking to guarantee enhanced data quality, regional professional staff would also ideally require multiple taxonomic expertise (butterflies, birds, plants, bats), which narrows the field of potential professionals available to take up this role, and would be likely to discount some professionals with the best skills in one of these taxonomic groups.

5.1.4 Remote area coverage

Using professional surveyors, remote areas that are currently poorly sampled by volunteers could be specifically targeted to ensure they were represented. This could also, for example, enable country-level trends to be generated for species more consistently across the schemes. However, there is a spectrum of options which could be employed to address the spatial coverage gaps, and would not necessarily require a wholesale shift to professional surveyors. For example, professional surveyors could be employed to provide "top up" sampling in remote areas not monitored by volunteers; or additional work could be done to build local partnerships with land owners who can contribute to monitoring these remote areas.

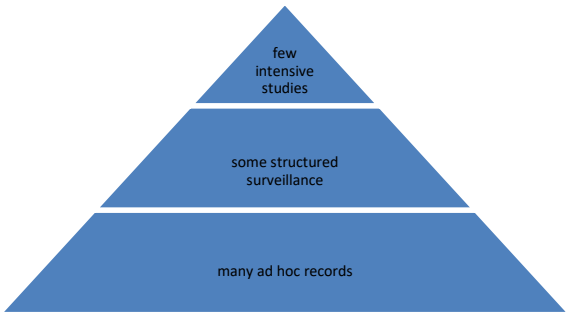
5.2 Increased reliance on unstructured data

Given the analytical advances in using unstructured data to generate species trends (section 3.3), could this form of recording replace structured surveillance schemes? A recent study

[18] N.B. this is the sum of the numbers reported by individual schemes – there may be some overlap in volunteers between schemes, but also underestimates from surveys by pairs or groups of volunteers, in which only one person submits the data.

looked at whether unstructured butterfly records reflect the population variability shown in transect monitoring (Mason *et al*, 2017[19]) using 33 butterfly species. Whilst overall there was a strong correlation, there was considerable variability in the strength of the relationship between species. Only 8 out of 33 species had a strong relationship (i.e. r^2>0.5) between year to year abundance and distributional changes. This study suggests that although useful, distribution records are not equivalent to outputs from structured surveillance obtained through the UKBMS. Also, as illustrated in section 2.2, whilst some analyses of impacts on pressures have been able to make use of ad-hoc recording data, other analyses have relied on structured surveillance data. Section 2.3 also shows how both types of data are useful for answering distinct management related questions.

Box 3. The surveillance hierarchy



The surveillance hierarchy illustrates the fact that there is a trade-off between the level of detail and the number of samples that can be collected. It is generally accepted that a combination of all levels is the best approach as each layer has pros and cons, and the different levels in the hierarchy complement each other.

Other limitations with unstructured data are:

- recorders generally only record species presence, so a lack of record may be a true absence or not,
- there may be bias in where recorders sample (e.g. recorders may seek out particularly biologically rich areas)
- the level of volunteer effort associated with collecting the record is often unknown
- there is often a lack of repeat visits to a specific site, which makes data less sensitive in detecting change.
- less contextual information (e.g. habitat type) is collected compared to structured surveillance schemes, so cannot be used to train EO or some other analyses.

5.3 Increased reliance on intensive monitoring

The most structured form of UK environmental monitoring is 'intensive studies' such as the Environmental Change Network (not supported by JNCC) (see Box 3). These tend to be long-term research projects, restricted to a small number of sites (mostly NNRs) due to their expense. As they are restricted to a small area, sites studied are not representative of the wider environment, and such studies cannot answer questions considering widespread trends in UK biodiversity. Sites also need constant access and instrumentation for monitoring. However, these types of studies can be very useful in improving understanding of processes and relationships between variables.

5.4 Increased reliance on new technologies

EO has considerable potential for making site-based monitoring more efficient, by identifying areas where significant changes have occurred, that can be investigated more fully though field survey. However, it should be noted that EO cannot generally detect species, so is unlikely to ever deliver equivalent outputs to species surveillance schemes. The smallest pixel size available from the freely available Sentinel 2 satellite imagery is 10m^2, and from the Sentinel 1 (radar) data is 5m^2. Work is underway to use EO to identify crop type or tree

[19] http://onlinelibrary.wiley.com/doi/10.1111/icad.12242/abstract

species, and whether trees are diseased. However, the resolution is not high enough to distinguish changes to herbaceous or understorey communities that, for example, the NPMS may detect. Therefore, as EO habitat detection and condition analyses improve, the NPMS is likely to retain value for detecting changes, as well as providing a continuing reference dataset for use in EO analyses.

