Invasive Birds

Global Trends and Impacts

Edited by **Colleen T. Downs** and **Lorinda A. Hart**

CABI

44 Using citizen science to study exotic and invasive birds

Corey T. Callaghan[1]* and Daniel M. Brooks[2]

[1]*Centre for Ecosystem Science, School of Biological, Earth and Environmental Sciences, UNSW Sydney, Sydney, NSW 2052, Australia;* [2]*Houston Museum of Natural Science, Department of Vertebrate Zoology, Houston, TX 77019, USA*

Citation: Callaghan, C.T. and Brooks, D.M. (2020) Using citizen science to study exotic and invasive birds. In: Downs, C.T. and Hart, L.A. (eds) *Invasive Birds: Global Trends and Impacts*. CAB International, Wallingford, UK, pp. 362–367.

44.1 Introduction

Citizen science, broadly defined as cooperation between a range of experts and amateurs, involving some sort of public engagement, education and data collection (Jordan *et al*., 2015), is rapidly expanding our knowledge of biodiversity across multiple taxa (Silvertown, 2009; Dickinson *et al*., 2012), and is useful for planning and implementing conservation strategies (Danielsen *et al*., 2014). Thanks to citizen science data, the temporal and spatial scales of ecological questions being addressed are becoming refined. However, there is frequently a gap between the scale of data collection and the potential for conservation-oriented policies (Pocock *et al*., 2018). The study and management of exotic and invasive birds is generally one of small scale, and targeted responses are necessary. Citizen scientists are readily being used as sentinels in a variety of projects aimed at studying invasive species (Theobald *et al*., 2015). Table 44.1 provides some selected examples of such projects, including cane toads *Rhinella marina*, Mediterranean geckos *Hemidactylus turcicus* and invasive plants.

Ornithological research has long-relied on citizen scientists to enhance our knowledge of the ecology and life history of our native avifauna. Some of the longest-running citizen science projects are, indeed, bird focused, such as the Christmas Bird Count or Breeding Bird Surveys in Britain (Risely *et al*., 2010) and North America (Sauer *et al*., 2014), or bird atlassing (e.g. southern Africa; SABAP2, 2019). These projects have added to our general understanding of the distribution and population trends of many bird species, including exotic birds. Many opportunistic observations made by non-professional ornithologists are frequently used in the study of exotic birds. For example, Thibault *et al*. (2018) relied in part on opportunistic observations of the Red-vented Bulbul (*Pycnonotus cafer*) in a recent review of the potential impacts of this species. While this type of informal use of citizen scientists has traditionally been utilized in the study of exotic birds, citizen science is now 'mainstream' (Theobald *et al*., 2015). With a few exceptions (e.g. Brooks, 2013; Conn *et al*., 2017), the formal application of citizen science to exotic and invasive bird management has been relatively unexplored and is currently being underutilized.

In this chapter, we highlight the current usage of citizen science in furthering our knowledge of exotic and invasive bird populations. To do this, we split citizen science projects aimed at studying and tracking exotic birds into two categories: (i) those that are part of a broad-scale biodiversity collection scheme; and (ii) those that are species' focused. We summarize some of the current literature that integrates citizen science data and the effects, management and implications of introduced birds. We rely on select examples to highlight the potential of citizen science aimed at gathering various types of information about exotic birds and conclude by discussing a vision for the future of citizen science aimed at studying exotic birds.

44.2 Citizen Science and Invasive Birds

The potential impacts of non-native birds (Temple, 1992; Baker *et al*., 2014) and the rise of 'invasive species denialism' (Russell and Blackburn, 2017) highlight the critical necessity of better understanding the role of introduced birds and their impacts. The impacts of invasive birds, in particular, are frequently debated, but indeed contribute to global biotic homogenization (McKinney and Lockwood, 1999) and are potentially a major threat on islands (Sax and Gaines, 2008; for further reviews, see the relevant chapters in this volume). In a

*Corresponding author: c.callaghan@unsw.edu.au

Table 44.1. Select examples of citizen science projects aimed at tracking invasive species populations.

