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Efficacy of eBird data as an aid in conservation planning and monitoring

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ABSTRACT. One of the world's largest citizen science projects is eBird, a database that has been used primarily to address questions of bird distributions and abundance over large spatial scales. However, addressing finer-scale questions is also possible, depending on survey coverage and whether assumptions and limitations are matched to the scale of inferences. Our objective was to determine if the eBird database could be used to develop estimates of bird abundance and diversity comparable to those from standardized shorebird surveys. We compared a year of standardized shorebird surveys by trained observers at Snook Islands Natural Area located in Palm Beach County, Florida, to a year of eBird observations from the same site. Total species richness derived from eBird (25 species) was higher than that from standardized surveys (20 species). Similarly, we found the Shannon diversity index calculated from eBird was higher (2.81) than the same index calculated from standardized surveys (2.21; $P < 0.001$). The higher diversity and species richness may reflect the greater effort of eBird participants (35,289 person-hours) compared to our standard surveys (2126 person-hours). We found only a slight difference in parameter estimates between data obtained from eBird and from standardized surveys. Potential use and value of eBird as a tool for land managers and conservationists may be greater than currently realized, but studies conducted in a wider range of ecosystems and locations are needed to develop generalizations.

RESUMEN. **Eficacia de datos en el eBird para apoyar esfuerzos de conservación y el monitoreo de poblaciones**

Uno de los proyectos de ciencia ciudadana más grandes del mundo es el eBird, una base de datos que se ha utilizado principalmente para abordar las cuestiones de la distribución y la abundancia de aves a través de grandes escalas espaciales. Sin embargo, es posible para abordar las preguntas de más fina escalas, dependiendo de la cobertura de la encuesta y si los supuestos y limitaciones de la encuesta se hacen coincidir con la escala de inferencias. Nuestro objetivo fue a determinar si el eBird podría ser utilizado para desarrollar estimaciones de la abundancia y diversidad de aves comparables a los de las encuestas normalizadas de aves playeras. Se comparó un año de encuestas de aves playeras en Snook Islas Area Natural, ubicada en el condado de Palm Beach, Florida, a un año de observaciones en eBird desde el mismo sitio. La riqueza de especies total derivadas de eBird (25 especies) fue superior a la riqueza de especies estimada por las encuestas normalizadas (20 especies). Del mismo modo, encontramos que el índice de diversidad de Shannon calculada a partir de eBird fue mayor (2.81) que en el mismo índice calculado a partir de encuestas normalizadas (2.21, $P < 0.001$). Los valores más altos de la diversidad y la riqueza de especies, estimados por eBird, pueden reflejar el mayor esfuerzo de los participantes en eBird (35,289 horas-persona) con respecto a nuestras encuestas normalizadas (2126 horas-persona). Sólo se encontró una pequeña diferencia en los valores de los parámetros entre los datos obtenidos por eBird y de las encuestas normalizadas. El uso potencial y el valor de eBird como una herramienta para la gestión de tierras y para conservacionistas puede ser más grande de lo que se había creído, pero para desarrollar más grande generalizaciones se necesita más estudios sobre una amplia variedad de ecosiste más.

Key words: avian, Citizen Science, Shannon diversity, shorebirds, species richness

Citizen science uses the public to collect vast amounts of data across an array of habitats and locations over long periods of time (Bonney et al. 2009). The main advantage of citizen science projects is the low cost and ease with which a large quantity of data can be collected. eBird, first launched in 2002 (Sullivan 2009), is one of the largest citizen science projects (Wood et al. 2011). eBird takes advantage of the tens of thousands of people who identify birds every day by creating a central repository for them to submit their observations (Sullivan et al. 2009, 2014). For example, by 2013, eBird had collected over 140 million observations submitted by 150,000 different observers, with 10.5 million hours in the field, demonstrating an exponential increase in data collection over the last decade (Sullivan et al. 2014).

eBird was designed to maximize participation through use of a simple data entry structure that matches, to the degree possible, the

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normal activities of birdwatchers worldwide (Wood et al. 2011). When a volunteer observer submits an eBird record, they map the location of their birding area and, based on the date, eBird generates a list of species likely to be seen. Information about the count is included (start time, duration, and distance covered) as is the number of individuals of each species seen. Another incentive to encourage participation is the use of a smart phone as a data recording instrument because eBird has a mobile app that facilitates data entry in the field.

