Creating a Successful Citizen Science Model to Detect and Report Invasive Species

TRAVIS GALLO AND DAMON WAITT

The Invaders of Texas program is a successful citizen science program in which volunteers survey and monitor invasive plants throughout Texas. Invasive plants are being introduced at alarming rates, and our limited knowledge about their distribution is a major cause for concern. The Invaders of Texas program trains citizen scientists to detect the arrival and dispersal of invasive plants in their local areas and to report them into an online, statewide mapping database. In order to test the value of citizen scientists' data, we compared Invaders of Texas citizen scientists' observations of Arundo donax *(giant reed) with previously recorded* A. donax *observations in Texas and found an increase in the reed's overall distribution. A comparison with observations from the Invasive Plant Atlas of New England, a similar citizen science program, confirmed that, given proper training, citizen scientists are able to detect and report invasive plants in their local areas, and the data they collect can be used by professional scientists.*

Keywords: citizen science, Texas, Arundo donax*, early detection, online mapping database*

Humans have surpassed natural forces as the chief global disperser of vascular plants, and the large volume of international commerce virtually guarantees that new weeds will turn up in new ranges (Mack and Lonsdale 2001). Potentially invasive species are being introduced into the United States at an alarming rate, and our knowledge of their actual distribution is limited. Invasive plants, animals, and fungi are the second-leading cause of native plant endangerment, exceeded only by habitat destruction and degradation, and influence biodiversity, aesthetics, recreation, and property value (Wilcove et al. 1998, Mack et al. 2000, Leung et al. 2002). The majority of plants used in agriculture, forestry, and horticulture in North America are not native to the continent (Reichard and White 2001). In the history of the United States, over 5000 nonnative invasive plants have been introduced for food crops, land restoration, erosion control, or ornamental purposes and have become established in our natural ecosystems (Morse et al. 1995). Some of these species have caused major economic loss in agriculture, forestry, and other segments of the US economy, not to mention grave harm to the environment through the displacement of native plant species (Pimentel et al. 2005). Invasive plants spread at a rate of 14% per year and, on public lands, consume 4600 acres of wildlife habitat per day (Babbitt 1998).

Cheatgrass (*Bromus tectorum*), an introduced plant that now covers millions of acres in western North America, illustrates how an invasive plant can outcompete and dominate native plants in a region (Rossman 2001). Because of the sporadic introductions and rapid spread of invasive plants, many resource managers, biologists, and policymakers have limited knowledge about the extent of infestation by invasive plants in their regions. For proper management of invasive species, there is not only a need for data on where they occur but also a need for that data to be freely and readily available to enable cost-effective responses by resource managers (Buhle et al. 2005, Delaney et al. 2008). Such information provides a quantitative rationale for policymakers to allocate society's resources most effectively and efficiently (Leung et al. 2002). We have created a model program in Texas that relies on citizen scientists to collect invasive species data, which is then recorded in a public database that resource managers can access for weed management, scientists can use for predicting weed distributions, and policymakers can use to understand the scope of invasive species problems.

Citizen scientists are volunteers who participate as field assistants in scientific studies (Cohn 2008). Citizen scientists currently play an active role in a wide range of ecological projects, and their contribution has enabled scientists to collect large amounts of data over wide areas at a minimal cost (McCaffrey 2005, Braschler 2009). Early citizen scientist programs were created merely as educational tools, but there has been a growing focus on using citizen scientists to collect long-term data. Many citizen scientist–based networks help address the needs of ecologists and scientists to collect data for large-scale projects, such as breeding bird surveys,

BioScience 61: 459–465. ISSN 0006-3568, electronic ISSN 1525-3244. doi:10.1525/bio.2011.61.6.8