Selected example	Description	Reference
GeckoWatch	A project aiming to map the fine-scale distribution of Mediterranean House Gecko in the USA	https://nhm.org/community-science-nhm/geckowatch
iMapInvasives	A broad project aiming to share information about location, search efforts and treatment outcomes of invasives. Largely focused on plants	www.imapinvasives.org/
TexasInvasives.org	A broad portal aimed at distributing information on invasive species across taxa and enlisting citizen scientists' help	https://texasinvasives.org/
FeralScan	An Australian citizen science project aimed at collecting information on Australia's pest species, including fox, cat, pig, cane toad, and Common Myna and European Starling	www.feralscan.org.au/
Cat Tracker Australia	A two-part citizen science project which first had participants fill out an online survey about their pet cats, and then had volunteers allow their cats to be GPS tracked, gaining knowledge about cat behaviour in the urban environment	https://biocollect.ala.org.au/acsa/project/index/ffa9440e-b2a0-4b89-9545-929503c750dc
Texas Invasive Bird Project	Evaluates status of six species of invasive or introduced birds in the state of Texas	www.hmns.org/invasivebirds

world of climate change, sea-level rise and a myriad of other ecological threats, monitoring of invasive bird species generally receives little attention. Of the top 100 of the world's worst alien species, only three are birds: the Common Myna (*Acridotheres tristis*), Red-vented Bulbul and Common Starling (*Sturnus vulgaris*) (Lowe *et al.*, 2000). This is potentially indicative not only of the minimal impacts introduced birds can have on their ecosystem compared with other taxa but also perhaps of the lack of knowledge on the impacts that introduced birds have on their novel environment. Furthermore, these effects may be rather local in spatial scale, and potentially undetected in broad-scale studies. Frequently, even the most basic information (e.g. life history, breeding biology, phenology, and positive or negative interactions with local avifauna) are lacking for introduced species in their introduced range.

44.2.1 Current usage of citizen science in invasive bird research

Citizen science projects vary in their design, objectives and participation. Citizen science projects can be structured or unstructured, with a continuum between these two delineations (Welvaert and Caley, 2016). Similarly, citizen science projects that have furthered the knowledge of introduced birds can be delineated into two types: (i) the use of broad-scale citizen science data, generally from an already-existing, broader-scoped project; and (ii) the use of targeted citizen science projects, focused on a specific taxon or geographical extent. We describe both below.

Use of broad-scale citizen science data to study exotic birds

Ornithology, perhaps more than any other taxon-driven science, has greatly benefited from citizen science. Indeed, one of the longest-running citizen science projects, the Christmas Bird Count (National Audubon Society, 2012), centres around counting birds annually. These types of data have been used to help understand the effects of Common Starlings on cavity-nesting species (Koenig, 2003) and to help elucidate trends in exotic species, such as the recent range expansion by the Eurasian Tree Sparrow (*Passer montanus*) in North America (Burnett *et al.*, 2017) and the Eurasian Collared-dove (*Streptopelia decaocto*) in Florida (Romagosa and Labisky, 2000).

More recently, broad-scale citizen science data are revolutionizing ecology, providing spatial and temporal scales unimaginable mere decades ago (Pocock *et al.*, 2018). These data refer to spatiotemporal coordinates of observations of a given species. Examples of broad-scale citizen science projects include iNaturalist (an app used to collect data on all taxa; iNaturalist.org, 2018), GBIF (an aggregator providing data from a variety of sources; www.gbif.org/) and eBird (a bird-specific, semi-structured project relying on birdwatchers submitting their observations; Sullivan *et al.*, 2014). Data collected from these databases can be used to track the status of specific species in a simple fashion, monitoring trends over time (e.g. Callaghan and Brooks, 2017), or provide opportunistic observations of where a species occurs (e.g. Thibault *et al.*, 2018). Given a reasonable temporal scale, these data can provide detailed information on the spread of an invasive species, habitat associations and effects on other species (Bonter *et al.*, 2010). Bonter *et al.* (2010) relied on citizen science data to investigate the colonization of the Eurasian Collared-dove throughout the USA, finding that this species was more likely to occur in landscapes that had been highly modified by human activity, and that it apparently had minimal impacts on site-level abundance of other dove species. However, these are broad macroecological patterns, potentially not revealing local-level impacts of this species.