To further improve data quality, eBird enlists the help of volunteer experts who develop regional filters based on the chosen spatiotemporal coordinates and date of observations. These filters set limits for the species observed as well as a maximum number of individuals for that species for those submitting volunteer observations. If a count surpasses the max, or a bird is reported outside the specified date range, the record is flagged for further scrutiny by an expert reviewer. As of 2011, a network of over 450 regional experts had reviewed more than 3.5 million records (Wood et al. 2011). Another feature that helps ensure high quality data is the participation of an active subset of "power users", with 90% of checklists submitted by the 10% most active users. This does not mean these power users are expert birders, but does ensure a clear investment in the project as well as a higher level of eBird expertise through sustained participation (Wood et al. 2011).

The popularity of eBird and its high degree of data integrity have led to more than 90 peer-reviewed scientific publications that have either used eBird data or studied aspects of the eBird project (Sullivan et al. 2014). These have mostly addressed questions of bird distribution and abundance over broad spatial and temporal scales (a list of publications can be found on eBird's website: http://ebird.org/content/ebird/about/publications/).

eBird has yet to be widely used as a tool to answer small-scale questions about bird abundance or distribution at specific sites or in response to specific land management projects. Management actions on refuges and public lands are typically made at a fine spatial scale because this is the scale where manipulation or regulation is most feasible. Also, because species diversity is easiest to calculate and monitor in a case-specific way (Bestelmeyer et al. 2003), there is a benefit to considering diversity at a small scale. The application of other avian citizen science databases has been predominantly for broad-scale questions (Gregory and Baille 1998, Sauer et al. 2003), primarily because weaknesses in data integrity are minimized at that scale (Link and Sauer 1999). However, eBird was designed to minimize data integrity problems so there may be less reason to restrict use of the database to large-scale questions. We tested the utility of eBird for a small-scale estuary restoration project in southeastern Florida. Our goal was to determine if inferences about avian diversity differed based on analyses of data collected by eBird participants and data collected by professionally trained observers conducting standardized shorebird surveys.

METHODS

Our study site was Snook Islands Natural Area (26.6159905, −80.0461936), a restoration project of the Palm Beach County Department of Environmental Resources Management in Florida (ERM; The Nature Conservancy 2013). Completed in 2005, 40 ha of wetland habitat was restored in the Lake Worth Lagoon. A boardwalk was added in 2012, allowing access by birders.

Bi-monthly shorebird surveys began in April 2014 with the exception of June and July when only one survey was conducted per month. Surveys were conducted by trained observers. Time of day, timing of tides, and optimal weather conditions were taken into consideration when planning survey dates to maximize the number of birds detected during surveys. To compare the two sources of data, observations of bird abundance were obtained from the eBird database for the Snook Islands site for the time period during which standardized surveys were conducted (1 April 2014–31 March 2015). All complete eBird checklists (vetted records only) during this time period, regardless of time of day, tide, or length of survey, were filtered for all shorebird species ever observed in Florida. The unit of measure pertaining to the eBird data used in this study was the "sampling event identifier."

We compared the two data sources using species richness (S) and the Shannon diversity index (H'), two standard metrics of ecological communities (Magurran 1988). Species richness is the total number of species observed, whereas the Shannon diversity index accounts for species richness as well as evenness, based on relative

Table 1. Species recorded for each of the data sources used in the comparison at the Snook Islands Natural Area, Palm Beach County, Florida, from April 2014 until March 2015. Twenty-five species were recorded throughout the year using the eBird database, and 20 species were recorded on our shorebird surveys.

Both databases	eBird database only
American Oystercatcher (*Haematopus palliatus*)	American Avocet (*Recurvirostra americana*)
Black-bellied Plover (*Pluvialis squatarola*)	Lesser Yellowlegs (*Tringa flavipes*)
Black-necked Stilt (*Himantopus mexicanus*)	Long-billed Dowitcher (*Limnodromus scolopaceus*)
Dunlin (*Calidris alpina*)	Pectoral Sandpiper (*Calidris melanotos*)
Killdeer (*Charadrius vociferus*)	Wilson's Phalarope (*Phalaropus tricolor*)
Least Sandpiper (*Calidris minutilla*)	
Marbled Godwit (*Limosa fedoa*)	
Piping Plover (*Charadrius melodus*)	
Red Knot (*Calidris canutus*)	
Ruddy Turnstone (*Arenaria interpres*)	
Sanderling (*Calidris alba*)	
Semipalmated Plover (*Charadrius semipalmatus*)	
Semipalmated Sandpiper (*Calidris pusilla*)	
Short-billed Dowitcher (*Limnodromus griseus*)	
Solitary Sandpiper (*Tringa solitaria*)	
Spotted Sandpiper (*Actitis macularius*)	
Western Sandpiper (*Calidris mauri*)	
Whimbrel (*Numenius phaeopus*)	
Willet (*Tringa semipalmata*)	
Wilson's Plover (*Charadrius wilsonia*)	

