Rachel E. McCaffrey

School of Natural Resources, University of Arizona, Tucson, AZ 85721;
rachmcc@email.arizona.edu

Abstract

Long-term monitoring projects and studies designed to survey large, variable areas often face a similar challenge: data collection. Researchers can sometimes overcome this obstacle by designing studies that utilize the skills of volunteers, or citizen scientists. Citizen scientists currently play active roles in a wide range of ecological projects, and their contributions have enabled scientists to collect large amounts of data at minimal cost. Because bird-watching is popular among members of the general public, bird-monitoring projects have been among the most successful at integrating citizen scientists. Several large-scale studies, such as the Christmas Bird Count and Breeding Bird Survey, have successfully relied on citizen scientists to collect data. As urban areas expand and scientists work to find ways to manage wildlife in cities, information about the associations among animals and urban environments is needed. By utilizing the large pool of potential participants in urban areas, citizen science–based studies can play an important role in collecting this information. One such study, the Tucson Bird Count (TBC), has successfully utilized citizen scientists to collect information on the distribution and abundance of birds across an urban area. The results from the TBC have been used in numerous scientific studies, and they are helping wildlife managers identify important sites for birds within the city, as well as land-use practices that sustain native birds.

birds, bird survey, citizen science, monitoring, Tucson Bird Count

Introduction

The value of employing volunteers from the general public (i.e., citizen scientists) to collect data has been recognized for a long time, but there has been a recent surge in studies based on citizen science. Although many early citizen science programs were primarily conceived as educational tools—as a way to increase participants' knowledge about science (Brossard, Lewenstein & Bonney, 2005)—there has been a growing focus on the use of citizen scientists to collect long-term data (Brewer, 2002; Evans et al., 2005). For research projects that require many observers, such as studies designed to assess the status of local resources, establish baseline ecological measures, or identify the impaageolTj 172.5 0 a14Tc -0forc -urbaniv4is

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remarkable resource (Ely, 2000; Altizer, Hochachka & Dhondt, 2004). In many cases, lone professional scientists, lacking the necessary funding and manpower, are unable to gather the broad-scaled yet

range of environments throughout Tucson during the breeding season (the Route Program). The original sampling scheme allowed for inferences about bird/habitat associations to be drawn from the TBC data (Ramsey & Schafer, 2002), but several of the most bird-rich sites in Tucson were not included. As a result, the Park Monitoring Program was established as an additional component of the TBC. In the Park Monitoring Program, volunteers survey birds in their local parks, washes, or other areas of interest on a quarterly basis. Experience gained from designing the TBC program, recruiting volunteers, making the data available to the public and researchers, and confronting the challenges associated with such a study, can serve as an example for other researchers interested in establishing citizen science–based projects in urban areas.

The design of the TBC Route Program is modeled after that of the BBS: One survey site is randomly located within each one-square-kilometer (1 km²) cell of a grid covering the Tucson area, following a stratified random sampling design (for a detailed description, see Turner, 2003). Adjacent sites are grouped into routes, with an average of ten sites per route. Using maps and information available at the TBC website, volunteers select a route (or routes) to survey. (Once a route is adopted, it is unavailable to other volunteers.) Each year between April 15 and May 15 (the peak breeding season in Tucson), volunteers survey the sites along their route on a morning of their choice, conducting a five-minute unlimited-radius point count (per Blondel, Ferry & Frochet, 1981) at each site.

In 2001, 661 randomly located sites on 63 routes in the Tucson area were surveyed (Tucson Bird Count, n.d.). With the exception of sites that have been relocated due to changes in accessibility or other disruptive factors, site locations are permanent, allowing for the same sites to be surveyed each year. Tucson has grown by more than 30 square miles since 2000 (locatE-96 c17.C-17.0fTj 74s20 gTD5iles 84rownlocated the ex

participants as they select their route or park to survey, and they can change their selections from year to year. Participants changing the areas they survey could potentially reduce the consistency of results, but excessive changes have not happened. Rather, allowing participants this freedom and flexibility of selection has helped them find areas they are interested in monitoring long-term.

