CITIZEN SCIENCE:
THEORY AND PRACTICE

The Strategic Use of Multimedia in the Great Georgia Pollinator Census Citizen Science Project

CASE STUDIES

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ABSTRACT

In August of 2019, citizens from across the state of Georgia, USA, participated in the Great Georgia Pollinator Census (GGaPC). This University of Georgia Extension initiative recruited citizen scientists to count for 15 minutes the number and types of insects visiting pollinator plants. The project was web based and used multiple media strategies to recruit citizen scientists, to educate the participants on the entomology required, and to collect the data generated. WordPress website-building software allowed us to create the project website (*GGaPC.org*). This served as the center of the project as it contained project details and educational materials as well as the portal for uploading count data. The social media outlets Facebook and Instagram were used to promote the project and to provide insect identification and pollinator education, and social media memes were created easily using Canva software. MailChimp emailing services assisted us in providing educational e-newsletters and local counting event newsletters to participants and partners. The Zoom online meeting platform allowed our team to meet with partners and Extension offices across the state to share resources and to plan events. More than 4,600 counts were uploaded, documenting more than 131,000 insect visits tallied from 134 Georgia counties including 135 schools. Multimedia tools allowed us to conduct the project with limited personnel on a small budget while providing comprehensive participant education and an extensive project reach.

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INTRODUCTION

Interest in pollinating insects is high worldwide, and we have seen that interest in our state of Georgia, USA. A University of Georgia Extension outreach program demonstrated the interest of Georgians in pollinator conservation (Griffin and Braman 2018). Georgia estimates for pollination services are US$367 million annually, so the interest is not only ecological but also economical (Barfield et al. 2015). Educating Georgia citizens on pollinator health while generating a baseline of Georgia pollinator populations were determined to be dual priorities for the University of Georgia Extension. Additionally, there has been tremendous growth in the use of citizen science for documenting insect pollinator numbers. The Bumble Bee Watch project records populations of bumble bees (*https://bumblebeewatch.org*), and Monarchs Across Georgia documents monarch migration (*https://eealliance.org/monarch-across-ga*). Citizen scientists take ownership of these projects and feel a personal stake in the subject (Miller-Rushing et al. 2012). This empowerment may translate into increased conservation activities (Kelly et al. 2019).

Past citizen science identifies barriers to the generation of useable data when working with insects. Recruiting participants who are interested and who have some experience with insects can improve data quality (Birkin and Goulson 2015). Engaged citizen scientists are a more cost-effective way to conduct a project than employing professional scientists (Gardiner et al. 2012). For the Great Georgia Pollinator Census (GGaPC), effective recruitment and training in insect identification using multiple educational outlets was imperative to project success (Ratnieks et al. 2016). The project design is a compromise between creating an ideal statistical model of data generation and making the project straightforward enough to recruit the citizen scientists (Pocock et al. 2015).

With the strategic use of multimedia and web-based technology, the statewide GGaPC citizen science project was designed with limited dedicated personnel and a low budget, covering a state with over 59 K square miles and a population of more than 10.3 million (US Census Bureau 2020). The core team consisted of a project coordinator, an information technologist, a graphic artist, and a graduate student experienced in multimedia. All team members had job duties outside of this project, so its success was also dependent on the involvement of project partners who promoted the project and hosted, for example, pollinator gardening classes and counting events. These partners were not only other academic institutions but public gardens, civic groups, and businesses. The budget consisted of the salaries of the team, and the cost of the website server and the printing of graphics material. The GGaPC can be used as a model for projects in which multimedia strategies maximize the project's reach and potential impact while minimizing funds and necessary personnel.

PROJECT GOALS

We defined three goals for the project:

- To increase pollinator habitat across the state. We know that bee decline has been linked to habitat loss and fragmentation (Hicks et al. 2016; Potts et al. 2006). A statewide effort to increase pollinator habitat could be important to bee conservation. We also know that gardeners who identify with being environmentally friendly are motivated to make proper plant choices (Kiesling and Manning 2010). University of Georgia Extension professionals work in assisting these gardeners in choosing plants suitable for their ecosystem with few disease and pest insect issues. Even gardeners with a suitable pollinator flower garden often do not understand the nesting needs of insects, and their landscape may have no nesting materials or nesting habitat available. Increasing pollinator gardens used for education within schools and communities can also have a positive impact on citizen attitudes about biodiversity conservation (Zelenika et. al 2018). With a focused initiative, sustainable pollinator habitat could be increased in our state.
- To improve the entomological literacy of the citizen scientists to enable potential interest in pollinator conservation. University of Georgia Extension professionals find that many of their clients identify only the honey bee as a pollinator, overlooking the hundreds of native bees and other pollinators that pollinate flowers and crops. They struggle with insect identification and cannot differentiate between a pest insect and a beneficial one. Research done by Lander (2020) showed how these types of projects could impact participants in behavioral and cognitive ways. They learn as they participate, and as a result their behavior changes to reflect what they learn. For our project, we were hopeful that as participants went through the process of preparing for the Census they would become more interested in pollinators, would learn about them, and would eventually became pollinator advocates. Through projects like GGaPC, citizen scientists are empowered to share their new knowledge with others in their communities, and the impact of the project spreads (Hsu and Nourbakhsh 2020). Citizen science and community science often go hand-in-hand (Dosemagen and Parker 2019). Although entomology is listed in Georgia education standards, science educators are not often trained in entomology

