Engaging schools with long-term monitoring of nature

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Abstract Biodiversity-monitoring citizen science schemes provide valuable long-term monitoring data and benefit participants. There is increasing interest in engaging young people with nature. The British Trust for Ornithology's 'What's Under Your Feet?' project shows how schoolchildren can monitor soil invertebrates. Although individual projects like this are often funding- and time-limited, more generic long-term biodiversity-monitoring citizen science schemes may be equally suitable for school participation. Exemplar schemes from the UK are reviewed, and the potential advantages in school participation for teachers and students are highlighted in order to raise awareness of this potential opportunity.

The year 2021 is potentially a critical one for the future trajectory of life on Earth, with pivotal meetings on biodiversity (UN Convention on Biological Diversity (CBD)) and climate change (UN Framework Convention on Climate Change). The approaching CBD Conference of the Parties is driving an international stocktake of the status of the natural world. Citizen science is an increasingly important source of large-scale biodiversity-monitoring data on distributions, abundances and trends of species. In the UK, structured monitoring schemes provide annual monitoring data on the abundance of birds, diurnal mammals, flowering plants and ferns, butterflies and bats, while unstructured records of a much wider range of taxa are collected and used to document species distributions. It is these data that contribute to national assessments of the state of biodiversity, such as the UK 'State of Nature' report (Hayhow *et al.*, 2019) that has documented a net biodiversity loss since the 1970s. While the same 'State of Nature' report starts with an inspiring two-page spread on what nature means to young conservationists, there are concerns about the impact that the biodiversity crisis can have on the health and well-being of young people. The strongly publicised climate crisis has already been shown to negatively affect children and young people (Sanson, Van Hoorn and Burke, 2019).

There are many benefits to engaging young people with nature, including increased awareness of local biodiversity (White, Eberstein and Scott, 2018), increased knowledge (Boyd and Scott, 2021) and improved mood and well-being (Harvey *et al.*, 2020). In this article, I suggest that involving young people in structured citizen science projects provides an opportunity for positive engagement by encouraging them into the natural world and to collect data that can be used to tackle the issues they are concerned about. I start by describing the range of citizen science schemes available, and indicate how they provide different sorts of data relevant to these global issues. I then review a number of approaches to engaging young people with citizen science in schools, before suggesting some opportunities for schools to take advantage of existing long-term biodiversity-monitoring citizen science schemes.

Citizen science

The involvement of volunteers in recording species observations is one of the most established forms of citizen science. For example, the British Trust for Ornithology (BTO) Heronries Census provides the longest-running example of large-scale population monitoring in the UK, extending back to 1928. These schemes provide invaluable long-term data that support conservation, for example underpinning conservation assessments and supporting analyses to identify threats and inform solutions to real-world problems. They vary in their intensity of data collection, the effort or commitment required by volunteers and the value of the data collected for different purposes (Pearce-Higgins *et al.*, 2018).

'Mass participation' approaches involve large numbers of people in recording or counting the abundance of highly detectable and identifiable species. More-difficult-to-identify species tend to be monitored by a smaller number of skilled participants through 'unstructured biological recording'. These are often the only large-scale and long-term data available for many taxa in the UK and can have high impact, but both mass participation and unstructured data require careful analysis to account for underlying skew and bias in the data. The introduction

of structure to the collection of biological data through 'focused recording' can significantly enhance the information to be gained, but requires more direction and coordination to be successful, often by a coordinating organisation responsible for volunteer support and analysis of the resulting data. True 'monitoring schemes' are the ideal approach to collecting robust scientific data, requiring volunteers to follow carefully designed methods, often with repeated visits to the same location in order to monitor changes through time. The resulting data are used for biological monitoring, conservation and research purposes, informing real-world policy and management decisions.

Biodiversity citizen science in schools to monitor nature

There is increasing interest in the potential to engage schoolchildren with nature. The biodiversity-themed March 2010 issue of *SSR* was timed to coincide with the 2010 CBD that formed the last global stocktake of global biodiversity. Eleven years later, a range of projects have been undertaken in schools across a range of taxa, from soil invertebrates (Martay and Pearce-Higgins, 2018), to bees (Roy *et al.*, 2016) and birds (White *et al.*, 2018; Martay and Pearce-Higgins, 2020), and for a range of purposes, from testing particular hypotheses (Martay and Pearce-Higgins, 2020) to positively engaging children with the environment (Harvey *et al.*, 2020).