Finally, connectedness is maintained between TBC personnel and project participants in several ways. First, the results submitted by each TBC participant are available immediately and publicly on the TBC website, so volunteers are able to see how their results fit into the overall project. Second, via e-mail, articles in the Tucson Audubon Society newsletter, and a recently established annual newsletter, participants are regularly updated about the TBC's results and how they are being used.

The TBC website was designed to facilitate necess0ed by partici-0.3446 -0.145 T
participants' involvement in the project, make the data collected through the project easily accessible to the public, and provide information about the project to interested parties. At the website, participants can register for the TBC, take the required self-test, view a map of available routes, select a route or park to survey, enter their data, and view results. Enabling participants to carry out these administrative tasks themselves reduces the burden on TBC personnel and speeds up the process. An additional benefit of participants entering their data via the website is a decreased risk of transcription mistakes, as participants themselves (as opposed to TBC personnel) are entering data that they recorded. The data is automatically recorded in the TBC's digital database, allowing participants to immediately review their results (and make corrections, if necessary). To further ensure the validity of the data, TBC staff review all count results submitted, correct obvious errors, and contact participants to verify any unusual or unexpected observations.

Results entered by participants are publicly available in real time on the TBC website in tabular format and as distribution maps. As a result, during each survey period, the tables and maps are constantly updated as participants enter new data. By clicking on any of the survey sites on a distribution map, users can view which other species were observed at the site. The results and distribution maps from previous Route and Park Monitoring program surveys can also be viewed at the website, allowing users to see how the distributions or abundances of various species have changed over time. An additional tool available on the TBC website is the
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of nonnative cavity-nesting birds on the health of saguaro cacti (*Carnegiea gigantea*; Hutton, 2005). In addition, data from the TBC have served as baseline information for a number of scientific studies, ranging from an investigation of the impact of West Nile virus on Tucson's birds to a comparison of riparian birds in Tucson and Phoenix riparian areas. The TBC data has also been used in local land-use planning (Pima County, 2004), and to evaluate potential sites for natural resource parks (Rosen & Mauz, 2001).

While the TBC is an example of how citizen science and urban ecological monitoring can be integrated, executing such a program poses challenges. Both components of the TBC—the citizen scientists and the urban setting—have presented obstacles over the program's five-year history. All TBC volunteers are required to take a self-test prior to regis tration to ensure that they meet minimum requirements, but variation remains among participants' abilities to detect birds by sound and sight. With the TBC, this hurdle is overcome in survey design (routes are arranged so that multiple observers cover any one part of Tucson) and during data analysis (patterns of distribution and abundance are analyzed at broad scales, rather than at specific points, reducing potential observer biases). The volunteer nature of a citizen science–based project also poses challenges. With the TBC, this has manifested itself in the difficulty in getting certain routes monitored—those that are deemed less "birdy" or are otherwise unattractive to participants. In Tucson, many of these routes are clustered in one region of the city, and the less frequent monitoring of these routes has led to gaps in the TBC's citywide coverage. Initial attempts to combat this problem by encouraging existing participants to adopt these routes were relatively unsuccessful. To solve the problem, future efforts to

volunteer-based, citywide urban bird-monitoring project in the world (Turner, 2003). Lessons learned through the TBC about study design, volunteer management, and the importance of making results available and useful may be helpful in the establishment of other urban bird-monitoring projects. Urban areas offer enormous potential for citizen science projects, not least because a large number of prospective volunteers are already in place. The ecology of urban areas is a growing field that requires further investigation; the type and scope of information citizen scientists can provide is invaluable. In the case of bird-related projects, there is the additional advantage that many experienced birders are interested in participating in projects designed to benefit birds, and they bring an established skill set to the project.

The breadth of data that can be collected by an organized group of citizen scientists allows researchers to conduct studies that might otherwise be impossible: Patterns of distribution and abundance can be mapped on a large scale and surveys can be regularly repeated, enabling researchers to monitor changes in populations over time. Results from these studies can be invaluable in identifying key areas of ecological importance within a city and tracking how changes in land use and other environmental factors influence bird communities. As urban areas expand, determining how populations of native wildlife can be sustained in cities is becoming more important. Data collected by citizen scientists can be a vital tool in helping meet this challenge.