abundances, in the community. The Shannon index increases as both the richness and evenness increase (Magurran 1988). We first calculated the overall Shannon diversity indices on the pooled data from each data source and compared them using a robust *t*-test (Hutcheson 1970, Zar 1999). Second, we used a one-tailed *t*-test to examine possible differences between the two sources of data for both species richness and Shannon index, using month as a replicate.

We repeated this procedure taking into account effort from each data source. Effort was represented by dividing species richness and Shannon diversity indices by a log-adjusted value of the minutes spent surveying. We then performed two-tailed *t*-tests to test for any significant differences in the adjusted data for both species richness and the Shannon index. Significance for all tests was set at $\alpha = 0.05$, and all analyses were carried out in R statistical software (R Core Team 2015).

RESULTS

Raw species richness based on eBird data was 25, compared to 20 from standardized surveys (Table 1). The Shannon index as calculated from the eBird database was 2.81 compared to 2.21 for the standardized surveys. Based on Hutcheson's robust *t*-test, the Shannon index derived from the eBird database was significantly greater than that derived from the shorebird surveys ($t_{222} = -4.3$, $P < 0.001$).

Both sources of data revealed a similar pattern in temporal trend for species richness and the Shannon diversity index (Figs. 1 and 2). However, eBird data estimates for species richness ($t_{21.2} = 3.2$, $P = 0.002$) and the Shannon diversity index ($t_{19.3} = 4.4$, $P < 0.001$) were higher for every month.

Sixty-two different eBird observers collectively made 559 unique trips to Snook Islands Natural Area from 1 April 2014 to 31 March 2015. The eBird observers spent 35,289 min surveying birds compared to 2126 min by trained observers. After controlling for amount of time spent surveying, the temporal patterns remained similar, but eBird values were no longer consistently above the standardized survey values (Figs. 3 and 4). We found no significant difference between the data sources in either species richness ($t_{14.0} = -0.7$, $P = 0.47$) or species diversity ($t_{20.4} = 0.2$, $P = 0.83$) when using month as a replicate.

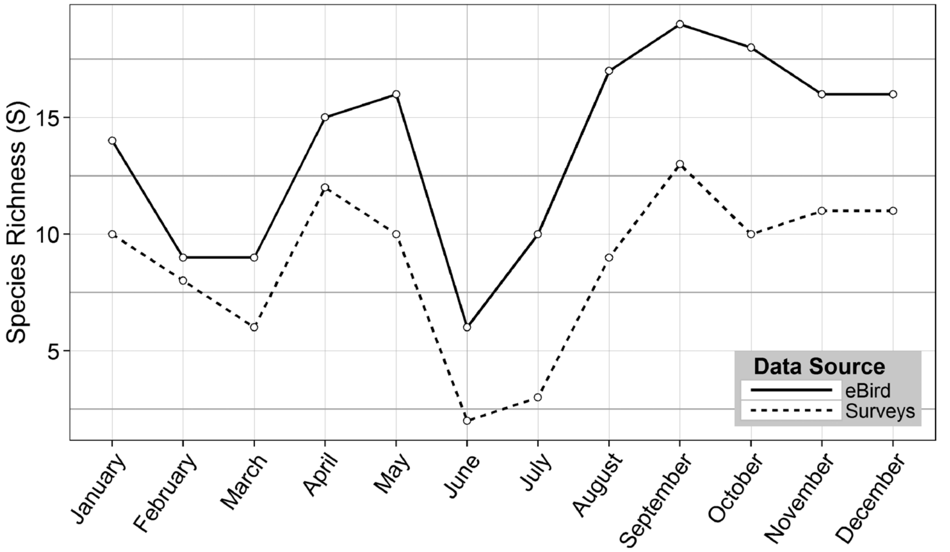

Fig. 1. Temporal trends in shorebird species richness at Snook Islands Natural Area, Palm Beach County, Florida, from April 2014 to March 2015 as calculated from field surveys conducted by trained observers and from the eBird database.