Other new technologies such as acoustic bat detectors and smart phone apps have clear potential for enhancing the surveillance schemes, and their application is being actively developed. However, although the technology is more efficiently collecting a better product, the recorder is still being required to go out to deploy the technology, so cost savings may be minimal.

5.5 Modelling impacts on species using pressures data

Natural systems are complex, with many interactions between different environmental variables and between species. If there were a direct and complete explanatory link between pressures on the environment and state of biodiversity/natural capital, then it would be most cost-effective to monitor the cheaper of the two and infer the other parameter. However, currently, there is limited understanding of the complex relationships between pressures and biodiversity, resulting in low confidence that just focussing on the former will be informative about species status when fed into an appropriate model. For example, it could be inferred that species are likely to be undergoing negative population trends in an area due to knowledge of a certain pressure or combination of pressures, but since there is a level of uncertainty over this prediction, it would hold a lot more influence on policy making if the evidence confidently demonstrated that the species were declining. Hence for best understanding and policy influence, surveillance of both the pressure and response variables (such as those recorded by the surveillance schemes) is required.

6. Changes to the Terrestrial Evidence Programme

Phase 2 of JNCC's Terrestrial Evidence review will evaluate UK government requirements for long-term biodiversity monitoring. If existing JNCC terrestrial surveillance is not adequately contributing towards these requirements, then different options for shifting investment within the TEP will be evaluated, including their cost-effectiveness and potential outputs. However, any modifications to the current TEP must occur within the current programme budget unless additional funding is made available. This section provides more detail about the current finances, content and history of the TEP.

6.1 Change in budget over last 10 years

Between 2007/08 and 2016/17 the TEP budget has been cut from £1.18M to £1.04M. Over this decade the Retail Price Index has increased by 30.6%, reflecting an average inflation rate of 2.9% per year[20].This means that in real terms the budget in 2016 had reduced to the equivalent of just £721k, or less than two-thirds of the 2007 budget (Figure 2).

The amount of JNCC staff time involved in managing the portfolio of surveillance schemes has remained relatively constant.

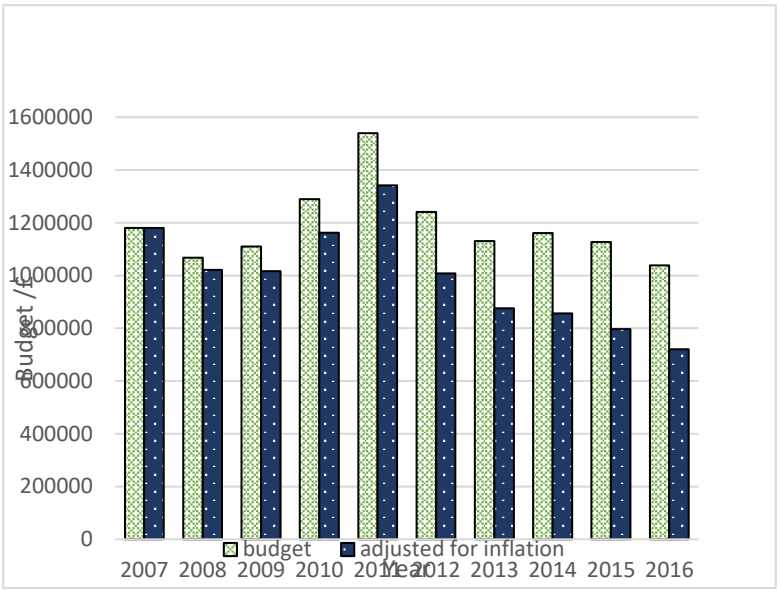


Figure 2: TEP budget (excluding JNCC staff costs)

6.2 Change in TEP scope over last 10 years

Throughout the last decade, the TEP has been responsive to budgetary pressures, internal reviews, and analyses to improve the suite of activities funded and to keep on top of emerging issues and technologies.

