Strategies to transform natural resource extension with iNaturalist and engage the public in biodiversity conservation

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Abstract

Participatory citizen science is an increasingly popular tool which provides non-formal education and learning activities. iNaturalist—a free open-access—participatory citizen science platform provides a place to engage the public in natural resource programming. Here, we explore practical applications for integrating iNaturalist into extension programming. We highlight two approaches: (1) self-guided programming, where participants independently engage in biodiversity documentation and professionals contribute identifications, and (2) facilitated programming, which involves extension professional led structured events and projects. We discuss the unique advantages of using iNaturalist in these contexts and offer recommendations for quantitatively measuring and reporting its impact in extension programs.

Keywords: citizen science; community science; participatory science; iNaturalist; natural resource management

Background

Participatory citizen science—also referred to as community science—relies on cooperation between a range of experts and nonexperts (Jordan et al., 2015). As a growing interdisciplinary academic discipline (Bonney et al., 2016; Jordan et al., 2015), citizen science is increasingly used in natural resource management (McKinley et al., 2017) and recognized as a valuable tool for Extension programming (Blair et al., 2018; Clyde et al., 2018; van de Gevel et al., 2020). Such a cooperative approach allows for the collection of large-scale biodiversity data, which can be used to inform and enhance various educational and outreach programs.

An increasing body of work is documenting the learning and education outcomes of individual participation in citizen science projects (Roche et al., 2020). Participation in citizen science enhances ecological literacy (Brossard et al., 2005; Cronje et al., 2011; Severin et al., 2023), improves understanding of the scientific process (Bonney et al., 2009), and fosters a greater sense of environmental stewardship (Chow et al., 2014; Jordan et al., 2011; Jordan et al., 2019). These benefits are significant for individual participants and align closely with the goals of Extension programming. By integrating citizen science into Extension programming (Blair et al., 2018; Meyer & Drill, 2019), educational and engagement benefits of citizen science can be further realized, contributing to local natural resource management and conservation efforts.

Among biodiversity-focused citizen science platforms, iNaturalist is one of the most successful platforms with over 200 million observations globally from 3 million users (www.inaturalist.org; Seltzer, 2019). Despite its growing use in biodiversity research and natural resource management (Mesaglio & Callaghan, 2021), the integration into Extension programming remains underdeveloped. Our objective is to provide various 'ideas at work' of how iNaturalist can be used in Extension programming.

A brief introduction to iNaturalist

Although a thorough introduction to iNaturalist is outside our current scope, we provide a brief introduction to iNaturalist. First and foremost, "*iNaturalist is an online social network of people sharing biodiversity information to help each other learn about nature*" (https://www.inaturalist.org/pages/about). iNaturalist allows participants to contribute observations (i.e., photos and/or recordings) of any organism or traces thereof, along with associated spatiotemporal metadata. The rapidly improving computer vision software provides users with an initial list of identification suggestions based on the provided image and location of observation. Observations are then identified and verified to the highest possible taxonomic resolution by the iNaturalist community. An observation is deemed "Research Grade" when it meets the site's metadata quality criteria and has two or more suggested identifications with more than two-thirds agreement at a species level. Importantly, iNaturalist is accessible both as a phone app and a website. Additionally, iNaturalist offers the ability to create and join projects, which can be tailored to specific research goals, educational initiatives, or community science campaigns (e.g., Kirchhoff et al., 2021). For a more in-depth introduction to iNaturalist we recommend reading Mesaglio (2024) and visiting the iNaturalist about page (https://www.inaturalist.org/pages/about).

Why iNaturalist is well suited for the mission of Extension

Given its broad accessibility, user-friendly interface, and robust community support, iNaturalist serves as an excellent platform to further Extension programming. Citizen science offers two main benefits, it improves user understanding of biodiversity and provides valuable data for research to enhance our understanding of the natural world. By encouraging members of the community to observe and document biodiversity, iNaturalist makes science accessible and engaging for people of all ages and backgrounds. This democratization of science helps fulfill the Extension mission of making higher education resources available to the broader public. Hitchcock et al. (2021) provide evidence that iNaturalist participants gain valuable skills in species identification and ecological observation, contributing to a deeper understanding of local biodiversity. Users learn about the species they encounter and observe. This participation increases public knowledge and awareness of biodiversity and cultivates a deeper appreciation for the environment. By integrating iNaturalist into Extension programming, extension professionals can enhance their outreach and impact. In turn, increased participation on iNaturalist will result in more data that researchers can use to answer ecological questions, such as determining species distributions and abundance, studying species biology and behavior using secondary imagery data, and integrating data in policy planning (Mesaglio and Callaghan 2021).