Studies relying on broad-scale citizen science data need not be species specific. For instance, one can confirm the patterns of exotic species abundance, diversity and richness in relation to their environment (e.g. Blair, 1996; Brooks and

Page, 2012), contrasting this with patterns of native abundance, diversity and richness (C.T. Callaghan *et al.*, unpublished data). These types of studies can help by demonstrating exotic diversity 'hotspots' for birds, potentially helpful in highlighting areas where further, more detailed research should be carried out.

Another example of the benefits of broad-scale citizen science projects is relying on citizen scientists to monitor invasive species, alerting government officials on the first presence of a species, whether it be a new location or not (BirdLife International, 2015). This has helped to eradicate the Ruddy Duck (*Oxyura jamaicensis*) in the UK and has helped collect data on exotic geese species to help inform eradication and management efforts (see Chapters 27 and 28, this volume). The use of citizen scientists to detect, monitor and report invasive species has been successful with other taxa, such as plants (Gallo and Waitt, 2011; Mannino and Balistreri, 2018).

Despite the potential for these data to help inform exotic/invasive bird species management, there are several concerns that researchers should be aware of. First, there are several spatial and temporal biases associated with broad-scale biodiversity data that researchers need to account for in their study design if intending to use these data (Boakes *et al.*, 2010). Second, there are biases associated with the submission of exotic species reports, in particular, to some citizen science projects. In a survey of 804 respondents of the birding community (Callaghan, 2017), 68% of the respondents submitted their sightings to eBird. Of these, only 53% reported all exotic bird species, 36% reported only those exotic species that are 'countable' on their life lists (defined by the American Birding Association) and 11% did not report any exotic birds to eBird. These results suggest that people intending to use these datasets to gather information need to assume that they may be incomplete records when compared with native species. Furthermore, these data are rather limiting, generally restricted to biodiversity occurrence. The values of these data are predominantly focused on where species occur in their environments, and the range in which they occur, neglecting potential behavioural, ecological and life history components.

There are important considerations necessary before investigating the effects of non-native bird species, based on data derived from broad-scale citizen science projects:

1. A researcher should understand the limitations of using these types of data, generally restricted to presence-only data, but can demonstrate correlative associations with habitat and interspecific interactions.
2. A researcher should also be aware of the spatial (more sightings near human populations and from Anglophone countries) and temporal (more sightings in recent years and potential intra-annual variability) biases. At the least, analyses should account for these different levels of effort, both spatially and temporally.
3. A researcher should focus on making the results published from any data relying on citizen scientists available to the same individuals who made it possible.

Targeted citizen science projects

Contrasting with the use of broad-scale citizen science projects are targeted citizen science projects focused on a small set of taxa, or a specific taxon. Given that exotic birds generally make up a small proportion of the local avifauna, these are, by definition, targeted. They are aided by a social media push to inform participants of the goals of the project and can take a variety of forms.