Table 5. Changes to TEP investment since 2007

Year	Driver for change	Action	Impact
2008	Surveillance strategy review identified plants as a major gap in surveillance	NPMS development commissioned, and launched in 2014	Data from 711 sampling monads returned from the first 3 years of the field season. Analytical work underway to develop data applications and habitat indicators.
2009	Need for enhanced butterfly sampling in wider countryside	WCBS launched within UKBMS	WCBS has been taken up by many BBS surveyors and existing UKBMS volunteers.
2011	Budgetary pressures and TEP prioritisation	Cessation of funding to NGC	Some aspects of the NGC analysis (e.g. Mountain hare trends) would be useful for Article 17 reporting; Country Agencies must now liaise directly if they want to use these data.
2015	Development of EO applications led to expansion of work area	Work on EO in JNCC split from TEP to form a new EO Monitoring Applications programme	JNCC are likely to receive £170K extra income in 2017/18 to develop EO work.
2016	Budgetary pressures	Cut to (~£59K annual) budget for exploratory	Reduced JNCC capacity to undertake additional tasks. Before it was cut, these funds

[20] Inflation rate obtained from: http://www.thisismoney.co.uk/money/bills/article-1633409/Historic-inflation-calculator-value-money-changed-1900.html#ixzz4ls5bwWcL This calculator uses annual RPI (Retail Prices Index) data. Unlike CPI this takes into account costs of home, e.g. rent, mortgage repayments, council tax. These are relevant to NGO partners, particularly those that rent or do not own their premises outright.

		and developmental work.	supported work such as: designing a plant surveillance scheme, contributing to a research project looking at impacts of nitrogen deposition on vegetation, a review of the International Waterbirds Census, and investigation of new technologies, e.g. Earth Observation.
2017	Requirement to develop surveillance portfolio to align more closely with user needs, and to enhance analytical applications of data.	Realignment of funds within TEP enabled establishment of the TSDA contract.	Enhanced capacity to undertake analytical and developmental work across schemes and taxonomic groups.

Figure 3 illustrates the changes to funded schemes within TEP since 2007. Throughout this period, there has also been an increase in sample size collected by many of the schemes (Figure 4[21]). This includes increased sampling in some commonly less-well recorded areas of the UK, due to targeted promotion/training workshops. These developments have been possible by making efficiency savings in schemes, for example by 'investing to save' in developing and promoting online recording (Figure 5). Also, in cases, partners have increased their financial support to schemes. For example, the amount Butterfly Conservation put into the UKBMS in 2011 was £68,900, and by 2017 this almost doubled to £123,500. However, continuing to increase financial pressure on NGOs is not sustainable.

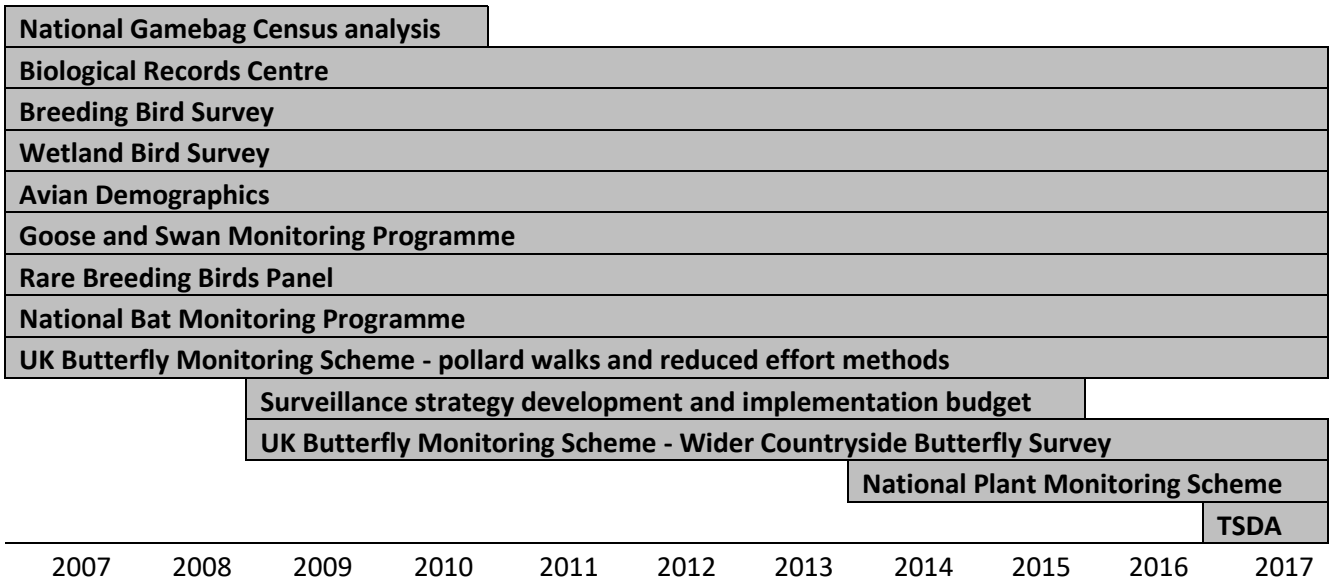


Figure 3. Projects funded by the Terrestrial Evidence budget over the last decade, showing when support for projects started and ended

[21] Figure 4 plots number of sample sites for each scheme – note there may be several sample units at each sample site, for example there are typically 5 'plots' within a NPMS site. For GSMP, data is limited to key volunteer based surveys coordinated by WWT (i.e. excluding data collected by other groups or staff).