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Glossary

A record of organisms heard or seen within a given radius of a survey site during a set period of time.

A line used in ecological surveys to provide a means of measuring and representing graphically the distribution of organisms (*Oxford Dictionary of Ecology*).

Figure 1. Map of the Tucson Bird Count study area showing major washes, roads, Route Program survey sites, and Park Monitoring Program locations.

Figure 2. Distribution and abundance of Gambel's quail across the Tucson Bird Count Route Program study area. Although actual survey site locations are randomly located within each 1-km² cell, results are shown at cell centers.

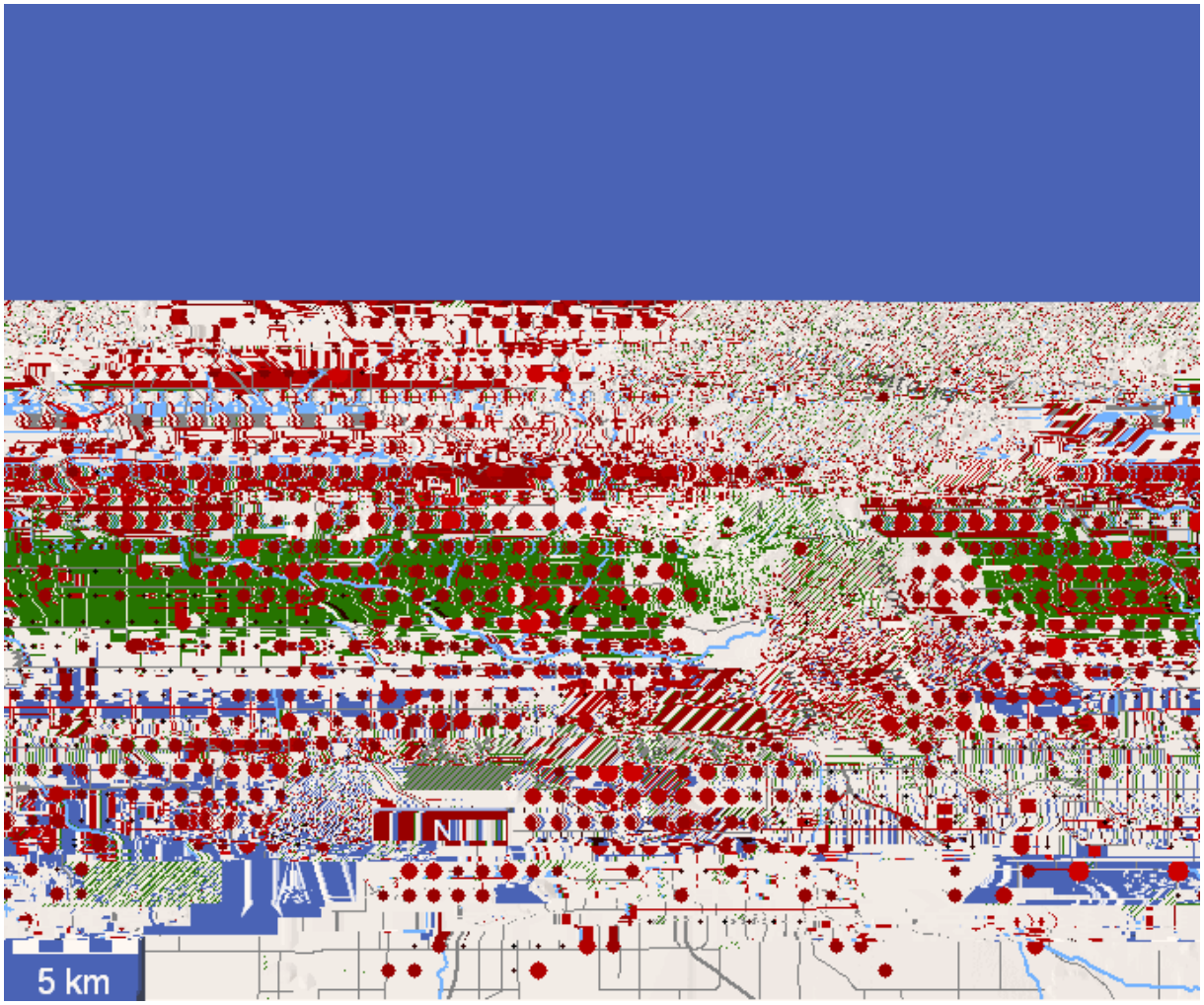
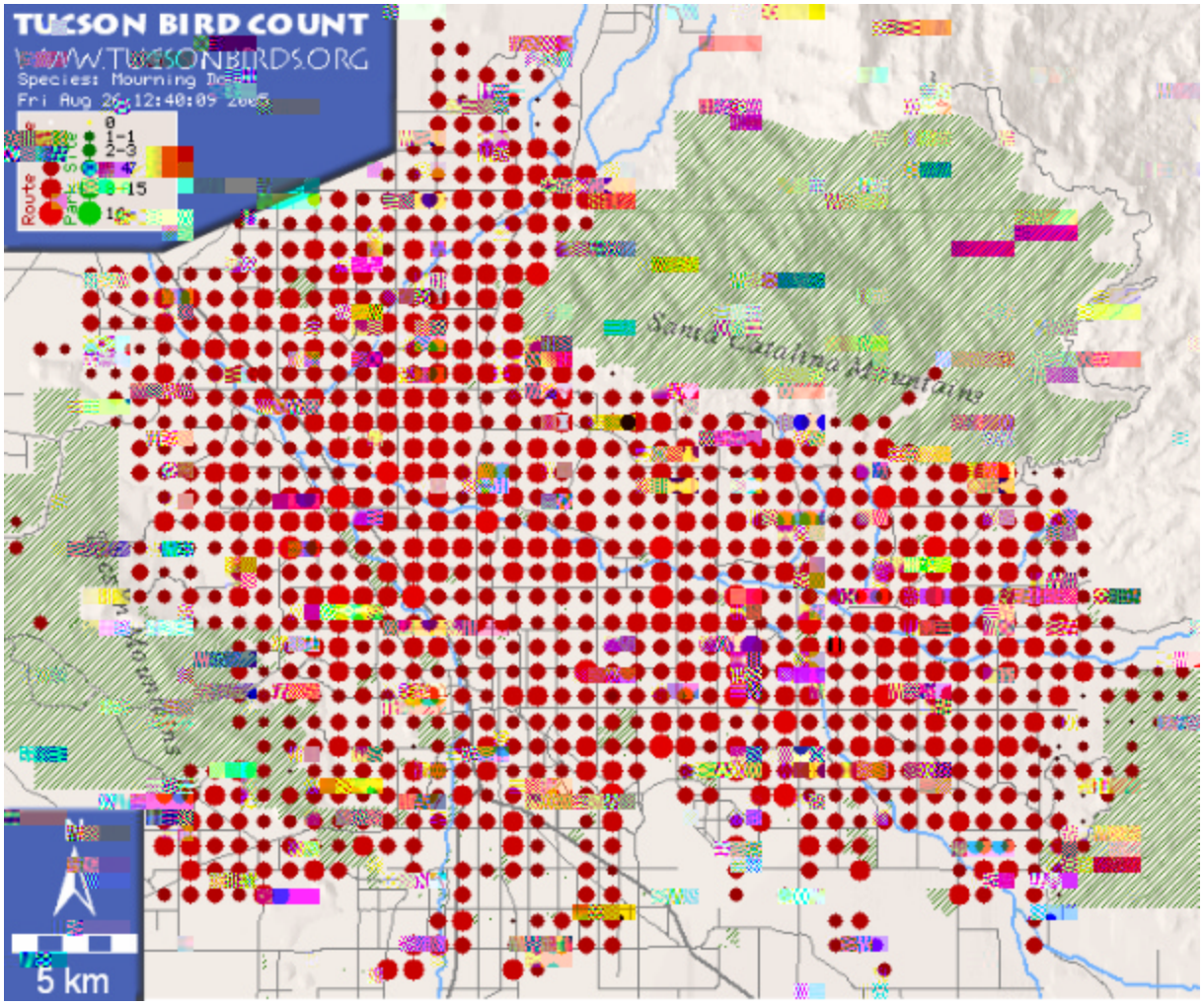


Figure 3. Distribution and abundance of rock pigeons across the Tucson Bird Count Route Program study area. Although actual survey site locations are randomly located within each 1-km² cell, results are shown at cell centers.