and might not be comfortable teaching the subject. GGaPC aimed to increase educator resources and teacher confidence in the subject. Research done by Schönfelder and Bogner (2018) using honey bee hives shows that exposing students to insects in a positive way, overcoming perceived danger and fear, can result in increased interest in bees and their plight. This increase in bee interest can be true for educators as well as students. During the 2013–2014 school year, Georgia had 1,583 Title 1 schools—those identified as having a high percentage of their student population from low-income households (Georgia Department of Education 2014). We believed that educators would welcome a project that provided resources to all teachers for teaching pollinator entomology, as well as provided a free, or low-cost, science, technology, engineering, and math (STEM) program to Title 1 schools. As other citizen science projects have shown, the GGaPC could serve as a catalyst for environmental activism within the schools and at students' homes (Dosemagen and Parker 2019).

- To generate useful data on pollinator population numbers in our state. As of 2019, there was no baseline pollinator population data that included several different insect species. This baseline data is necessary to assess any pollinator population change (Roublik 2001). In the future, the data could be used to determine population change in conjunction with weather fluctuations such as temperature extremes, drought, etc. It could also be used to look at differences between geographic locations. Since we asked participants to count on a favorite pollinator plant, this data can also be used to determine species of plants that are attractive to pollinators.

The GGaPC initiative was primarily a web-based project, meaning that the project was housed on a website instead of a physical location. Using web-based technology allowed us to involve more participants over a wider geographic area than if the project coordinator needed to be at each location. This approach enabled us to provide more resources and more interaction with fewer personnel and less funding.

METHODS

PILOT PROJECTS

To design a successful statewide pollinator counting project, we conducted two years of pilot projects in 2017 and 2018 (Griffin and Braman in review). The basic protocol used in 2017 was repeated in 2018. In 2017, we recruited fifty interested school and community garden leaders to participate. All of them indicated an interest in increasing their knowledge and being active participants. The centerpiece of our education efforts was the creation of our *Insect Identification and Counting Guide*. It was filled with insect photos and easy identification clues such as insect size and morphology. It was delivered to participants by email, and it could be easily shared and printed. We supplemented participants' education with online training and one-on-one consulting. The training included insect identification, counting methodology, and data submission.

Citizen scientists were asked to count for ten minutes, two times per week, for four weeks in September. the number of insects that landed on a favorite pollinator plant. September was chosen to accommodate schools in a month in which Georgia community gardeners remain active. Insects' favorite plants were defined as plants that showed heightened insect activity. Teachers supervised student participants and submitted only verified counts.

During the 2017 counts, a hurricane destroyed some pollinator gardens and limited counting activity. Several schools had a scheduled break during this period, and no counting was conducted for that week. This reinforced the need for a shorter project during a time of fewer scheduling conflicts. The project perimeters were the same for the 2018 pilot project with the same project participants during the same fall time period.

The pilot project was successful, and per Pockock et al. (2015), we considered what we'd learned about the interests and needs of the participants as we designed the GGaPC. To increase effectiveness in a statewide project, we planned to shorten the overall duration, increase interaction with the support team, and set aside shorter dedicated observation times.

After feedback from participants and data analysis from the two pilot project years, we adjusted the project for a statewide audience. We determined the best way to generate useful data while expecting accurate counts was to ask participants to count the number of insects that landed on one pollinator plant and put those insects into one of eight categories:

- carpenter bees
- bumble bees
- honey bees
- small bees
- wasps
- flies
- butterflies
- other insects

We also determined that fall was the appropriate time for school groups to be able to participate with no competing

field trips or standardized testing. However, we moved the counting dates up in the calendar to August 23rd and 24th to avoid any school breaks and to decrease the chances that inclement weather would affect participation. In addition, pollinator plants bloom across the entire state at that time, enabling participants to easily locate a plant for counting. Please note that in these projects our participants were volunteers who uploaded their own data, so no form of consent was necessary.

BRANDING

The term "brand" in reference to the GGaPC encompasses its over all identity and public image. Many tools were created to promote the brand. Following the ideas presented by Bastos and Levy (2012) in their re-evaluation of branding practice and theory, symbols were created to help serve as brand indicators. These symbols included a logo and insect mascots created by the University of Georgia's Office of Communication and Creative Services, shown in ***Figure 1***. The mascots were simple colorful depictions of various pollinators that included a bee, a moth, a fly, a beetle, and a butterfly. The mascots and logo were used on all types of online media, as well as on bookmarks, flyers, hats, and stickers. The advantage of the simplicity of the mascots and the logo is in their re-usability. As brand markers, these symbols can be used again in the future to re-establish the project's identity as long as the project continues.