How iNaturalist can be integrated into extension programming

iNaturalist offers numerous opportunities for integration into Extension programming, accommodating various levels of engagement. We propose categorizing these opportunities into two main themes that together help influence short-, medium-, and long-term impacts (Figure 1): self-guided programming and facilitated programming. Self-guided programming is where individuals independently contribute to biodiversity data collection by making observations and identifications. This is already taking place: participants already use the iNaturalist app or website to document local species at their own pace, fostering personal interest and engagement in biodiversity without the need for structured programs. While this approach requires minimal direct interaction, extension professionals can play a key role by providing identifications and feedback on observations, thereby enhancing the learning experience for participants and contributing to data availability for natural resource management. Facilitated programming, on the other hand, requires active involvement and guidance from extension professionals. Examples include hosting bioblitzes, creating and managing projects, and organizing workshops or educational events which leverage iNaturalist. These activities engage participants in hands-on biodiversity documentation and provide structured learning experiences. In the following sections, we will provide detailed ‘ideas at work’ for integrating iNaturalist into Extension programming and quantifying impact under these two themes.

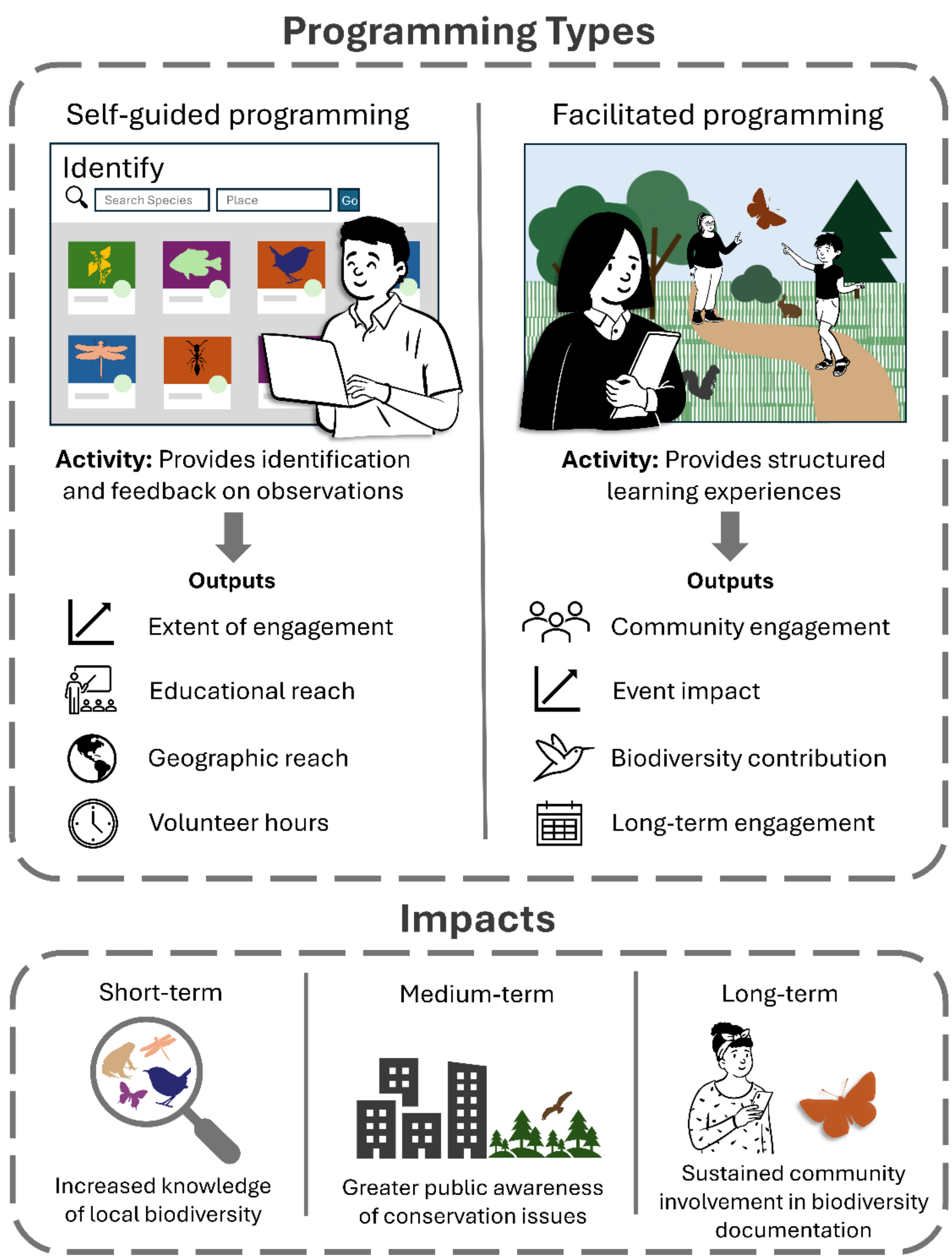

Figure 1. Overview of Self-Guided and Facilitated Programming Approaches in Extension Programming Using iNaturalist. Self-guided programming involves independent contributions from participants, such as providing iNaturalist identifications (https://www.inaturalist.org/observations/identify). Facilitated programming includes structured events and projects led by extension professionals, such as bioblitz events which may provide

guided tours and hands-on activities to engage participants. This diagram outlines the expected short-term, medium-term, and long-term impacts of both self-guided programming and facilitated programming.

Self-guided programming — the importance of identifications