For example, the Houston Museum of Natural Science has been working on a variety of local exotic species, relying on the public's input and participation (Texas Invasive Bird Project, 2018). For instance, we have used a variety of means to distribute forms to birdwatchers and interested members of the public to better understand the occurrence and ecology of introduced birds. From this, we now know specific aspects of ecology, behaviour and reproductive biology for species such as the Red-vented bulbul (Brooks, 2013; see Chapter 5, this volume), Egyptian Goose (*Alopochen aegyptiaca*; Callaghan and Brooks, 2016, 2017), Scaly-breasted Munia (*Lonchura punctulata*) and other small granivores (Brooks and Page, 2012; Conn *et al.*, 2017; see Chapters 21 and 22, this volume). These projects extend the broad-scale biodiversity data (see above) and rely on detailed questionnaires to assess various unknown aspects of exotic bird biology. For example, questions asked include a description of the habitat where the bird was seen, whether breeding was documented, whether any positive or negative interspecific interactions were observed and whether supplementary feeding was observed. Not all questions are necessarily applicable for all species. Respondents frequently send in photos, which aid in interpreting the results.

The following steps should be considered before implementing a targeted citizen science project aimed at exotic birds. Much work has been aimed at providing guidelines for the implementation of citizen science projects (e.g. https://ecsa.citizen-science.net/blog/collection-citizen-science-guidelines-and-publications, accessed 15 November 2019), but the following steps are detailed from our own experience and are aimed at exotic bird research in particular:

1. A researcher should first investigate whether a detailed citizen science research project is already under way on a potential species of interest, helping to reduce the number of citizen science projects made available to potential volunteers (Bonney *et al.*, 2014).
2. The species in question should be relatively abundant, where you would expect a reasonable number of responses. For instance, if an exotic species is only present in small numbers, then the likelihood of participants encountering it would be low, diminishing the chances of data being collected.
3. However, the species should be not so far established (e.g. House Sparrow, Common Starling) that there is: (i) already well-known data on these instances; and (ii) that management/control of the population is not viable.
4. We recommend ground-truthing 10–15% of the observations. This involves visiting the location that respondents are reporting and: (i) checking for the presence of the exotic species; (ii) checking that the habitat descriptions match; and (iii) generally making sure that the reports make sense.

5. Be sure to publish results in due course and share these results with the broader citizen science network. It is important to identify the milestones that have been completed to the participants.

44.2.2 The potential of citizen science in invasive bird research

So far, we have highlighted some previous research that has relied on citizen science to investigate the ecology and diversity of exotic birds and delineated the overlap between citizen science and exotic bird research into two categories. But how much potential is there to rely on citizen scientists in enhancing our knowledge of exotic birds in the future?

Amateur birders have incredibly acute knowledge of local natural history that is often overlooked by 'professional' ornithologists (Callaghan *et al.*, 2018). Regarding exotic birds, many birders do enjoy watching and observing them (86%; Callaghan, 2017). As many as 57% of respondents to a survey about exotic birds said that they had travelled specifically to a location to see an exotic bird. As exotic bird populations continue to increase, so does the popularity in birding globally, and most birders are armed with cameras and recording equipment. This suggests that there is potential for birders to substantially contribute to the future study of exotic/invasive species. Indeed, 'unnatural history' (Callaghan *et al.*, 2018) could play a crucial role in future monitoring of potential negative impacts of introduced birds on native ecosystem functions. For instance, interactions between introduced and native species can and should be documented and published in scientific literature – and this published literature, even if only published in local or regional journals, should be made available to the greater ornithological community. Too frequently, potential impacts of exotic birds are labelled anecdotal and speculative but have been observed (Mo, 2015). These can be captured in short research notes with relative ease. This is most likely to occur through increased connection between amateur and professional ornithologists.

Given that one of the largest concerns with invasive birds is that of economic concerns, we are surprised that we could not find any targeted citizen science projects aimed at documenting economic effects of invasive birds, such as projects that enlist volunteers to monitor crop damage by exotic species or nesting species on telephone poles. Indeed, we envision this as a particularly important area to be explored. With some foresight, researchers could design studies that aim to monitor different economic aspects of exotic birds.