Several online-specific strategies were implemented to boost engagement and awareness. The domain name *GGaPC.org* was chosen for ease of memory and name length. The hashtag #GaPollinators was encouraged, and the slogan "Be part of Georgia pollinator history" was used from the beginning of the project. Guidelines on successful hashtag use, as presented by Saxton et. al (2015), include using a non-generic hashtag and using the positive community engagement of that hashtag to help promote the cause. #GaPollinators was selected to avoid being too generic without being so specific as to be obscure and interfere with the organic growth of the hashtag on social media. The slogan was chosen to generate excitement and to allow the participants to feel they were a part of something significant and vital. This encouragement of community sharing and engagement was used in turn to help promote the positive growth of the hashtag and brand. We also wanted to emphasize the positive nature of this project to steer the initiative away from the negativity often seen in conservation issues. Instead of focusing on problems that needed to be fixed, we wanted to promote positive change through community effort as part of our brand. Our media campaign did not stress pollinator insect decline but instead emphasized the positive gains in planting pollinator habitat, learning about insects, and recording their numbers.

Figure 1 The project logo was colorful and contained insect mascots that could be used independently.

Additional multimedia content and tools were created and chosen in line with the positive community-oriented feel of the brand. These included social media memes, short videos, and educationally focused themed social media weeks. Since much of the brand's implementation and expansion was created and nurtured online, the importance of the online media tools should not be understated. Online platforms were a key construct of the project's brand strategy.

PROJECT WEBSITE

For the GGaPC, the website domain (*https://GGaPC.org)* was secured and the site was created through WordPress (version 5.2.5) and with the use of the plug-in Elementor (Pro 2.7.3). With the assistance of an information technology (IT) professional and using online instruction, the project coordinator was able to create and maintain the content of the website. Both WordPress and Elementor were straightforward and not difficult for a non-IT person to customize. The resulting webpage was attractive but still easy to manipulate. An IT professional was secured to provide website security and to handle server issues as well as answer technical questions.

The public website contained four pages: a home page, an educator page, an event page, and a frequently-asked-questions page. The home page contained a form that enabled citizens to enroll in the project. Those who enrolled received a monthly educational e-newsletter created through the MailChimp email service (*mailchimp.com*). The newsletters covered topics such as differentiating between insects, creating a sustainable pollinator garden, learning what bees are native to Georgia, and timing of butterfly migration. The project coordinator used the information from the sign-up list to determine where to recruit counters for the project. In areas of Georgia that had fewer sign-ups, we worked with the local UGA Extension office and project partners to promote GGaPC through social media, local contacts, and even newspaper stories.

To generate excitement, a clock that counted down the days until the Census began was embedded in the

website. An updated *Insect Counting and Identification Guide* was available on the front page as well. Using what was learned from the pilot projects, we updated this guide with an increased number of photographs as well as more deliberate insect descriptions. The guide could be downloaded, printed, and shared. Our slogan, "Be part of Georgia pollinator history," was repeated throughout the website.

The educator page contained a focused lesson plan created by one of our pilot project educators with links to other curricula. Additional resources were added to make this initiative a no-cost STEM program for schools with pollinator gardens. All materials were easily downloadable and printable. Examples of how to tie the disciplines to the project were covered. Designing native bee nest boxes was an engineering project. Creating insect haiku poetry tied the project to language arts. Insect origami and photography were art projects. Linking the project to math involved graphing insect counts and comparing the numbers of each insect type.

The events page was updated regularly with details on a variety of participatory opportunities such as workshops on building pollinator habitat and identifying insects, and practice pollinator counts, which were hosted by the University of Georgia Extension personnel and other partners.

Local search engine optimization (SEO) was used to promote engagement through organic web searches for Georgia residents. Mobile usage during the Census was anticipated to be significant, so the site was developed with a mobile-first mentality. This made it easier for anyone to interact with the Census at any stage regardless of where they were connecting.

As the Census grew in visibility, attention from a larger audience brought increasingly aggressive attempts to access the internals of the website. To increase security, we built the site on an affordable Virtual Private Server and isolated the WordPress installation from all other sites. The forms were stress tested and utilized a honeypot mechanism to reject any entries by automated bots. This added multiple layers of control to reduce potential cyber attacks. The server and all of the website information were moved to a hardened, more secure hosting infrastructure.

PROJECT PARTNERS

Stakeholders were recruited as project partners and included other academic institutions, public gardens, public service organizations, non-profit groups, and private businesses. Callaway Gardens, Bee City USA, Georgia Native Plant Society, University of North Georgia, Georgia Department of Natural Resources, Environmental Resources Management, and The Garden Club of Georgia all participated as project partners. Partners were asked to engage in promotion through their social media outlets and in their work, and they were encouraged to host in-person workshops and events relevant to pollinator health. They conducted workshops on pollinator gardens, insect identification, and bee health using resources we provided for them as well as their own materials. For example, a group of University of Georgia Extension agents from several small counties coordinated their resources to host events on pollinator gardening, bee home creation, and insect identification; partners from the University of North Georgia hosted a public workshop focused on native bees; and a professor from Georgia Tech led the creation of an on-campus milkweed garden.

Partners created their unique Census counting events held on the designated counting days. Some hosted public events during which counters visited the gardens and led a workshop or gave a tour of the garden and then provided their participants with assistance in counting. Others invited volunteers or public officials for a private guided count. We found that some participants felt more assured in their counting with support from more experienced entomologists, and enjoyed participating in a group setting. Personnel from Callaway Gardens hosted a public group count at which participants learned more about that garden and visitors received assistance in Census counting. The project coordinator hosted a private event, inviting valued volunteers for a unique day of bee home building and guided counting at the Georgia Mountain Research and Education Center. The organization of the partner program allowed for flexibly for all partners to benefit from being part of the program. Many partners reported that they had new visitors to their properties because of the Census and that they were able to expand their outreach.

