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Introduction

Since the environmental movement in 1960s, environmental citizen science for addressing the relationships between environment and humans has gradually been concerned as a promising field to indirectly benefit ecosystems (Haklay, 2020). Because of the geographical large scale as well as spatio-temporal variation requirement, environmental citizen science research has involved many observative and sensing activities throughout contributory projects (ibid.). According to Pocock (2017), the related research approaches in ecology and environment followed the trend from systematic and elaborate ones to mass participation and simple ones. In this context, an overwhelming amount of environmental citizen science projects and applications have been created to contribute to those investigations.

Launched in 2002, eBird is already among the largest biodiversity-related citizen science projects over the world, collecting and sharing bird observations as open access data (eBird, 2021 and Sullivan et al., 2017). As a contributory project, eBird project is organized by the Cornell Lab of Ornithology, with hundreds of partner agencies, thousands of regional professionals, and hundreds of thousands of participants involved (eBird, 2021). This essay will thoroughly analyse the performance of eBird from three perspectives, including the concept of project establishment, data management and project contribution. Throughout the analysis, disciplinary, organisational, technological, ethical, and policy elements will be discussed.

Concept of project establishment

Because the biodiversity observations for many species are not scalable and unequal in terms of spatio-temporal extents recommended to investigate regularity at the population level (Tatsuya et al., 2016), eBird aims to take the advantage of collective wisdom to understand bird movement and further benefit bird conservation. To achieve the temporal and geographical coverage required by the project, each individual birdwatcher can record related information in the checklist format with their unique experience and knowledge anywhere anytime. In the process, potential useful information, such as photos and audio recordings, can be stored and freely shared. In

that case, this project can support the data-driven strategies to science, education and conservation.

The provided information allows users to comprehensively understand the population-level bird movements at global scale. Besides, according to Cornell Lab of Ornithology (2017), by combining the sightings with remote sensed habitat data from NASA, species distribution models can be generated to present the spatio-temporal visualization in the landscape. In addition, researchers and students can freely use the datasets at a variety of spatial scales to contribute to improvement of bird conservation strategies.

Data management of the project

eBird platforms

People can explore species on eBird website or eBird mobile which is available for both iOS and Android operation systems (Sullivan et al., 2014). The free mobile app can support offline data collection anywhere, which can avoid negative effect of information divide and facilitate public participation in larger geographical coverage. The platforms also collect vital contextual information, since the scientific value of the data can be incredibly improved with the background information about how the observations are collected (Kelling et al., 2019). Regarding the data security aspect, data collected and digitised by eBird applications are stored within a secure and accessible repository, archived daily (eBird, 2021). Besides, although people should register first to make contributions, data are all collected anonymously, ensuring the safety of personal identity. Mentioned by Lagoze (2014), grounded in those careful data curation strategies, eBird can better produce scientific outputs and benefit stakeholders engaged in the data lifecycle.

Considering the interface design, consistent styling and effective functions can promote more pleasurable interaction. For example, it is possible to check the real-time distribution maps for various species, as well as receive alerts based on users' preferences. Besides, the frequently used tags are all listed on the top of the webpage, such as 'Explore', 'Submit', 'Science' and 'Help', although no forum menu for communication functionality can be found.

Data quality assurance

Quality of the collected data is of critical importance in citizen science projects, which has been emphasized by the eBird manager. Although sufficient quantities of data and information can be obtained from citizen science projects, inherently noisy and heterogeneous characteristics of crowdsourcing data are inevitable. As indicated by Watson & Floridi (2018) and Gilfedder et al. (2019), data quality could probably be guaranteed after the collected data being evidenced by multiple supportive and accountable reviewers. Besides, in the era of artificial intelligence (AI), processing the human-generated data with AI iterative algorithms can dramatically improve the data quality (Kelling et al., 2013). Therefore, eBird has designed several countermeasures, including establishing reviewer teams, measuring observer variability by setting other samples as reference and addressing uneven sampling by species distribution models (Kelling et al., 2015).

Among them, establishing reviewer teams is the main and fundamental approach. During data submission, observers are provided with a likely-birds checklist for the certain season and geolocation from the checklist filters, which are designed by the most knowledgeable bird distribution professionals in the world (eBird, 2021 and Kelling et al., 2011). Whenever unusual birds or high counts are reported, the data will be reviewed (ibid.). To ensure the best data quality in eBird, more than 1300 volunteer reviewers have become the backbone, scouring incoming data for accuracy, providing feedback for participants and suggesting methods for bird identification or data collection (Kelling, 2018). It is also an opportunity for participants to engage in data evaluation stage of the project. For example, active individuals who have reported a large number of high-quality observations would probably be contacted by eBird and recruited as reviewers (Kelling, 2018). In addition, Kelling (2018) also mentioned that eBird plan to establish more effective reviewer teams by assigning matching tasks (such as checking metadata accuracy or educating observers) to reviewers with different strengths and create multiple platforms for different reviewing functions. With those improvements, data quality is expected to be further guaranteed in an effective way.