Christmas bird counts, FeederWatch, Galaxy Zoo, REEF, and various other monitoring programs (Trumbull et al. 2000, Brewer 2002, Brossard et al. 2005, Lee et al. 2006, Cooper et al. 2007, Delaney et al. 2008, Bonney et al. 2009, Fitzpatrick et al. 2009, Sullivan et al. 2009). The Internet has broadened our capacity for public outreach; has made large-scale, real-time information sharing possible; and has been remarkably successful in advancing scientific knowledge (Bonney et al. 2009, Sullivan et al. 2009). Data from these citizen science–based projects have allowed organizations to track population data, create better distribution maps for species, and inform management decisions through published scientific literature (Bonney et al. 2009). Although citizen scientist programs are commonly used to survey and monitor native species, few have involved invasive species issues, and those that have were usually short term or focused on eradication efforts (Delaney et al. 2008, Galloway et al. 2009). The growing threat of invasive species has increasingly drawn attention to the importance of documenting the distribution and spread of introduced organisms (Fitzpatrick et al. 2009). The Invaders of Texas program is a successful citizen science initiative focused on long-term surveying and monitoring of invasive plants throughout Texas and contributes valuable data to help researchers better understand their distributions.

The Invaders of Texas program is a collaborative effort among the Lady Bird Johnson Wildflower Center, US Forest Service Forest Health Protection, the Texas Forest Service, the Texas Master Naturalists, and the Texas Parks and Wildlife Department. Invaders of Texas is an innovative program whereby citizen scientists are trained to detect the arrival and dispersal of invasive species in their own local areas and to report them into an online, statewide mapping database. The Invaders of Texas program is designed so that any time a person is engaged in an outdoor activity, he or she can collect distribution data. The program also raises awareness about invasive species in natural areas. The overarching goals of this program are to train a large, geographically distributed network of citizen scientists to find and report outbreaks of selected invasive species in Texas; to validate and use that data to develop maps of invasive species in order to improve our understanding of invasive species distributions in Texas; to create partnerships with and provide information to regional resource managers and agencies to control or eradicate invasive species; to provide opportunities for volunteers to help in these eradication efforts; and, through continuing education, to educate our volunteers to a level at which they can train the next generation of citizen scientists. Over the last five years, the program has created a network of citizen scientist teams, organized geographically into regional satellite groups. These satellite groups are connected to local resource managers, who coordinate appropriate responses in order to control the spread of unwanted invaders. The program was developed in 2005, and in 2006 and 2007, the program was introduced in 12 unique areas in Texas. In 2008 and 2009, we expanded the program by hiring a full-time coordinator and conducting 13 more training workshops, focused on the three ecoregions identified as having the highest priority in the Texas Wildlife Action Plan (Bender et al. 2005). In this article, we describe the Invaders of Texas program and show how the data obtained from citizen scientists can be used to further our knowledge about the distribution of invasive species in Texas.

The model: The satellite network and training

Regional teams, called *satellites*, are the foundation of the Invaders of Texas program (figure 1). Texas covers 266,807 square miles, and represents 8.8% of the US mainland; therefore, it would be impossible for a centralized organization to provide expert assistance to all citizen scientists. Each satellite has a volunteer leader, who is responsible for managing local issues, organizing and conducting workdays, and acting as the intermediary between the central coordinators and the satellite members. In addition, each satellite is connected to a local network, with local experts to help with local issues and to answer local questions. Our success can be attributed to the satellite network structure. Dedicated satellite leaders and strong satellite structure are essential in a state as large as Texas. To keep the citizen scientists engaged, it is important to facilitate a connection among local resource managers, professional scientists, and the citizen scientists (Fore et al. 2001), and the satellite network offers this connection.

Citizen scientist training workshops are organized by the satellite leader and administered by personnel from the Wildflower Center or the Texas Forest Service. The program recruits heavily from the Texas Master Naturalist program because that program is well established throughout Texas and its members are well versed in outdoor skills and knowledgeable about the local flora and fauna. The satellite leader is responsible for recruiting citizen scientists and locating a venue for the workshop. The satellite leader is also responsible for supplying specimens of 10–12 local invasive plant species that are commonly found and easy to identify. We have found that this approach allows people to become familiar with invasive species in their area and reduces the anxiety associated with trying to learn in one day how to identify a large number of invasive species.