All partner workshops and events were promoted on the project website and through project social media. A monthly partner e-newsletter was sent to each partner using the MailChimp email service. MailChimp allowed the project coordinator to customize the newsletters using project logos and to schedule delivery of the newsletters so that they could be written in advance. These partner newsletters contained information on the progress of the project as well as educational materials that could be used in their workshops and links to social media memes. All partners were given access to project logos for their use and were encouraged to use the project hashtag, #GaPollinators. The use of a hashtag allowed us to track the scope of the project.

The project coordinator made a personal visit to several partners to create joint promotional videos and social media memes that focused not only on the Census, but on the work done by the partners as well. The director

of Georgia Tech's Urban Bee Lab joined the Census coordinator in an original promotional video that was used at Georgia Tech and at the University of Georgia (*https://vimeo.com/324983253*). Several of these worked with their local county University of Georgia Extension offices to hold joint events. It is important to note that the use of project partners increased the success of the project. They became an active part of the project by recruiting participants, training counters, and facilitating data uploads. Project partners were basically giving the same educational training that the main project staff were giving. This train-the-trainer aspect meant that the scope of our project was wider without an increase in our staff or our funds. The project partners were able to use the project to showcase their gardens or mission as their recompense.

EXPANSION OF MULTIMEDIA

The effectiveness of a citizen science project requires frequent communication with participants using educational tools (Pocock et al. 2015). While going through a citizen science project together, organizers and participants can develop strong relationships that can remain impactful past the life of the project (Hsu and Nourbakshsh 2020). Building relationships with our participants was considered as our project team developed a strategic plan for using social media, our e-newsletters, and website features for coordinated information sharing and education throughout the months leading up to the actual Census.

To determine what social media platform would be most valuable to teachers, we polled them using email. Results showed the social media Facebook platform was especially popular with teachers. Teachers indicated that they viewed it as a way to share with school administrators and parents what their classes were engaged in learning. The Facebook group, Georgia Pollinator Census, was created for participants to post photos of their activities leading up to the Census, such as pollinator garden creation and pictures of their Census counting. We also used it as a way for participants to pose questions to the project coordinator. University of Georgia entomologists were involved in the Facebook group, available to answer questions and create posts. We used the platform Instagram, with the name @GaPollinators. Facebook allowed us to share videos, to encourage others to post photos, to pose questions, and to create polls that facilitated participant involvement.

Facebook and other social media platforms also allow page administrators to generate page analytics—how many likes, comments, and shares a post gets, as well as information on group membership growth (*analytics.facebook.com*). We used Facebook program analytics to gauge the success of our social media efforts and adjusted accordingly. If analytics showed that posts with very detailed entomology were not liked, commented on, or shared, we adjusted our level of detail in the next post. Our WordPress website and MailChimp gave similar analytics, letting us know how many people visited the website and how many newsletter recipients opened each newsletter.

Using our strategic media plan, we began in January, 2019 featuring University of Georgia researchers and their work in insect conservation on all of our media platforms. This was a way for the audience to get to know the people behind the research. We featured our partner organizations and shared their insect research as well. We found, anecdotally and through Facebook program analytics, that our posts would be shared on other university social media pages, on our partners' pages, and on our participants' pages. This gave our outreach a much-expanded audience without an increase in project personnel or funding.

In the March of 2019, we focused our educational pieces on creating sustainable pollinator habitat in Georgia's ecosystems using topics such as plant selection, seed starting, soil nutrition, and best garden management practices. Plants traditionally blooming in August, during Census time, were emphasized. Example gardens were shown through photos and videos. Partners such as the Georgia Native Plant Society and the University of Georgia Horticultural Department shared their plant recommendations, and several plant professionals were videoed supporting the Census and promoting their favorite pollinator plants. Social media is effective when it features real people and becomes relatable, and we found, according to Facebook analytics, that our participants responded to our efforts with increased post engagement (Grissa, 2017).

We hosted themed weeks on our Facebook page. For example, we had a milkweed-themed week in January in which we showed step-by-step how to prepare and plant milkweed seed, a larval plant for the Monarch butterfly. We featured professionals from several partners demonstrating seed starting techniques, and educated participants on what type of milkweed plants were appropriate for their area of Georgia.

As spring approached, our content focused on best planting practices, and participants posted photos of their new gardens on our social media pages. Toward summer, our focus shifted to the insect identification that would be needed for successful participation in the Census. Each week, we emphasized a different identification skill. For example, we taught the differences between a bee and a fly, showing the differences with photographs and videos of live insects. We focused on a few key elements that were not overly difficult to understand but would equip citizen scientists with the education they needed to generate useful data during the Census.

Canva publishing design website (*Canva.com*) was used to create #FunFactFridays. Canva is an online tool that allows the user to upload photos and generate text on a template social media meme. It takes just minutes to upload a photo and create content using this platform. Our #FunFactFridays were more detailed than our other posts. They shared educational snippets such as how wing venation is used in species insect identification and how bees use tarsal claws. We heard from educators and teachers that these posts were used on classroom smartboards and on garden webpages.