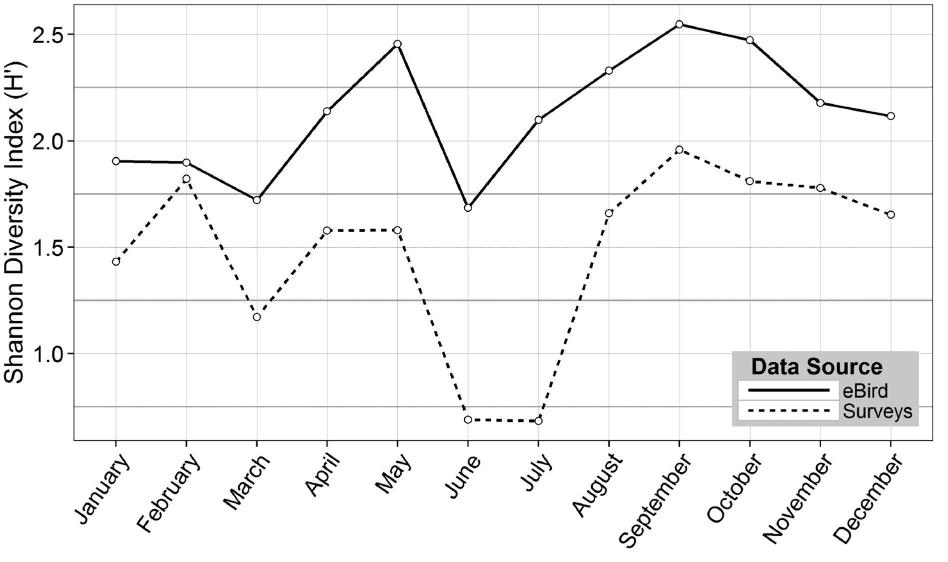

Fig. 2. Temporal trends in shorebird Shannon diversity index at Snook Islands Natural Area, Palm Beach County, Florida, from April 2014 to March 2015 as calculated from the surveys conducted and the eBird database.

DISCUSSION

Our results demonstrate that, at our study site, the quality and quantity of data, which is a common concern with citizen science projects (Dickinson et al. 2010), achieved through use of the eBird database was sufficient to provide estimates of diversity similar to those provided by more expensive and intensive standardized shorebird surveys. When accounting for effort,

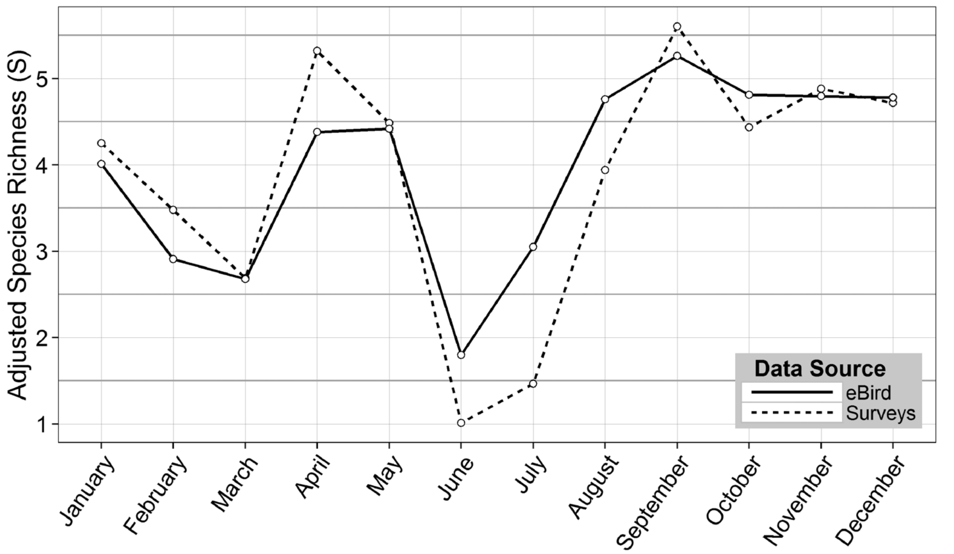

Fig. 3. The adjusted species richness temporal trends at Snook Islands Natural Area, Palm Beach County, Florida, from April 2014 to March 2015. Species richness was adjusted for effort associated with each of the data sources by dividing the species richness by the logarithm of minutes spent surveying per month.