All workshop participants attend a one- or two-day intensive training on the Invaders of Texas program using the 33-page Invaders of Texas training manual (*http://texasinvasives.org/invaders/toolkit.php*). The workshop participants are taught to identify local invasive plants, field safety, how to use a GPS (global positioning system) unit and digital camera, data collection and submission protocols, and how to submit the data into the online database. Once a participant has completed a workshop, he or she is free to create a personal profile and to start reporting invasive plants into the Invaders of Texas database.

In 2009, an online training program was created to recruit citizen scientists living in areas without established satellites or scheduled workshops. These recruits must complete eight

online training modules modeled after those in the Invaders of Texas training manual. Each module is accompanied by a quiz. Each recruit officially becomes a citizen scientist when all eight quizzes have been passed, and he or she can then log into a personal account and start reporting into the database.

Results of the satellite network and training. Since its inception in 2005, the Invaders of Texas program has conducted 36 workshops and trained over 870 volunteer citizen scientists. The citizen scientists have collectively logged over 3400 hours and submitted over 9000 species observations (table 1), which

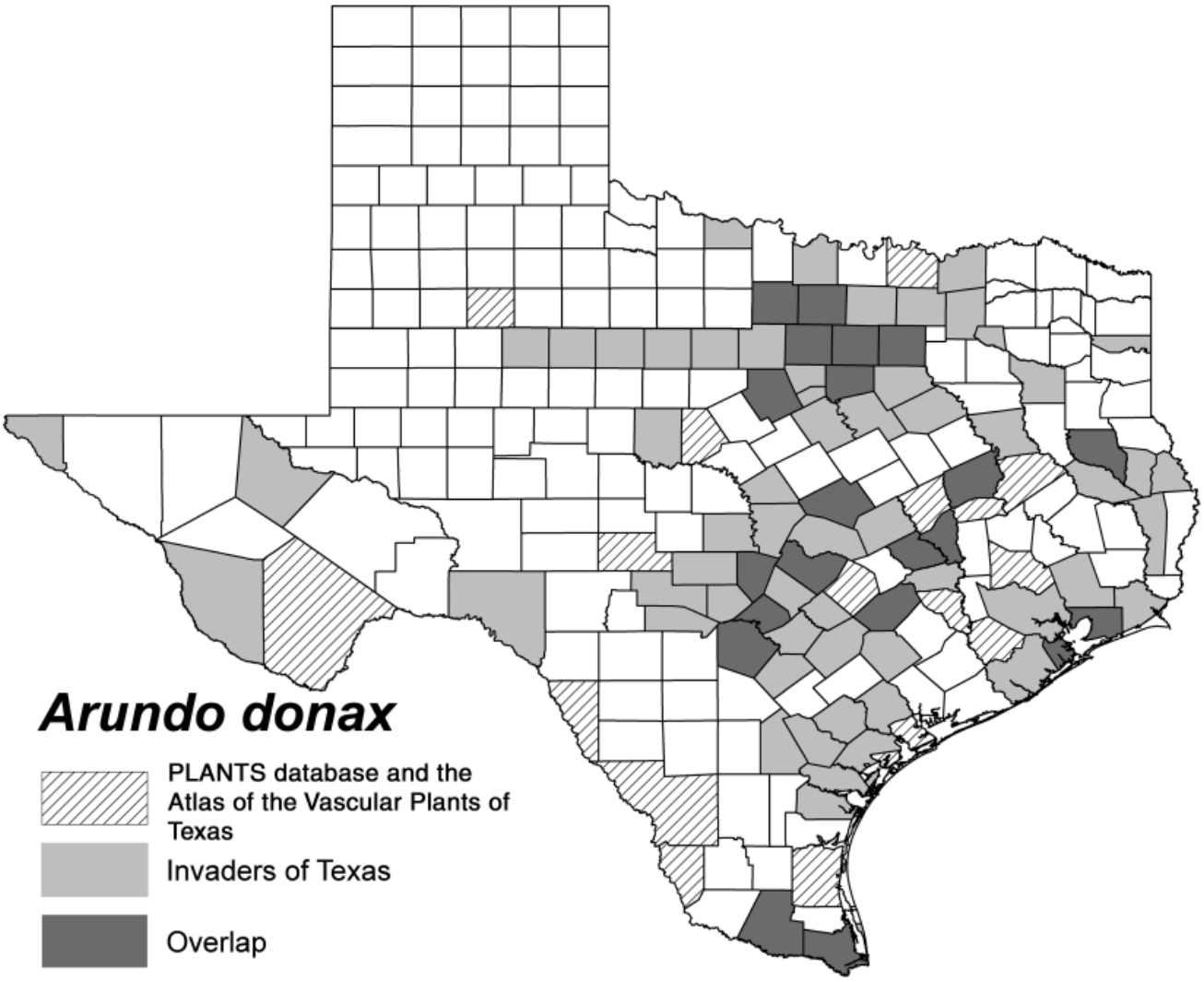

Figure 1. County map representing the increase in known county distribution of **Arundo donax** *compared with the PLANTS database and the Atlas of the Vascular Plants of Texas.*

Table 1. Yearly performance of the Invaders of Texas program.

Year	Workshops	Trained	Total	Observations	Hours
2005	1	19	19	270	412.67
2006	7	185	204	400	587.92
2007	6	70	274	1008	670.50
2008	4	75	349	3480	802.92
2009	13	353	702	3308	817.50
2010[a]	5	171	873	538	125.25
Total	36	873	—	9004	3416.75

[a] Through 31 April 2010

is approximately equivalent to $71,000 in saved labor cost (Independent Sector 2010).