The majority of projects would classify as mass participation or unstructured biological recording, focused on particular groups that are easy to identify, such as common and widespread birds (White *et al.*, 2018), or providing data on aggregates of species, such as bumblebees, that are difficult for schoolchildren to identify to species (Roy *et al.*, 2016). Some have sufficient methodological rigour that they can be regarded as focused recording or monitoring schemes. One such example is the BTO's 'What's Under Your Feet?' project, run in collaboration with EDF Energy's award-winning 'The Pod', and previously highlighted to young people as a successful earthworm-focused citizen science project (Burton and Cameron, 2021). This is described in more detail below to show how schoolchildren can provide scientifically valuable data for long-term monitoring.

'What's Under Your Feet?'

This project was set up in the autumn of 2015 to document temporal variation in soil-invertebrate abundance on school playing fields (Martay and Pearce-Higgins 2018), and to link that to the abundance of birds that feed on soil invertebrates (Martay and Pearce-Higgins, 2020), a number of which have declined in recent years, particularly in southern England. The methods were designed for use in both primary and secondary schools in three periods through the year – October, March and June – to look at seasonal changes. Samples of turf, 5 cm deep and 30 cm × 30 cm in extent, were dug and hand-sorted to count all soil invertebrates accessible to foraging birds. In addition, earthworms were measured and sorted into 2 cm size-classes in order to estimate biomass. All told, sampling and counting took 60–90 minutes depending upon class size and the number of invertebrates present. Data from other habitats were accepted to maximise participation opportunities. Schools were also asked to count birds using the school playing fields in a series of 15 minute surveys, and were provided with full-colour instruction sheets and identification keys.

Approximately 200–250 schools took part each year across the UK, with a total of 585 schools participating in the first three years (Martay and Pearce-Higgins, 2020), of which more than three-quarters were junior or primary schools. Sufficient data were collected to model variation in the abundance of 12 different invertebrate groups, demonstrating significant seasonal changes and differences between habitats that could be explained by the ecology of the different species groups. Importantly, for the original purposes of the project, although there was no evidence that soil invertebrates, and particularly earthworms, were less abundant in the south compared with the north, there was a strong negative effect of periods of dry weather on earthworm abundance and biomass in the soil samples. This suggests that the increased likelihood of dry weather or periods of drought in southern England, compared with the north, could result in a reduction in the availability of soil invertebrates for foraging birds. These findings were published in a peer-reviewed journal of soil ecology (*Pedobiologia*) in 2018 (Martay and Pearce-Higgins, 2018), demonstrating that schoolchildren were able to follow this methodology and produce sufficient data to support peer-reviewed publication and long-term soil-invertebrate monitoring. Further analysis showed that the abundance of soil-invertebrate-eating birds using school playing fields, such as thrushes, was positively correlated with the abundance of earthworms in the soil, raising the tantalising possibility that changes in bird populations may be used to measure soil health. These results were published in a second peer-reviewed journal in 2020 (*Ecological Indicators*) (Martay and Pearce-Higgins, 2020).

The project continued through to the summer of 2020, but the impacts of COVID-19 and the associated closure of most schools affected data collection. Despite delivering ecologically and scientifically valuable data, the future status of this project remains unclear owing to uncertain funding and the ongoing impacts of the COVID-19 pandemic.

This issue of funding is a challenge for many citizen science projects if they are to be anything other than short term. I would imagine that this is also a challenge for teachers who, having engaged with a successful project, may wish to keep running that activity for subsequent year-groups. As a solution to this problem, this article proposes that teachers make more of existing citizen science biodiversity-monitoring schemes, many of which are designed for ease of engagement, even if not targeted at schoolchildren.

Engaging schoolchildren with existing citizen science schemes for nature

Taking part

As noted earlier, there is a relatively large number of biodiversity-monitoring citizen science schemes in the UK (run by various organisations), some of which might be suitable for use by secondary schools (Table 1). I have

Table 1 Exemplar citizen science schemes that might be suitable for use in secondary schools