We took advantage of Facebook's polling function to create identification quizzes, which allowed the project coordinator to know which identification areas needed revisiting.

As the project progressed, the Facebook group grew to more than 1,000 members. This allowed us to do some additional informal citizen science using the polling function. During butterfly migration, we were able to poll our group members to see how many of them were seeing butterflies and in what amounts. This information was gathered very quickly and was useful to our partner, the North American Butterfly Association.

Leading up to the counting days, the project coordinator was available to visit garden groups and classrooms through the Zoom online meeting platform (*Zoom.com*). Zoom was chosen for its ease of use and popularity with school personnel. Several school groups took advantage of this offer, and the coordinator met with several classrooms to answer questions, learn about each school's pollinator garden, and show live insects. Zoom was also used to train University of Georgia Extension personnel on the project and to train teachers during the summer prior to the Census. Partner meetings were also conducted through the Zoom platform. Additionally, throughout the year, traditional newspapers, radio broadcasts, and online news outlets covered the project.

Three weeks before the Census dates, we educated participants on the actual counting process. In addition to insect counts, we asked the citizen scientists to record air temperature, weather conditions, their garden location and size, and whether or not honey bees were in the area. We wanted the participants to know why we were asking these questions and to expect them. We also wanted to let counters know of group events hosted by our project partners so that citizens with less certainty on their insect identification skills could join with others to participate.

The GGaPC project counting days were only August 23rd and 24th, a Friday and a Saturday. Each participant counted insects on a favorite pollinator plant for 15 minutes and to put these insects into one of eight categories. On the morning of the first counting day, we opened the webpage portal for participants to upload their counts. The portal was easily reached by one click from the project home page. The WordPress platform allowed us to create the form quickly and made it simple for counters to record their counts. On the data reporting portal, participants were led through a duplicate of the tally sheet that was included for download on the website. Questions asked as participants uploaded their data were ("*" means the answers were required):

- Participant's name*
- Email address*
- County where garden used for counting is located*
- Address of garden (for future garden mapping project)
- City of garden*
- Zip code of garden*
- How large is your garden? (Choices: Small [<1/4 of an acre]; Medium [>1/4 of an acre but less than 1 acre]; Large [>1 acre])*
- If you are counting as part of a school, an event or with a group please list the name or location of the event?
- Date of Count*
- Time at the start of your count*
- Air temperature at time of counting (in Fahrenheit)*
- Weather conditions at the time of counting (Choices: Sunny, Partly Sunny, Cloudy, Rainy)
- Common name of pollinator plant used for counting*
- Scientific name of pollinator plant used for counting (if known)
- Number of carpenter bees seen*
- Number of bumble bees seen*
- Number of honey bees seen*
- Number of small bees seen*
- Number of wasps seen*
- Number of flies seen*
- Number of butterflies/moths seen*
- Number of other insects seen*
- Are there honey bees within five miles of your garden? (Choices: I don't know, Yes, No)
- Did you create or add to a pollinator in preparation for this Census? (Choices: Yes, No)
- If you are an educator did you include the Census as part of a STEM program? (Choices: Yes, No)
- Did participating in this Census change your understanding of the benefits provided by the insects that visit your garden? (Choices: Yes, very much; Yes, moderately so; Undecided; No, not very much at all; No, not at all)
- Give us one fantastic fact you learned by participating in the Census
- Please give us any suggestions on how we could improve the Census

Several of these questions, such as those about weather and the location of honey bee hives, were asked for

possible future research. Impact and evaluation feedback were built into the questions. The WordPress form presented the results in real time, and we were able to build a spreadsheet with the results using the WordPress programming.

Throughout the counting days, the project coordinator and University of Georgia entomologists were available through email, text, and social media for questions. Our information technologist was available in case of a technological or web-based issue. During the second day of the counting project, the coordinator conducted a Facebook Live session demonstrating her counting technique at her home, adding a personal touch, and partners were encouraged to post photos of themselves in the process of counting.

One of the project participants created an "I Counted" social media meme that was made available to all participants to post on their social media accounts or to print out as a sticker to be given at counting events. Many participants shared photos of their counting experience on social media, often using the #GaPollinators hashtag.

A colorful certificate of participation was created and made available through the project website for participants to add their names and to print. The certificate was branded with insect mascots and logos. Several school groups posted photos of the presentation of the certificate to their classrooms. Certificates were framed and hung in classrooms, presented at garden meetings, and hung in garden kiosks.

RESULTS

Partners held forty events during the Census days. One hundred fifteen project events were held in 2019 related to the Census, on topics such as pollinator gardening, insect habitat, insect identification, and Census taking. A total of over 4,600 counts were uploaded with more than 131,000 insect visits tallied from 134 Georgia counties. ***Figure 2*** shows the scope of county participation. ***Figure 3*** shows the breakdown of insect visit counts over the categories. More than 1,100 participants indicated that they were counting as part of a STEM program. The number of counters who indicated that they created or added to a pollinator habitat as part of the project was 2,257. Counts were held at 135 Georgia schools.

Participants were asked if participating in the Census changed their understanding of the benefits provided by insects that visited their gardens. This question was important to our second project goal of increasing entomological literacy. ***Figure 4*** shows the participants' responses.