To measure the degree to which the Invaders of Texas program engaged citizens in data collection, we looked at the total number of observations entered and the number of citizen scientists who entered observations more than once (Lee et al. 2006). On average, the Invaders of Texas program recruited 104 volunteers per year from 2005 to 2009. One full year with a full-time coordinator resulted in the recruitment of 338 citizen scientists. Of the total pool of citizen scientists, 37% have submitted more than one observation, 43% of the citizen scientists trained in workshops submitted observations, and only 9% of those trained through the online training submitted observations. The average contribution per active citizen scientist was 32 observations.

The Invaders of Texas program has successfully recruited a cadre of citizen scientists to detect and report invasive species throughout the state of Texas. The low retention rate of workshop attendees (43%) is probably a result of our recruiting from the Texas Master Naturalist program. The Master Naturalist program requires members to achieve many training hours, which they can accumulate by attending Invaders of Texas workshops. This encourages some participants to attend merely to achieve training hours and not to participate as citizen scientists after the workshop. However, we feel that the value of recruiting people already knowledgeable about local flora and fauna and well versed in outdoor and safety skills is worth the trade-off. The online training program was created not only to recruit citizen scientists but also to raise awareness about invasive species in Texas. The online training is open to the public, and there are no minimum requirements after finishing the online training, which may be the cause of the low retention rate of 9%. Citizen scientist programs are not just about the data. A key aim of these programs is to raise public awareness about the issues at hand; to create a learning atmosphere, which would result in new scientific understanding and personal perceptions of species, habitat, and conservation; and to raise awareness on the local level about invasive species, which may translate back into tangible participation by citizens (Brewer 2002, Evans et al. 2005, Braschler 2009). Therefore, the value of public outreach through the online training is well worth a low reporting rate.