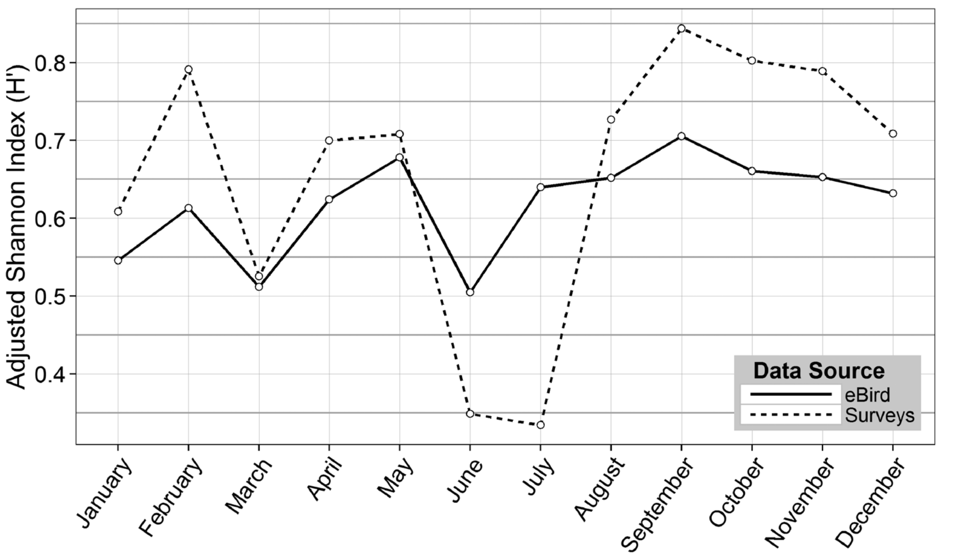

Fig. 4. The adjusted Shannon diversity index temporal trends at Snook Islands Natural Area, Palm Beach County, Florida, from April 2014 to March 2015. The Shannon diversity index was adjusted for effort associated with each of the data sources by dividing the Shannon diversity index by the logarithm of minutes spent surveying per month.

we found no significant difference between biodiversity metrics calculated from our standardized surveys and the eBird database, suggesting that the eBird database could substitute for standardized surveys at the project level in our study. Without accounting for effort, analysis of the eBird database revealed significantly higher species richness and Shannon diversity index of shorebirds, which is not surprising given that eBird observers spent ~16 times more time surveying the study area. This highlights one of the main benefits of a popular citizen science database, i.e., the sheer volume of data collected.

The balance between data quality and quantity is critical for any citizen science project (Hochachka et al. 2012), and eBird has found that balance to investigate questions at large spatial and temporal scales (Wood et al. 2011). Our study demonstrated that eBird is not just applicable to questions at a large scale, but can also be applied to questions about small-scale individual projects. When controlling for observer effort, our estimates of diversity from eBird did not differ from those based on standardized surveys. We note that future studies could broaden the scale to include a larger number of sites as well as investigate minimum thresholds of eBird data (i.e., number of visitors, number of checklists, and frequency of checklists) necessary to provide useful estimates of diversity. Our study site was visited by a large number of eBird participants, a characteristic shared by many sites around the world, especially those near human populations and known for natural values. Concentrating observer effort in a subset of locations introduces sampling bias when looking at broad-scale questions, which is often cited as a potential flaw of citizen science projects (Dickinson et al. 2010). However, if inferences are to be drawn only about sites within the areas of high sampling effort, then the bias is eliminated. Indeed, most environmental restoration and management projects are in human-dominated landscapes where the sampling effort is likely to be unusually high.

Finally, the number of eBird records originating from outside North America is increasing (Wood et al. 2011), thus expanding the global area and sites from which eBird data can be used to make inferences. For example, many remote geographic regions throughout South America are not satisfactorily sampled with formal quantitative surveys (da Silva 1995), but the rise of ecotourism and increase in visitation (Center for Responsible Travel 2015) improves the chances of having adequate coverage in the eBird database. This may be especially true for well-known and heavily birded areas, such as World Heritage Natural sites and Ramsar Sites.

We suggest that the eBird database is a viable alternative to common shortcomings in monitoring of avian biological diversity and is currently not being exploited to its fullest potential. Land managers and restoration project managers frequently rely on species diversity monitoring programs to assess spatial and temporal biodiversity trends (Yoccos et al. 2001). However, the cost of ensuring sufficient temporal and spatial coverage (Mac Nally et al. 2004) is a common limitation for managers in monitoring these trends. Therefore, the ability of managers to use eBird, an open-access citizen-science database with broad spatial and temporal coverage, has important implications for avian conservation.

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