Another major threat of introduced birds is genetic swamping of native species (Huxel, 1999). For instance, the native American Black Duck (*Anas rubripes*) has become genetically more similar to the Mallard (*Anas platyrhynchos*) because of hybridization with introduced domestic types (Mank *et al.*, 2004), and a similar scenario has occurred in the White-headed Duck (*Oxyura leucocephala*) because of the introduced Ruddy Duck in Europe (Muñoz-Fuentes *et al.*, 2007). Relatively little attention has been paid to the potential for citizen science to track hybridization of introduced species with native species, but we hypothesize this is a potential avenue of future citizen science projects, especially with a revolution in genetics (Allendorf *et al.*, 2010) and a willingness of the public to collect feathers for science (e.g. Brandis, 2016).

44.3 The Future of Citizen Science and Invasive Bird Research

The public, apart from birders, are often unaware of what birds are native and non-native. But birds are appreciated by the non-scientific public (Cocker *et al.*, 2013), and invasive birds are the least supported for eradication and control programmes of all taxa (Bremmer and Park, 2007). We hypothesize that an added benefit of introducing targeted citizen science programmes aimed at better understanding non-native birds could be increased understanding on the potential impacts of exotic birds, if any. Indeed, people with prior knowledge of control and eradication programmes are more likely to support control programmes (Bremmer and Park, 2007), suggesting that increased knowledge could benefit management of exotic and invasive bird populations. With other taxa, such as plants (Jordan *et al.*, 2011), citizen science programmes have been shown to translate into knowledge gain and behavioural change by the participants (Jordan *et al.*, 2011).

Citizen science projects are continuing to increase in their prevalence but are currently being underutilized in invasive bird research. Many populations of exotic species are relatively 'new'; as you will see in the preceding book chapters in this volume, documented negative interactions between exotic and native species are generally lacking. We believe this gap can potentially be filled by citizen scientists. Ultimately, professional ornithologists need to better communicate with amateur ornithologists, recognizing their knowledge of local natural history, including the role that exotic birds play in their introduced ecosystem. Both broad-scale citizen science data and targeted citizen science projects can play an important role in furthering our understanding of the role of exotic birds in the environment.

44.4 References

Allendorf, F.W., Hohenlohe, P.A. and Luikart, G. (2010) Genomics and the future of conservation genetics. *Nature Reviews Genetics* 11, 697–709.

Baker, J., Harvey, K.J. and French, K. (2014) Threats from introduced birds to native birds. *Emu* 114, 1–12.

BirdLife International (2015) Citizen scientists help track invasive species in Belgium. Available at: http://datazone.birdlife.org/sowb/casestudy/citizen-scientists-help-track-invasive-species-in-belgium (accessed 12 November 2019).

Blair, R.B. (1996) Land use and avian species diversity along an urban gradient. *Ecological Applications* 6, 506–519.

Boakes, E H., McGowan, P.J.K., Fuller, R.A., Chang-qing, D., Clark, N.E., *et al.* (2010) Distorted views of biodiversity: spatial and temporal bias in species occurrence data. *PLoS Biology* 8, e1000385.

Bonney, R., Shirk, J.L., Phillips, T.B., Wiggins, A., Ballard, H.L., *et al.* (2014) Next steps for citizen science. *Science* 343, 1436–1437.

Bonter, D.N., Zuckerberg, B. and Dickinson, J.L.(2010) Invasive birds in a novel landscape: habitat associations and effects on established species. *Ecography* 33, 494–502.

Brandis, K. (2016) Australia's waterbirds are disappearing – but nuclear physics can help save them. *The Conversation*, UK. Available at: https://theconversation.com/australias-waterbirds-are-disappearing-but-nuclear-physics-can-help-save-them-57044 (accessed 12 November 2019).

Bremmer, A. and Park, K. (2007) Public attitudes to the management of invasive non-native species in Scotland. *Biological Conservation* 139, 306–314.

Brooks, D.M. (2013) Ecology, behavior and reproduction of an introduced population of Red-vented Bulbuls (*Pycnonotus cafer*) in Houston, Texas. *Wilson Journal of Ornithology* 125, 800–808.

Brooks, D.M. and Page, G. (2012) High diversity of invasive Passerids at a park in southeast Texas. *Bulletin of the Texas Ornithological Society* 45, 23–29.