Data collection and submission

For each invasive species occurrence, the citizen scientists record the species, the date of the observation, the amount of time spent in the field, the GPS coordinates, the amount of disturbance, the patch type, the abundance of the species, and notes about the location onto a field data sheet. These data, along with a digital image that is required for validation purposes, constitute a single species observation. On their return from the field, the citizen scientists log in and enter their field data into the database. In order to facilitate data entry, there is a one-to-one correspondence between the items on the field data sheet and those on the online data entry form. One lesson that we have learned is that citizen scientists are uncomfortable making advanced scientific decisions. Originally, the citizen scientists were required to report numerous ecological parameters for each observation, but this proved to be intimidating and resulted in fewer species observations. Because the primary goal for the program is to develop baseline maps of targeted invasive species, we scaled back the collection criteria in favor of more observations while still meeting the minimum standard of the North American Weed Management Association (NAWMA 2002). This change has proven effective and has increased the number of species observations submitted by the citizen scientists.

Citizen science–based projects have long been criticized for lacking scientific rigor and certified audits (Irwin 1995, McCaffrey 2005, Delaney et al. 2008, Fitzpatrick et al. 2009); therefore, all of the Invaders of Texas program's data are verified by experts with photographic evidence submitted using an online system devised for validation. After they are validated, all of the observations are made public through the database.

Invaders of Texas database

The Invaders of Texas database is supported by a fully functional Web application that performs three functions: (1) it serves as the data submission system for citizen scientists to log in and report their early-detection data (including image uploads), (2) it has a "behind the scenes" validation system so that the trained validators can edit or verify the species observations submitted by the volunteers, and (3) it provides an easily accessible venue for government and nongovernment organizations to freely export the citizen science data from the Web site. The Invaders of Texas mapping application uses a Google Maps interface (Google, Mountain View, California). This allows visitors to the Web site to view observations categorized by satellite or by species and to map individual species occurrences. This mapping system includes all of the functionality and ease of use provided by Google Maps, and all of the map points are linked to records in the database.

To better assist resource managers, scientists, and policymakers with their understanding of the distribution of invasive plants in Texas, all data collected by the citizen scientists are made publicly available at *www.texasinvasives.org*. The database includes a tool that allows the public to freely export the citizen science data from the Web site into Microsoft Excel. The data can then be easily converted to KML, XML, CVS, or MDB files and imported into any geographical information system for further analysis.

Testing the citizen science concept

Arundo donax (giant reed) was chosen for a test of the value of the Invaders of Texas citizen scientists' data. *Arundo donax* is easy to identify and common throughout Texas, making it a suitable candidate for testing. Observation data for *A. donax* were exported using the "Export this data to Excel"

function of the database. Using ArcGIS Version 9.3 (ESRI, Redlands, California), a shapefile of individual observations and a digital county map were created from the Invaders of Texas data. County records from the US Department of Agriculture (USDA) PLANTS database (USDA 2010) and the Atlas of the Vascular Plants of Texas (AVPT; Turner et al. 2003) were digitized using ArcGIS and combined to form one map of previously recorded counties. These previously recorded counties were compared with the citizen scientist data to determine how many counties recorded by the citizen scientists were not previously recorded by Turner and colleagues (2003) or the USDA (2010).

The citizen scientist data from the Invaders of Texas program contributed 412 observations of *A. donax*. In PLANTS and the AVPT, together, *A. donax* was recorded in 39 counties. The Invaders of Texas citizen scientists recorded *A. donax* in 80 counties, 58 of which were not recorded in PLANTS or the AVPT (see figure 1). These results increase the recorded distribution of *A. donax* in Texas by a factor of 1.5 relative to the distributions given by PLANTS and the AVPT.

This simple analysis highlights the fact that the Invaders of Texas citizen scientists are contributing valuable information to the scientific community about the distribution of invasive plants in Texas. Using the citizen science data, we showed that *A. donax* is more widespread than was previously noted, and that the actual distribution of an organism is valuable information to resource managers, scientists, and policymakers. These preliminary results demonstrate that using citizen scientists to perform data collection has the potential to increase the amount of information about invasive species distributions.