Organisation	Scheme	Weblink	Methods summary
Bat Conservation Trust	Sunset survey	www.bats.org.uk/our-work/national-bat-monitoring-programme/surveys/sunset-sunrise-survey	Beginner-level survey to collect data on bats and other nocturnal wildlife.
British Trust for Ornithology (BTO)	Nesting Neighbours	www.bto.org/our-science/projects/nesting-neighbours	An accessible online survey for reporting and monitoring the nesting success of birds that contributes to the BTO/JNCC Nest Record Scheme.
	Garden BirdWatch	www.bto.org/our-science/projects/gbw	Year-round scheme to record birds in gardens on a weekly basis that has been running since 1995.
	BirdTrack	www.bto.org/our-science/projects/birdtrack	Free online portal to store sightings of birds. wherever and whenever they were seen, while also making them available for conservation and research. Mammals, dragonflies and other taxa can also be recorded.
Butterfly Conservation	UK Butterfly Monitoring Scheme	https://ukbms.org	Weekly counts of butterflies along line-transects.
	Butterflies for the New Millennium	www.butterflyrecording.org	Butterfly recording scheme that captures opportunistic distributional data from volunteers throughout the year.
	Big Butterfly Count	https://bigbutterflycount.butterfly-conservation.org	Largest single insect citizen science project in the UK, with over 100 000 participants undertaking standard 15 minute counts during three weeks in July and August each year.
	Garden Butterfly Survey	www.gardenbutterflysurvey.org	The Garden Butterfly Survey allows butterflies that visit gardens or other open spaces to be recorded over the course of a year.
	National Moth Recording Scheme	https://butterfly-conservation.org/our-work/recording-and-monitoring/national-moth-recording-scheme	Moth recording scheme that captures opportunistic distributional data from volunteers throughout the year.
	Moth night	www.mothnight.info	Moth Night is the annual celebration of moth recording throughout Britain and Ireland with many public events.
UKCEH	iRecord	www.brc.ac.uk/irecord	Free online portal to store sightings of all wildlife, wherever and whenever they were seen, while also making them available for conservation and research. Capability of submitting photos supports online verification.
	UK Pollinator Monitoring Scheme	www.ukpoms.org.uk	Flower–Insect Timed Count (FIT Count): 10 minute counts of insects visiting flowers, in gardens or countryside, accessible to all from April to September, with more than 2000 counts received during 2020.
PTES	Great British Hedgerow Survey	https://hedgerowsurvey.ptes.org	Maps national trend in hedgerow health, while simultaneously providing hedgerow management advice.

excluded schemes that rely on predetermined random sample locations that are unlikely to overlap with schools' grounds or local neighbourhoods – more detail about these can be accessed from JNCC's website (https://jncc.gov.uk/our-work/surveillance-schemes/). Instead, I have listed schemes that support data collection from any location. Many of these are designed to be engaging to attract new volunteers, and therefore have a good level of guidance, instructions and training. For example, the BTO provides a wide range of free bird-identification videos (www.bto.org/develop-your-skills/bird-identification), while Butterfly Conservation offers comprehensive butterfly identification material (https://butterfly-conservation.org/butterflies/identify-a-butterfly).

Encouraging secondary school participation in at least one of these schemes could have a number of advantages for the school and for the students involved:

1. Many schemes offer training and methods for young starters, providing resources for teachers, although these are unlikely to be tailored to school curricula.
2. Most schemes provide feedback to participants in the form of annual reports, social media and e-news outputs, providing current extra-curricular material.
3. Participating students will have access to ongoing resources and activities, providing opportunities for practical experience to support future career aspirations.
4. Being supported by dedicated organisations for the purposes of long-term ecological monitoring, the schemes are ongoing and therefore predictable from year to year.
5. The school and students are contributing to something bigger. The data will have impact and be used for a wide range of purposes from monitoring to scientific research.
6. Schemes generally provide an online archive of submitted data from a school, which can then be accessed and used to support additional teaching activities.
7. Some schemes provide access to additional data and information resources from the schemes, which may provide additional teaching opportunities (see below).

Making use of data

In addition to these engagement opportunities, some resulting scheme data may be downloaded for exploration by students, either to support particular learning objectives or student projects. For example, the BTO's *BirdTrends* website (https://app.bto.org/birdtrends) provides searchable information about the population status of a wide range of bird species in the UK (Woodward *et al.*, 2020), with data available to download as a CSV file. To illustrate how these data could be used, a simple comparison of the UK population trend for wrens, a small insectivorous bird vulnerable to cold winter weather (Pearce-Higgins and Crick, 2019), and mean winter temperature (December to February) from the Central England Temperature time-series (www.metoffice.gov.uk/hadobs/hadcet/) can be used to show how wren populations fluctuate in response to winter severity (Figure 1). This analysis could be extended in a number of ways. First, it could be used to look at the impacts of climate change, for example by using the regression model in Figure 1 to consider what would happen if the winters become warmer. Second, it could be used to compare the impacts of different aspects of the weather, such as temperature and rainfall or the responses between different seasons, on species. Third, it could be used to compare responses between species to identify those most sensitive to future climate change. Other portals, such as *iRecord*, provide the opportunity for users to explore and download their own records, while *BirdTrack* users can also undertake simple analyses online.