Figure 4. Distribution and abundance of mourning doves across the Tucson Bird Count Route Program study area. Although actual survey site locations are randomly located within each 1-km² cell, results are shown at cell centers.



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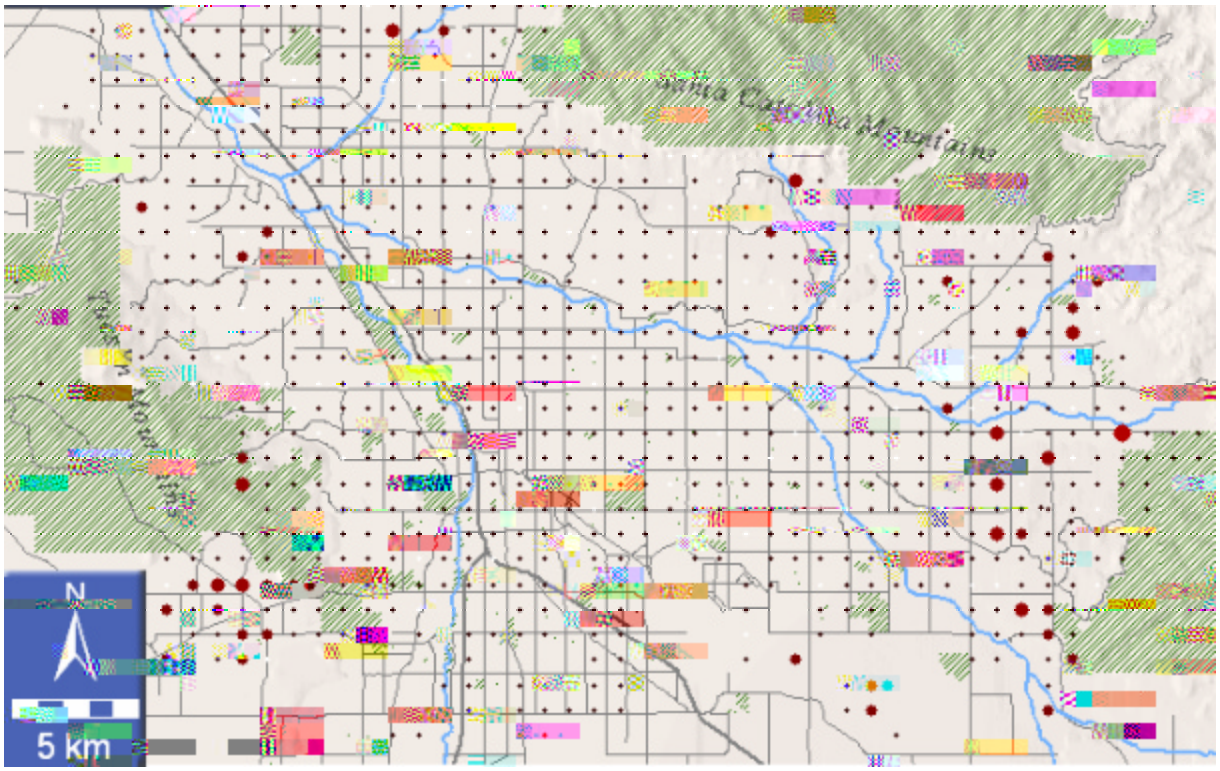

Figure 6. Distribution and abundance of American wigeon at the Tucson Bird Count Park Monitoring Program locations. Park locations are shown in yellow, with count results shown in green.