Similar citizen science programs

The Invasive Plant Atlas of New England (IPANE; Mehrhoff et al. 2003) is a similar, successful citizen science program for detecting invasive species. IPANE's mission is to create a comprehensive, Web-accessible database of invasive and potentially invasive plants in New England that will be continually updated by a network of professionals and trained volunteers (Mehrhoff et al. 2003). The Invasive Plant Atlas of the MidSouth (IPAMS; Victor Maddox, Department of Plant and Soil Science, Mississippi State University, personal communication, 12 January 2011) is a start-up citizen science program built around the IPANE model. Both IPANE and IPAMS cover a large area, much like the Invaders of Texas program, and they share many of the same challenges and successes. The Invaders of Texas and IPANE models are nearly identical. The major differences between the two are the amount of staff time each organization dedicates to the program, their degree of reliance on citizen scientists, the amount of direction given to the citizen scientists, and the amount of data on their field data sheets.

The Invaders of Texas program relies heavily on its volunteer satellite leaders through the satellite network and is run by only two paid staff members: one full-time coordinator and a part-time program director. IPANE does not have a regional satellite network and, therefore, dedicates more staff time to the program. IPANE has a half-time program coordinator and approximately six other staff members who contribute some time to the program (Sarah Treanor Bois, Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, personal communication, 13 January 2011). Both programs have a Web developer who is responsible for building their online systems and user interfaces.

The Invasive Plant Atlas of New England assigns its citizen scientists to public access areas within US Geological Survey quadrants (Mehrhoff et al. 2003), whereas the Invaders of Texas program does not direct its volunteers to specific locations but, instead, encourages the satellite leaders to make a connection with a local resource manager for access to public and private properties and also encourages more opportunistic observations. IPANE's method requires more staff involvement but ensures that all areas are eventually surveyed (Sarah Treanor Bois, Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, personal communication, 13 January 2011). The Invaders of Texas program requires less staff time to acquire the same data but runs the risk of an area's not being surveyed if a connection is not made between a local resource manager and the local satellite leader. Directing volunteers to a specific area also reduces the chances of an early detection of a new invader. Both programs resolve this problem by allowing the citizen scientists to record opportunistic observations outside their assigned areas. The two programs have a similar data sheet, which follows the standards put forth by the North American Weed Management Association (NAWMA 2002), although IPANE encourages its citizen scientists to collect absence data. By collecting absence data, the IPANE model creates a data set that is more useful to ecological modeling. According to Victor Maddox (Department of Plant and Soil Science, Mississippi State University, personal communication, 12 January 2011), the greatest challenge to starting IPAMS was working with state agencies and stakeholders in nearby states. As a single-state program, the Invaders of Texas program did not have to face these challenges.

The Invaders of Texas program, IPANE, and IPAMS are similar in their missions, but they differ in their approaches and goals. Each of them has created a well-rounded, efficient citizen science program to detect and report invasive species.

Conclusions

We have shown that, given proper training, citizen scientists are able to detect and report invasive plants in their local area, and with a working validation system in place, the data they collect can be used with confidence by professional scientists to perform their own analyses.

Through real-time communications and face-to-face interactions, citizen scientists make a personal connection

with local scientists and administrators (Evans et al. 2005). Dependable and repeated funding from state and federal partners has given the Invaders of Texas program stability and provided for a full-time coordinator to expand the program and respond to the needs of the citizen scientists and satellite leaders. A full-time coordinator who can focus solely on the program has increased recruitment of and contact with citizen scientists and has allowed the program to grow as a whole. Combining the Internet with a populace of trained citizen scientists can provide unprecedented opportunities to mobilize a community to address new environmental problems, in a sense creating the environmental equivalent of a "fire brigade," ready to act as the need arises (Cooper et al. 2007). Seamless integration among all program features (citizen scientists, satellites, and workshops) and the Web-based data entry and mapping systems allows us to effectively manage a large, geographically distributed network. The Invaders of Texas program can act as a model for other states that want to create their own "fire brigade" of citizen scientists to detect and report invasive species. The Invaders of Texas model could be easily adapted to other citizen science–based projects, such as urban forest surveys, rare plant monitoring, and so on.