Conclusion

I hope I have demonstrated that schools can contribute to long-term biodiversity-monitoring schemes and outlined the value of them doing so, for the schools and teachers themselves, and for the pupils taking part. While individual projects tailored for schools, such as the 'What's Under Your Feet?' project, can be highly effective and provide valuable scientific data, such bespoke projects can be difficult to sustain. Instead, there may be value in teachers taking advantage of existing long-term monitoring schemes, not just for their own purposes, but also to make a useful contribution. Some schemes may also provide access to long-term data that schools can use for their own teaching purposes. In making these suggestions, I don't want to underplay the challenges for teachers in doing this, particularly given work pressures, so in a secondary school context this may work best when teachers are able to work with keen students and school clubs and societies to support participation. The BTO has recently established a youth advisory panel (www.bto.org/yap) to help support these activities, a number of whom already run school clubs. Further research is required to quantify the potential benefits of contributing to long-term monitoring for schools and their students, but I hope that this article will be a stimulus for such work to occur. Finally, although the examples given are UK-focused, it is worth noting that similar schemes do exist in many other countries, and *BirdTrack* is global in extent and can be used anywhere.

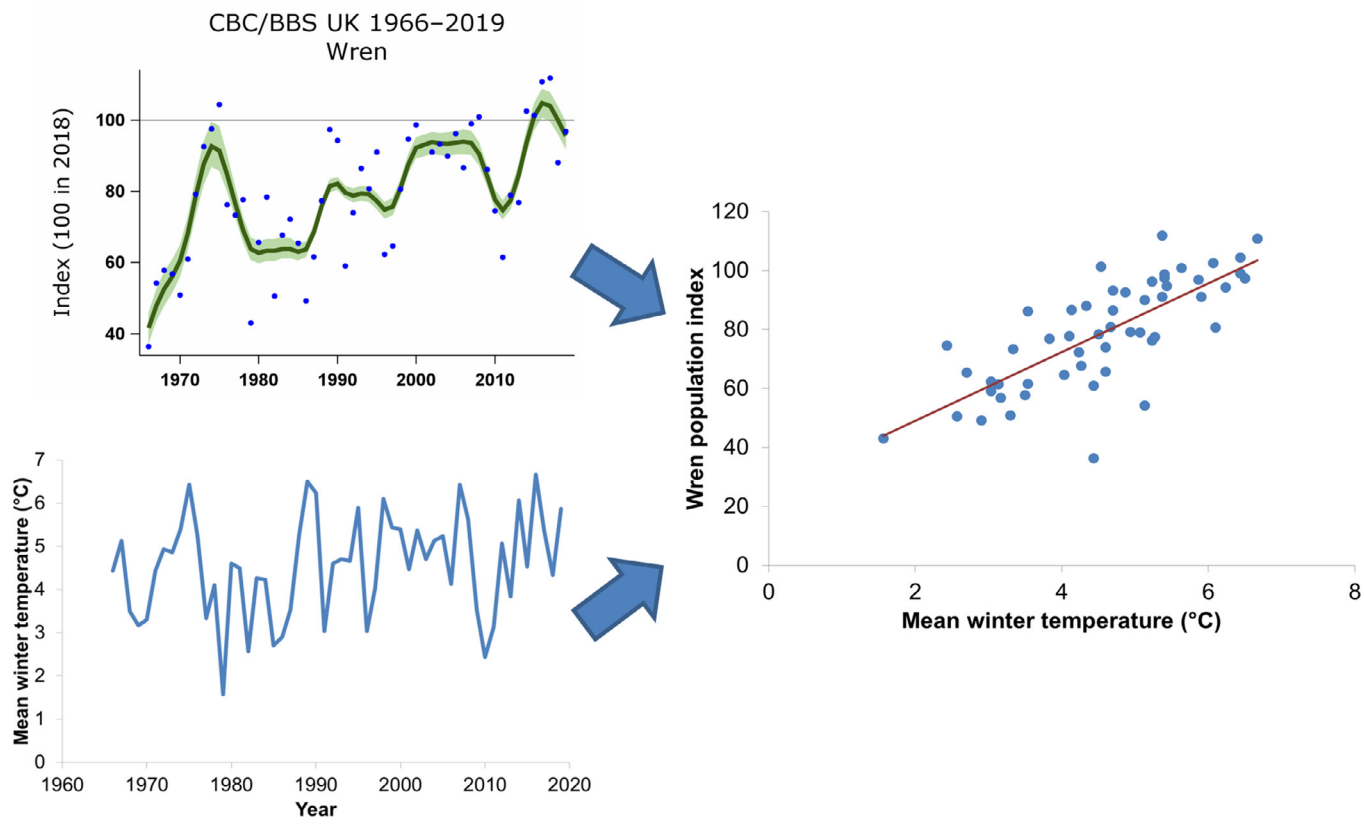

Figure 1 An example of how annual population monitoring data downloaded from the BTO/JNCC BirdTrends Report (top left) can be combined with annual variation in winter temperature from the Central England Temperature time-series (bottom left) to show how wren populations are larger after milder winters (right).

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