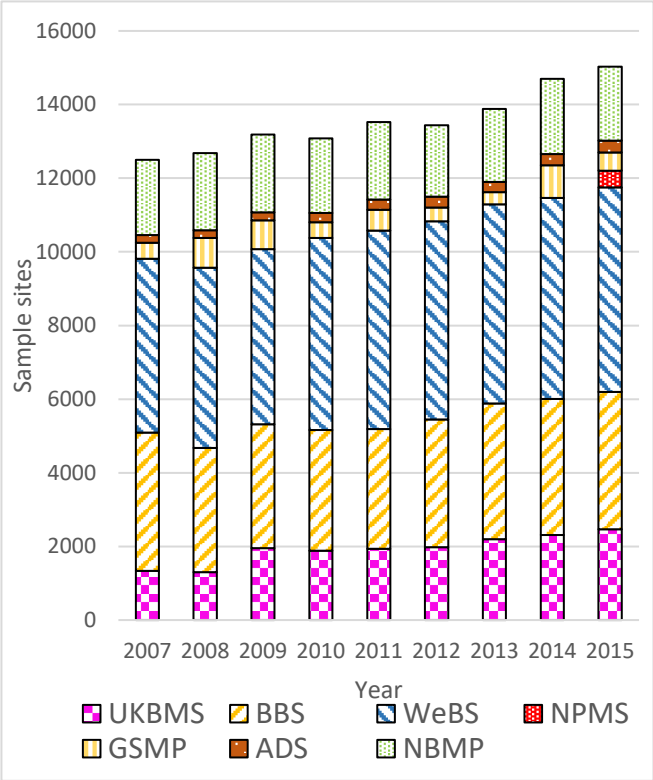


Figure 4. Number of sample sites for each scheme

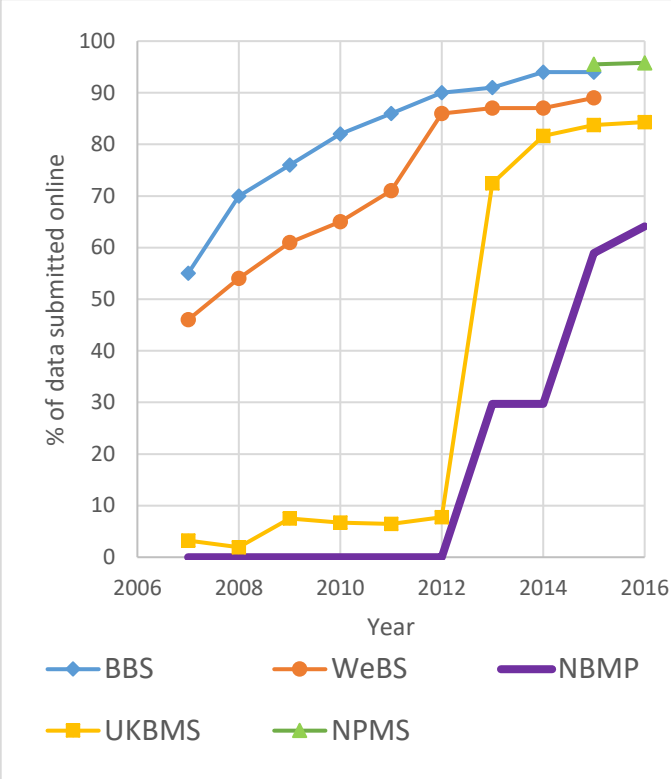


Figure 5. Percentage of data for each scheme submitted online

6.3. Impact of budget cuts

The TEP has reviewed the content and funding of contracts frequently over the past decade to work out where efficiencies can be introduced and savings made. Most recently, renegotiating the UKBMS and BTO contracts for the next 5 year period has highlighted that these schemes are now running at the minimum level of funding that can sustain them in their existing format. This minimum threshold of funding is required to support a project officer to liaise with volunteers, to manage data and host the scheme website/online recording, and to carry out basic trend analysis of results to feed back to volunteers and others (thus maintaining interest and engagement in the scheme).

Almost all budget associated with investigation and analysis within surveillance schemes (beyond basic routine trend analysis) has now been removed from individual scheme contracts, and many small areas of schemes have been cut. For example, in the UKBMS, scheme publicity is no longer funded, and significantly less time is funded for providing advice on use of data.