In conservation biology and ecology, citizen science programs provide the opportunity to enlist the public to help survey entire landscapes over long periods of time (Sullivan et al. 2009). Future use of citizen scientists on a national level to collect invasive plant location data is essential to a better understanding of the spread of invasive species across the country. There is no reason that this could not be done in the near future. The Invaders of Texas program offers a successful model for other states to follow. A large-scale collaboration of states using citizen scientists to gather invasive plant data would allow for massive data collection and further understanding of the spread and distribution of important invasive plants. These data could be used in many other analyses, such as those of how fast invasive species are currently spreading and how and where they will likely spread in the wake of climate change.

Acknowledgments

This article is dedicated to the memory of Leslie "Les" Mehrhoff, a pioneer in citizen science. His recent passing is a significant loss to the scientific community and the battle against invasive species. The authors thank the Invaders of Texas citizen scientists for their hard work and dedication. We also thank Mike Murphrey, Marilyn Sallee, and Karan Rawlins for their continued efforts with trainings, validations, and recruitment; Ron Billings and Scott Large for offering insight and reviewing the manuscript; Philip Hawkins for building the online interface and continued technical support; both Sarah Treanor Bois from the Invasive Plant Atlas of New England and Victor Maddox from the Invasive Plant Atlas of the MidSouth for taking the time to talk on the phone about their programs; and, finally, we would like to thank the Texas Parks and Wildlife Department's Horned Lizard License Plant Conservation Fund, the US Forest Service Forest Health Protection, and the Texas Forest Service for financial support.

References cited

Babbitt B. 1998. Statement by secretary of the interior on invasive alien species. Paper presented at the National Weed Symposium; 8–10 April 1998, Denver, Colorado.

Bender S, Shelton S, Bender KC, Kalmbach A, eds. 2005. Texas Wildlife Action Plan: 2005–2010. Texas Parks and Wildlife Department.

Bonney R, Cooper CB, Dickinson J, Kelling S, Phillips T, Rosenberg KV, Shirk J. 2009. Citizen science: A developing tool for expanding science knowledge and scientific literacy. BioScience 59: 977–984.

Braschler B. 2009. Successfully implementing a citizen-scientist approach to insect monitoring in a resource-poor country. BioScience 59: 103–104.

Brewer C. 2002. Outreach and partnership programs for conservation education where endangered species conservation and research occur. Conservation Biology 16: 4–6.

Brossard D, Lewenstein B, Bonney R. 2005. Scientific knowledge and attitude change: The impact of a citizen science project. International Journal of Science Education 27: 1099–1121.

Buhle ER, Margolis M, Ruesink JL. 2005. Bang for buck: Cost-effective control of invasive species with different life histories. Ecological Economics 52: 355–366.

Cohn JP. 2008. Citizen science: Can volunteers do real research? BioScience 58: 192–197.

Cooper CB, Dickinson J, Phillips T, Bonney R. 2007. Citizen science as a tool for conservation in residential ecosystems. Ecology and Society 12: 11–21.

Delaney DG, Sperling CD, Adams CS, Leung B. 2008. Marine invasive species: Validation of citizen science and implications for national monitoring networks. Biological Invasions 10: 117–128.

Evans C, Abrams E, Reitsma R, Roux K, Salmonsen L, Marra PP. 2005. The Neighborhood Nestwatch program: Participant outcomes of a citizen-science ecological research project. Conservation Biology 19: 589–594.