Insects were tallied at 4-H gardens, at pollinator habitats from the Garden Clubs of America, and at Daughters of the American Revolution gardens. People participated at several Georgia State Parks. Businesses also participated, with the Blue Ridge Humane Society hosting a count as well as the Slow Pour Brewing Company. The golfers at Oaks Grove Golf Course and several Girl Scout Troops counted. The monks at Monastery of the Holy Spirit also participated. Individuals counted at home and with their families.

PROJECT EVALUATION

On the website form that participants used to upload their insects counts, we asked for feedback on the project. This made it easy for participants to give immediate feedback without having to answer a separate project evaluation form or email. This meant less work for the Census team in having to contact participants for feedback.

Comments from participants:

> "I learned, for the first time, how to distinguish between carpenter and bumble bees and honey and small bees!"

> "That the fear you feel about pollinator decreases as your knowledge increases."

From students:

> "Bugs love tomatoes."

> "I got to see some animals that I have never seen before and to me that was really cool."

From an educator:

> "My fourth-grade class was excited to see the number of pollinators. They oftentimes miss the smaller species, as they focus on the larger, more noticeable, "cuter" animals. This experience helped them gain an appreciation and understanding of how connected all species are to the health of this planet. Happily, they found beauty in all too!"

DISCUSSION

Prior to the widespread use of the internet and web-based technology, the GGaPC would have been more challenging. Promoting the project would have involved newspapers and radio announcements instead of social media and e-newsletters. Educating the participants would have been done by a few in-person trainings. Paper tally sheets would

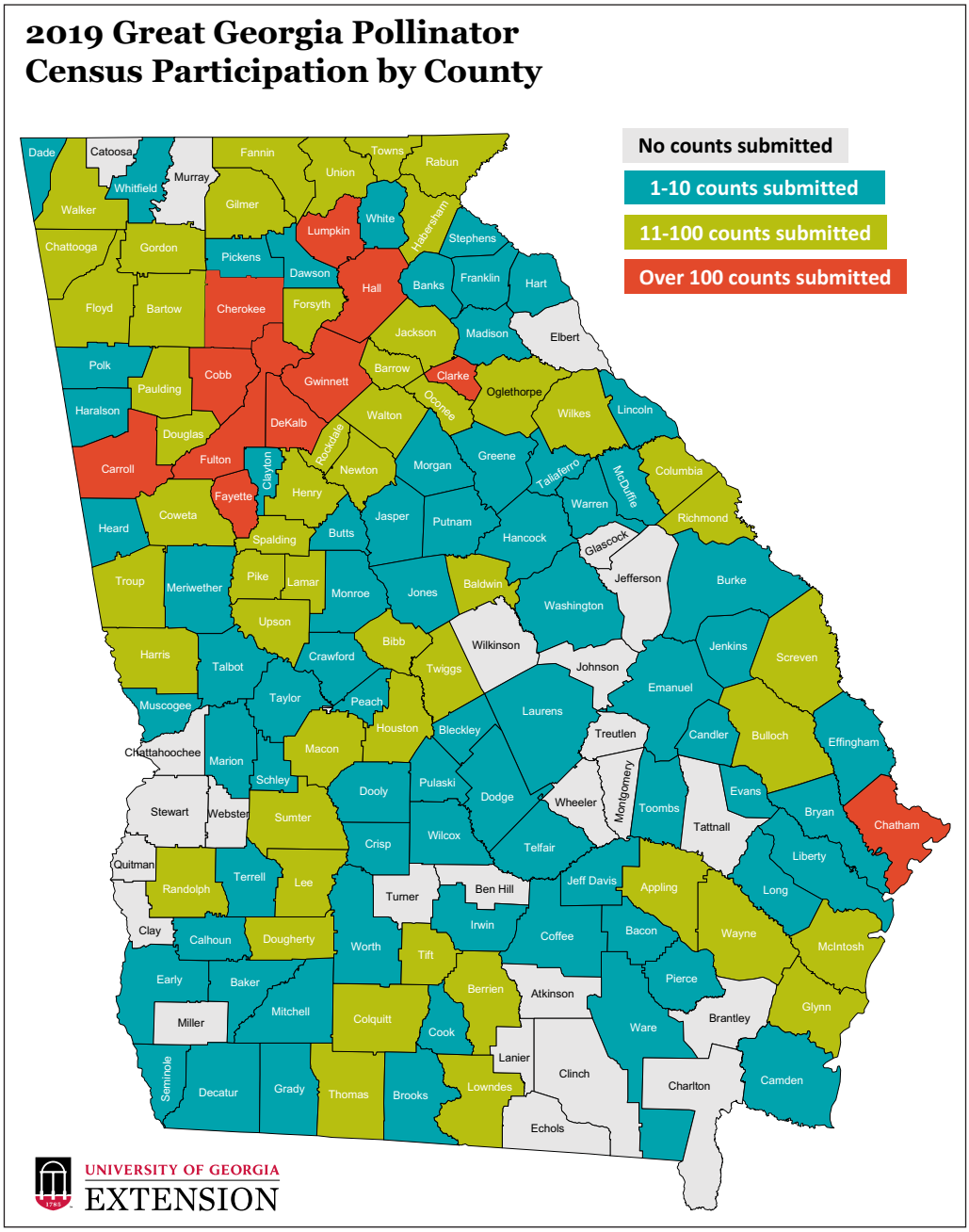

Figure 2 The Georgia county map of participation shows the effectiveness of our outreach.

have been mailed to the participants, and as counters went through the Census, questions would have necessitated a telephone call. Tally sheets would have been returned to the project coordinator by regular mail and added to a spreadsheet one by one. Certificates of Participation would have been individually mailed. The multimedia technologies currently available to us made the Census achievable with the resources available.