Project contribution

The project can perfectly balance the performance between scientific outputs, public engagement and different stakeholders' benefits. Since its inception, the publicly available eBird data have been applied in plenty of student projects, peer-reviewed papers and conservation decision-making processes, as well as facilitated bird research worldwide. According to Horton et al. (2019), by integrating eBird observations with weather surveillance radar data, the timing, intensity and distribution of migratory bird movements can be quantified. Based on the understanding, eBird data can also contribute to land management decision-making processes to identify the most appropriate wetland complexes under different future climate scenarios (Reese & Skagen, 2017). Furthermore, considering the contrary trajectories of urban expansion and biodiversity conservation, eBird can help with the selection, protection and development of necessary large greenspaces with varied habitat in the cities to mitigate bird biodiversity loss (Callaghan et al., 2018 and Perkins, 2020).

Apart from that, research on Journal of Applied Ecology has suggested that citizen science data not only can help the public better understand wildlife populations at theoretical level, but also can inform policies for safeguarding birds. As Figure 1 presents, after following structured procedures and correcting data biases with statistical models, eBird can make contributions for policy decisions. For example, Ruiz-Gutierrez et al. (2021) has claimed that the U.S. Fish and Wildlife Service was intending to define low-exposure areas for Bald Eagles based on eBird data and models, which indicates its direct contribution on shaping policy at the federal level.

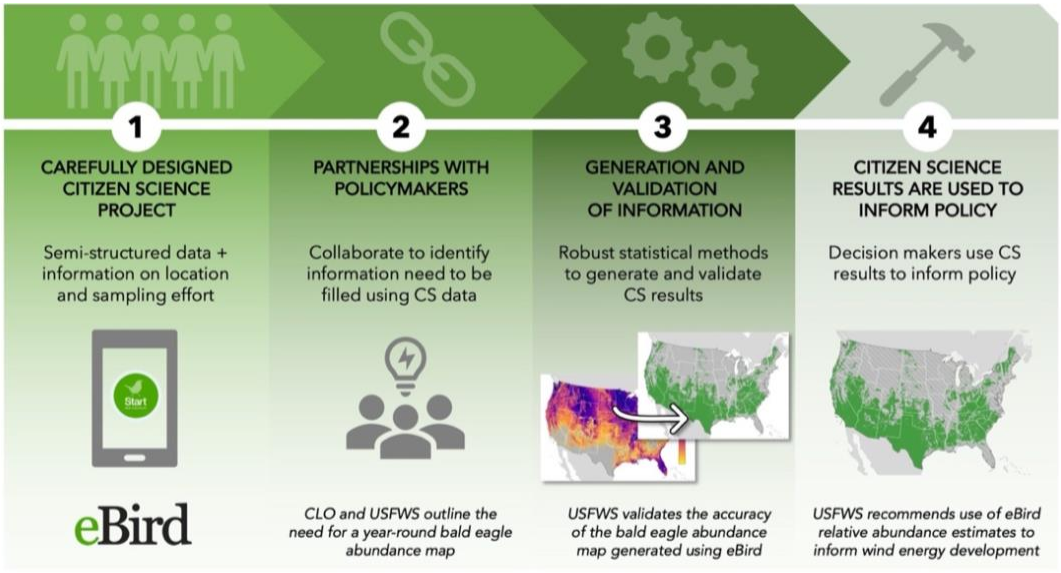

Figure 1: processes for applying eBird to inform policy (Ruiz-Gutierrez et al., 2021)

As a successful citizen science project, eBird has been evaluated by several research papers, discussing the potentials and limitations. According to Tatsuya et al. (2016) and La, Frank & Somveille (2021), the outstanding contributions of eBird are reflected in the records accumulation for long-term ecological research, conservation and monitoring across data-poorest countries and remote regions of the globe. However, the limitations of eBird models have been identified by cross validation. Investigated by Walker & Taylor (2017), after data biases being modelled appropriately, eBird could possibly be adopted to complement traditional survey data (such as Breeding Bird Survey data), but there are several disagreements should be considered and the algorithms should be improved further.

Conclusion

In conclusion, benefiting from the carefully designed disciplinary, organisational, technological, ethical elements, eBird has made significant contributions in different fields, including science, education and policy. Considering the project concept, eBird has taken advantage of collective wisdom to achieve larger geographical coverage of the environmental citizen science project and set bird conservation as the main goal. Regarding data management aspect, eBird can be used under iOS and Android operation systems with reasonable interface design. Besides, data privacy and quality can all be guaranteed, affirmed by other articles. Over the decades, eBird has made great contributions in science and education. Furthermore, the promising project also has proved its application potential in the policy field. Although the discussion in this essay might not comprehensive enough, it can be seen as reference to future research on eBird or other environmental citizen science projects.

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