In 2015/16, TEP explored some scenarios of the impact that different levels of cut would have to the surveillance portfolio. This concluded that a 5% cut year-on-year between 2016/17 and 2019/20 would lead to the loss of two major schemes, e.g. the UKBMS and NBMP, by 2020.

Partnerships have discussed making dramatic changes to the way schemes are run to make savings, including changing to longer reporting periods (e.g. biennial rather than annual), and getting a single provider to deliver all schemes. However, there is a shared feeling that longer reporting periods and the resulting delay in communicating outputs to volunteers would have a detrimental impact on retention. Partners would also face staffing challenges

with less frequent reporting. Having a single provider for all schemes is also unlikely to be successful. NGOs cannot transfer volunteer personal information between organisations due to data protection issues, so the single provider would have to recruit a volunteer network from scratch. In addition, many volunteers have a commitment or association with the particular NGO partner they work with currently, so recorder participation would likely drop if a shift to a single provider occurred.

6.4. Potential future improvements to TEP

One of the key aims of the TEP's new TSDA contract is to explore ways to develop the schemes, and cross-cutting analyses. Planned TSDA development work includes investigating improving scheme coverage, integration of novel technologies, and data flows to deliver more cohesive scheme outputs. Analytical work will focus on linking species trends to pressures, improving predictive modelling, and developing assemblage-level metrics. All scheme partnerships have signed up to the TEPoP statement of intent, indicating their willingness to work together and consider making changes suggested from TSDA work, where appropriate.

To accommodate or assist new technologies, JNCC's suite of surveillance schemes may need to adapt. For example, volunteer recorders may need to collect additional parameters when they carry out their surveys, or the sampling network may need an enhanced sample size in some areas. The fact that JNCC's suite of surveillance schemes includes a large network of volunteers (18,000+), means there is likely to be some flexibility in terms of which parameters can be recorded. Any changes would need to be carried out carefully, in close cooperation with scheme partners, to ensure that scheme volunteers do not get 'recording fatigue' and cease their involvement in the scheme. However, past experience suggests that volunteers can be willing to monitor more on surveys: BBS volunteers have had the option introduced to record butterflies and mammals on their BBS squares, and a significant proportion of recorders have taken up this option.

7.Conclusion

JNCC's TEP budget is approximately £1M per annum: 0.22% of the 2015/16 UK public sector spend on UK biodiversity (£453M, from UK Biodiversity Indicator E2a). This modest investment in JNCC terrestrial surveillance and recording schemes delivers evidence for a range of uses of benefit to governments, for example: informing on the impacts of pressures and conservation action; informing management; contributing to reporting requirements; and informing decisions around EU Exit.

The TEP supports a suite of surveillance and recording schemes, working in partnership with NGOs and research organisations (CEH). The surveillance schemes have increased in size and efficiency over the last decade, whilst budgets have been very restricted. Cuts have been made within the TEP and within schemes. Further cuts to the programme budget (or a flat budget, which given inflationary trends is effectively a cut) are likely to have major impacts, for example, the inability to continue structured surveillance for particular taxonomic groups.

The partnership nature of schemes and volunteer recorder approach results in slightly less control for JNCC than employing professionals to directly collect the data, but has many advantages, overall contributing to making the current approach value for money. Partners contribute their own funding and expertise in their specialist areas, and volunteers freely contribute significant time and resources. The use of large numbers of volunteers enables mass deployment of recorders across the UK simultaneously, in a way that would be challenging with professional recorders due to capacity issues. In addition, supporting volunteer recorders leads to benefits valued by the Devolved Administrations and Country

Agencies, including increasing the public's understanding of and skills in natural history and conservation management, and enhancing volunteer health through activity outdoors.

JNCC's suite of surveillance schemes, and support of recording through the BRC, align closely with JNCC's strategy, which specifies the importance of engaging with NGOs and the research community and the provision of robust scientific evidence.

The value of JNCC's current schemes is likely to be enhanced through the integration of new technologies and analyses, for example working with EO. Retaining a proportion of the TEP budget for analysis and development in the TSDA contract creates a mechanism to ensure that value is obtained from schemes, and that new technologies are integrated effectively as they develop.

As the impacts of climate change increase, the demands of a growing population intensify, and precautionary margins shrink, the need for biodiversity monitoring becomes ever more critical to support the nation's well-being and economy. With its many years of experience and expertise, JNCC is in an excellent position to respond to this need through continued support and development to terrestrial surveillance schemes that provide long-term, annually-updated biodiversity trends, using cost-effective methods.

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