The WordPress project website made the *Insect Counting and Identification Guide* available for download on any computer or smartphone. The cost of printing these guides and mailing them to participants would have been cost-prohibitive. Additional educational components were presented through social media and through e-newsletters. Facebook was used as an educational tool for our team, and we were provided with instant feedback. E-newsletters allowed us to expand our educational components with ease and low expense. These newsletters were created and sent in a matter of minutes as opposed to printing each newsletter, addressing envelopes, and sending them through the post office. Again, this would have been cost-prohibitive. These avenues allowed us to provide a better educational experience for the participants, ensuring more accurate insect counts for the project.

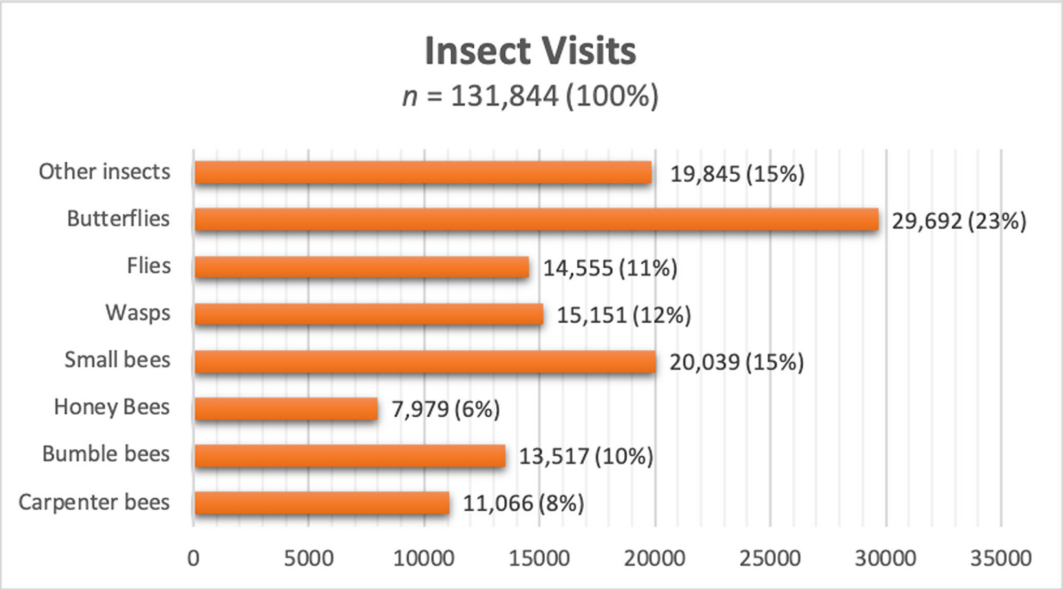

Figure 3 The number of insect visits recorded during the Census by category.

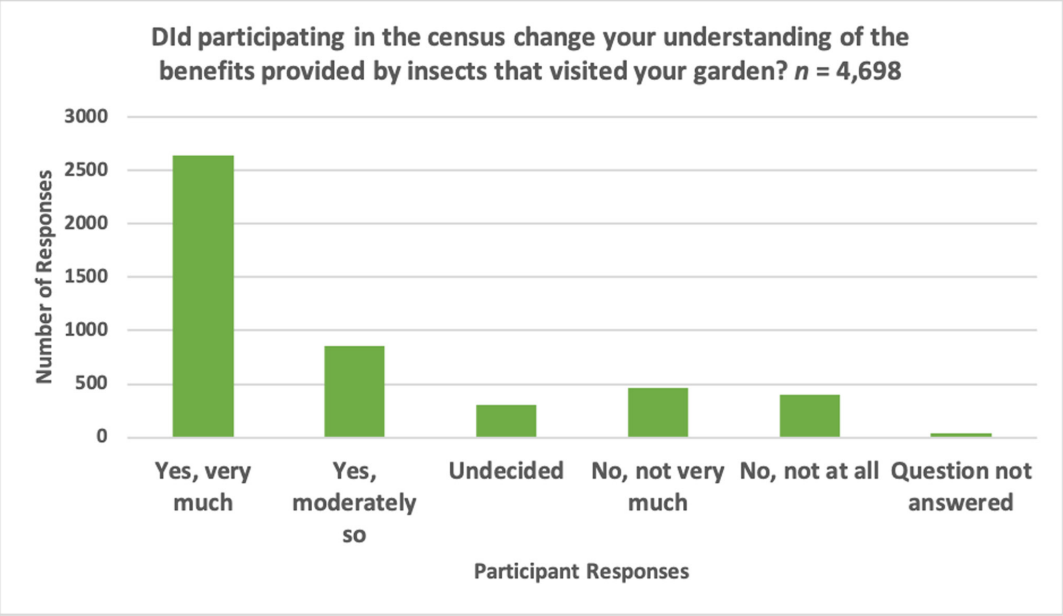

Figure 4 Responses of participants on understanding garden insects.