Fitzpatrick MC, Preisser EL, Ellison AM, Elkinton JS. 2009. Observer bias and the detection of low-density populations. Ecological Applications 19: 1673–1679.

Fore LS, Paulsen K, O'Laughlin K. 2001. Assessing the performance of volunteers in monitoring streams. Freshwater Biology 46: 109–123.

Galloway AWE, Tudor MT, Vander Haegen WM. 2009. The reliability of citizen science: A case study of Oregon white oak stand surveys. Wildlife Society Bulletin 34: 1425–1429.

Independent Sector. 2010. Value of volunteer time. (18 March 2010; *www.independentsector.org/volunteer_time*)

Irwin A. 1995. Citizen Science: A Study of People, Expertise, and Sustainable Development. Routledge.

Lee T, Quinn MS, Duke D. 2006. Citizen, science, highways, and wildlife: Using a Web-based GIS to engage citizens in collecting wildlife information. Ecology and Society 11: 11.

Leung B, Lodge DM, Finnoff D, Shogren JF, Lewis MA, Lamberti G. 2002. An ounce of prevention or a pound of cure: Bioeconomic risk analysis of invasive species. Proceedings of the Royal Society B 269: 2407–2413.

Mack RN, Lonsdale WM. 2001. Humans as global plant dispersers: Getting more than we bargained for. BioScience 51: 95–102.

Mack RN, Simberloff D, Lonsdale WM, Evans H, Clout M, Bazzaz FA. 2000. Biotic invasions: Causes, epidemiology, global consequences, and control. Ecological Applications 10: 689–710.

McCaffrey RE. 2005. Using citizen science in urban bird studies. Urban Habitats 3: 70–86.

Mehrhoff LJ, Silander JA, Leicht SA, Mosher ES, Tabak NM. 2003. IPANE: Invasive Plant Atlas of New England. Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs. (18 March 2011; *http://nbii-nin.ciesin.columbia.edu/ipane/*)

Morse LE, Kartesz JT, Kutner LS. 1995. Native vascular plants. Pages 205–209 in LaRoe ET, Farris GS, Puckett CE, Doran PD, Mac MJ, eds. Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals and Ecosystems. US Department of the Interior, National Biological Services.

[NAWMA] North American Weed Management Association. 2002. North American Invasive Plant Mapping Standards. (18 March 2010; *www.nawma.org/Mapping/MappingMain.pdf*)

Pimentel D, Zuniga R, Monison D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52: 273–288.

Reichard SH, White P. 2001. Horticulture as a pathway of invasive plant introductions in the United States. BioScience 51: 103–113.

Rossman AY. 2001. A special issue on global movement of invasive plants and fungi. BioScience 51: 93–94.

Sullivan BL, Wood CL, Iliff MJ, Bonney RE, Fink D, Kelling S. 2009. eBird: A citizen-based bird observation network in the biological sciences. Biological Conservation 142: 2282–2292.

Trumbull DJ, Bonney R, Bascom D, Cabral A. 2000. Thinking scientifically during participation in a citizen-science project. Science Education 84: 265–275.

Turner BL, Nichols H, Denny GC, Doron O. 2003. Atlas of the Vascular Plants of Texas. BRIT Press.

[USDA] US Department of Agriculture. 2010. The PLANTS Database. (18 March 2010; *http://plants.usda.gov/java/*)

Wilcove DS, Rothstein D, Dubow J, Phillips A, Losos E. 1998. Quantifying threats to imperiled species in the United States: Assessing the relative importance of habitat destruction, alien species, pollution, overexploitation, and disease. BioScience 48: 607–615.

Travis Gallo (tgallo@wildflower.org) is an ecologist, and Damon Waitt (dwaitt@wildflower.org) is the senior botanist, at the Lady Bird Johnson Wildflower Center at the University of Texas at Austin. Damon Waitt is also the founder, creator, and current program director of the Invaders of Texas program. Travis Gallo is the program coordinator and runs the day-to-day operations of the program.