Burnett, J.L., Roberts, C.P., Allen, C.R., Brown, M.B. and Moulton, M.P. (2017) Range expansion by *Passer montanus* in North America. *Biological Invasions* 19, 5–9.

Callaghan, C.T. (2017) Birders and Exotics – aesthetics, ecology, fair play: a survey of the birding community's strongly held views about exotic bird species. *Birding* 49, 28–36.

Callaghan, C.T. and Brooks, D.M. (2016) Ecology, behavior, and reproduction of invasive Egyptian Geese (*Alopochen aegyptiaca*) in Texas. *Bulletin of the Texas Ornithological Society* 49, 37–45.

Callaghan, C.T. and Brooks, D.M. (2017) History, current distribution, and status of the Egyptian Goose (*Alopochen aegyptiaca*) in the contiguous United States. *Southwestern Naturalist* 62, 296–300.

Callaghan, C.T., Martin, J.M., Kingsford, R.T. and Brooks, D.M. (2018) Unnatural history: is a paradigm shift of natural history in 21st century ornithology needed? *Ibis* 160, 475–480.

Cocker, M., Tipling, D., Elphick, J. and Fanshawe, J. (2013) *Birds and People*. Jonathan Cape, London.

Conn, A., Lazenby, L., and Brooks, D.M. (2017) Ecology, behavior and reproduction of an invasive population of Scaly-breasted Munias (*Lonchura punctulata*) in Houston, Texas. In: Brooks, D.M. (ed.) *Half a Century of Ornithology in Texas: The Legacy of Dr. Keith Arnold*. Miscellaneous Publications of the Houston Museum of Natural Science No. 7, Houston, Texas, pp. 40–53.

Danielsen, F., Pirhofer-Walzl, K., Adrian, T.P., Kapijimpanga, D.R., Burgess, N.D., *et al.* (2014) Linking public participation in scientific research to the indicators and needs of international environmental agreements. *Conservation Letters* 7, 12–24.

Dickinson, J.L., Shirk, J., Bonter, D., Bonney, R., Crain, R.L., *et al.* (2012) The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and the Environment* 10, 291–297.

Gallo, T. and Waitt, D. (2011) Creating a successful citizen science model to detect and report invasive species. *BioScience* 61, 459–465.

Huxel, G.R. (1999) Rapid displacement of native species by invasive species: effects of hybridization. *Biological Conservation* 89, 143–152.

iNaturalist.org. (2018) iNaturalist Research-grade Observations. Occurrence Dataset. Available at: http://doi.org/10.15468/ab3s5x (accessed 12 November 2019).

Jordan, R., Crall, A., Gray, S., Phillips, T. and Mellor, D. (2015) Citizen science as a distinct field of inquiry. *BioScience* 65, 208–211.

Jordan, R.C., Gray, S.A., Howe, D.V., Brooks, W.R. and Ehrenfeld, J.G. (2011) Knowledge gain and behavioral change in citizen-science programs. *Conservation Biology* 25, 1148–1154.

Koenig, W.D. (2003) European Starlings and their effect on native cavity-nesting birds. *Conservation Biology* 17, 1134–1140.

Lowe, S., Browne, M., Boudjelas, S. and de Poorter, M. (2000) *100 of the World's Worst Invasive Alien Species: A Selection from the Global Invasive Species Database*. The Invasive Species Specialist Group (ISSG), Auckland, New Zealand. Available at: https://portals.iucn.org/library/sites/library/files/documents/2000-126.pdf (accessed 12 November 2019).

Mank, J.E., Carlson, J.E. and Brittingham, M.C. (2004) A century of hybridization: decreasing genetic distance between American Black Ducks and Mallards. *Conservation Genetics* 5, 395–403.

Mannino, A.M. and Balistreri, P. (2018) Citizen science: a successful tool for monitoring invasive alien species (IAS) in Marine Protected Areas. The case study of the Egadi Islands MPA (Tyrrhenian Sea, Italy). *Biodiversity* 19, 42–48.