An important role of natural resource extension professionals has often involved fielding numerous inquiries such as "I see this in my backyard—what is it?". With the advent of digital photography and the ease of capturing images, these inquiries have evolved into "here is a photo of something in my backyard—can you identify it?". With iNaturalist, there is substantial demand from individuals seeking identifications to better understand the organisms they encounter: over 100,000 observations are posted globally per day. Providing identifications is a significant method to enhance the value of natural resource management and to foster knowledge gain among the public. There are many benefits to contributing to iNaturalist as an identifier (see Callaghan et al., 2022 and iNaturalist YouTube, 2022) and extension professionals can significantly enhance the overall value of these data by contributing their expertise as identifiers.

Quantifying the impact of these identifications

Providing identifications is an integral part of iNaturalist, and they are easy to achieve using the iNaturalist "Identify" webpage (https://www.inaturalist.org/observations/identify). This simply involves filtering observations to the region and taxon of expertise and examining images to provide identifications. Detailed information on how to use the identify tool is available in iNatHelp (2024). Identifications on iNaturalist provide a range of impacts, including enhancing natural resource management and fostering public knowledge, as discussed above. Here we provide four metrics to evaluate and quantify the impact of these identifications on individual engagement and natural resource management (Figure 2).

- ***Number of identifications*** reflects the overall volume of contributions made by extension professionals, indicating their active participation and the extent of their engagement in community science.

- ***Number of individuals*** for which identifications have been made highlights the reach and educational impact on community members who benefit from expert identifications, fostering a greater understanding and appreciation of biodiversity.

- ***Acreage*** of the observations which have been identified demonstrates the geographical coverage and environmental scope of the identified observations, illustrating the breadth of data across diverse habitats and regions available for natural resource management.

- ***Volunteer hours*** of those observations which have been identified estimates the total volunteer hours contributed by community members who make observations on iNaturalist for which an extension professional contributes. This metric is defined as 30 observations = 1 volunteer hour (see Appendix A) and highlights the collective effort and engagement of the public in documenting biodiversity for which an extension professional contributed.