Train-the-trainers sessions using Zoom online meetings allowed us to reach more trainers than would have be possible prior to this technology. Trainers were able to join the session from their office, download training materials, and promote their events within a short time frame and without travel time or cost. We were able to address their concerns immediately as they reviewed the materials. Social media allowed us to assist in promoting their events, and allowed them to share photos as their events unfolded. The partners were able to take ownership of the project and were supported as they planned and executed their events. This meant that the project had a broader scope with more participation than would have been possible otherwise, and those leaders were more involved with the initiative.

The use of social media generated excitement for the project. For example, the video created in conjunction with the Georgia Tech Bee Lab mentioned above was shared on social media and was viewed 845 times. Our Facebook group grew from 100 members to more than 1,000 by the August count. Having participants respond to a post with a photo of their own pollinator garden or an insect that they identified heightened the excitement for all

of the counters as analytics showed that as the project progressed, more posts were commented on and shared. During the counting days, posts of photos and videos from events allowed citizens to see what was happening with the Census across the state. Analytics showed us that 142 members of our Facebook group shared photos during the Census dates, resulting in 2,854 likes, comments, or shares. Entomologists were available during counting to answer questions in real time through social media and via email.

After insect counting was complete, participants uploaded their data to the webpage. As part of this process, we asked participants for feedback about the project. This allowed us to partially measure the project impact without having to contact participants afterward. The project team viewed collected data in real time. Any anomalies in the data, such as a counter entering 1,000 small bees viewed, were easily addressed by contacting the participant instantly through email. WordPress website technology allowed us to design the incoming data as a spreadsheet, and counting numbers were viewed instantly. Prior to this technology, the team would have been waiting for results to arrive by postal mail and to be hand-entered into a spreadsheet. This would have delayed results by weeks.

Photos posted on the Facebook page were used to show visual impact and behavioral change as a result of the project. For example, photos of new garden spaces created for the Census were posted and shared. If a group member posted an insect photo asking for identification, group members with new insect identification skills would answer (with administrator monitoring). Analytic software allowed us to measure engagement with the Facebook page, traffic to the website, and reaction to the e-newsletters. Teachers used posts from those days to promote their STEM activities to parents and to school administrators.

LESSONS LEARNED

Designing the project thoroughly and thinking through every possible problem is the most effective way to use this type of model. Be thoroughly familiar with what types of technology your target audience is comfortable with and become comfortable with it yourself. Learn the special features of your social media platforms and use them. Be aware that these may change as you go through your project. Monitor the social media platforms daily. Do not allow a member to highjack the project with their own agenda by posting comments that do not pertain to your project. With our project, a group that was very passionate about planting only native pollinator plants began to comment negatively on anyone who posted about non-native plantings in our Facebook group. We had to address the issue with the addition of membership rules that stated all types of gardeners were welcome. In retrospect, we would have had these rules from the beginning.

It is important to have access to an expert in online and web-based security. We were surprised at how quickly our project was targeted by cyber attackers who could have destroyed the project. Recruit and use project partners who are interested and have some experience with your topic. Train them well on the project so that they in turn will be effective trainers. These partners will increase your project reach without expanding your personnel and budget. Design the project so that they will receive some type of benefit for being an active partner. In our case, the benefit was the promotion and exposure of partners' gardens and own projects.

It is also important to learn about free online and web-based tools. At the time of this writing, Canva is a free tool that we used often to create social media posts. iMovie was used to edit short videos, and it was part of a package of factory-installed software on our computers. More professional software was available, but we felt the expense did not warrant the video quality we needed.

CONCLUSION

The GGaPC would not have been possible without the strategic use of multimedia and web-based technology. Administering the project without these tools would have been cost-prohibitive and demanded excessive time from the project team to the extent that the project would not have happened. We were able to work effectively with partners, creating more avenues for the education of Census counters and for participation in the project. Participants were well educated for the Census and were supported in generating useful data. A Georgian with no local project partner or nearby Extension office was able to be a part of the project with no in-person interaction, which allowed a broad base of participation. Through feedback on social media, Census counters indicated that they felt they were a vital part of an important project. These technologies allowed us to reach more participants and generate greater participation. With this model, we were able to build pollinator habitat, increase entomological literacy in our state, and generate and collect insect population data using four team members and limited funding.

Project partners were essential to the project. The Census would not have had the far-reaching participation it did without engaged project partners. Providing the partners with resources and a way to promote their gardens and programs made their involvement positive for them as well as for us.

DATA ACCESSIBILITY STATEMENT

The data generated from the 2019 Great Georgia Pollinator Census is currently being analyzed. A link to any published data will be listed on the project website, *https://GGaPC.org*.

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

BG was the project coordinator for the Great Georgia Pollinator Census and provided data analyses. RB was the IT professional for the project. MG contributed to the branding and strategic multimedia plan. YS provided background research. All authors contributed to drafting this work and critically revising it.

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