McKinney, M.L. and Lockwood, J.L. (1999) Biotic homogenization: a few winners replacing many losers in the next mass extinction. *Trends in Ecology and Evolution* 14, 450–453.

Mo, M. (2015) The Red-whiskered Bulbul *Pyconotus jocosus* in Australia – a global perspective, history of introduction, current status and potential impacts. *Australian Zoologist* 37, 461–471.

Muñoz-Fuentes, V., Vilà, C., Green, A.J., Negro, J.J. and Sorenson, M.D. (2007) Hybridization between white-headed ducks and introduced ruddy ducks in Spain. *Molecular Ecology* 16, 629–638.

National Audubon Society (2012) The Christmas Bird Count historical results. National Audubon Society, New York. Available at: www.audubon.org/conservation/science/christmas-bird-count (accessed 12 November 2019).

Pocock, M.J.O., Chandler, M., Bonney, R., Thornhill, I., Albin, A., *et al.* (2018) A vision for global biodiversity monitoring with citizen science. *Advances in Ecological Research* 59, 169–223.

Risely, K., Baillie, S.R., Eaton, M.A., Joys, A.C., Musgrove, A.J., *et al.* (2010) The Breeding Bird Survey 2009. BTO Research Report 559. British Trust for Ornithology, Thetford, UK. Available at: www.bto.org/sites/default/files/u16/downloads/reports/bbsreport09.pdf (accessed 15 November 2019).

Romagosa, C.M. and Labisky, R.F. (2000) Establishment and dispersal of the Eurasian Collared-Dove in Florida. *Journal of Field Ornithology* 71, 159–166.

Russell, J.C. and Blackburn, T.M. (2017) The rise of invasive species denialism. *Trends in Ecology and Evolution* 32, 3–6.

SABAP2 (2019) Southern African Bird Atlas Project 2. Available at: http://sabap2.adu.org.za/ (accessed 12 November 2019).

Sauer, J.R., Hines, J.E., Fallon, J.E., Pardieck, K.L., Ziolkowski, D.J. Jr. and Link, W.A. (2014) The North American Breeding Bird Survey, Results and Analysis 1966–2013. Version 01.30.2015. USGS Patuxent Wildlife Research Center, Laurel, Maryland.

Sax, D.F. and Gaines, S.D. (2008) Species invasions and extinction: the future of native biodiversity on islands. *Proceedings of the National Academy of Sciences USA* 105, 11490–11497.

Silvertown, J. (2009) A new dawn for citizen science. *Trends in Ecology and Evolution* 24, 467–471.

Sullivan, B.L., Aycrigg, J.L., Barry, J.H., Bonney, R.E., Bruns, N., *et al.* (2014) The eBird enterprise: an integrated approach to development and application of citizen science. *Biological Conservation* 169, 31–40.

Temple, S.A. (1992) Exotic birds: a growing problem with no easy solution. *Auk* 109, 395–397.

Texas Invasive Bird Project (2018). Texas Invasive Bird Project. The Houston Museum of Natural Science, Houston, Texas. Available at: www.hmns.org/invasive-birds (accessed 15 November 2019).

Theobald, E.J., Ettinger, A.K., Burgess, H.K., DeBey, L.B., Schmidt, N.R., *et al.* (2015) Global change and local solutions: tapping the unrealized potential of citizen science for biodiversity research. *Biological Conservation* 181, 236–244.

Thibault, M., Vidal, E., Potter, M.A., Dyer, E. and Brescia, F. (2018) The red-vented bulbul (*Pycnonotus cafer*): serious pest or understudied invader? *Biological Invasions* 20, 121–136.

Welvaert, M. and Caley, P. (2016) Citizen surveillance for environmental monitoring: combining the effects of citizen science and crowdsourcing in a quantitative data framework. *SpringerPlus* 5, 1890.