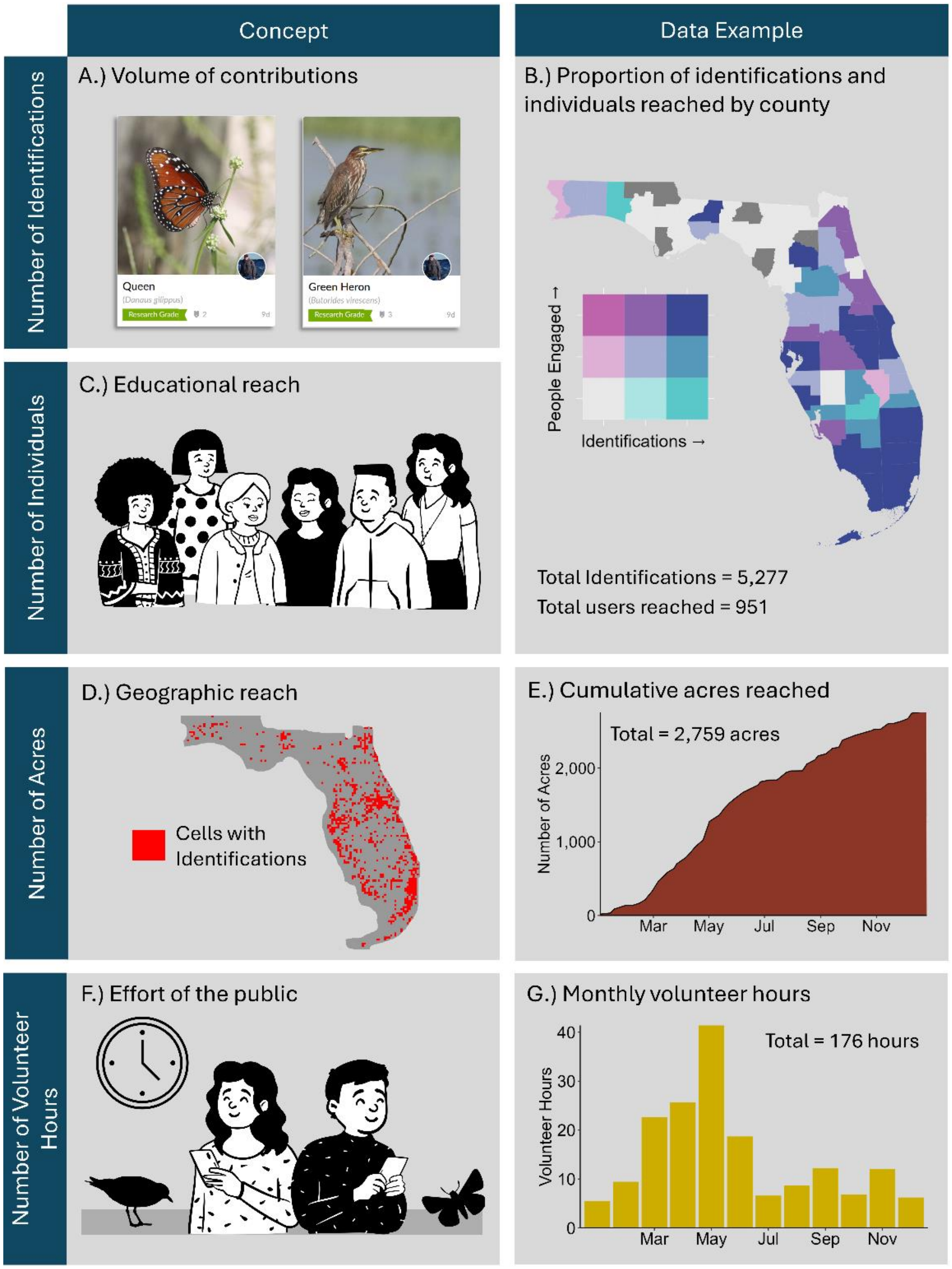

Figure 2. Four Methods to Quantify the Impact of iNaturalist Identifications. The left panel describes the concept, and the right panel provides a real data example. Panel B displays a choropleth map of Florida counties that weighs number of identifications and users reached. Panel E displays a cumulative graph of acres reached from identifications. Panel G displays the total volunteer hours by month where 30 identifications are equal to 1 volunteer hour.

Facilitated programming — educational events and bioblitzes

Facilitated programming involves direct engagement between extension professionals and participants. Such events can offer structured opportunities for hands-on learning and education. Programs can be tailored to a range of audiences such as youth, adult, or families (Aristeidou et al. 2021), or different interest groups (Pawson et al. 2020). This type of programming can be divided into longer-term projects and shorter-term, typically one-off, events.

Longer-term programming

iNaturalist allows the creation of projects on the platform that can focus on documenting the biodiversity of a specific place and provide tools to refine data collection protocols and/or interact with interested participants (see iNaturalist, 2024). Curating a project on iNaturalist allows extension professionals to create focused, ongoing initiatives that align with specific research goals, educational objectives, or conservation efforts. By curating a project, professionals can engage participants over a longer period, providing consistent feedback, resources, and learning opportunities. These projects can target specific taxa, geographic areas, or conservation issues, offering a structured framework for participant involvement. For example, Kentucky 4-H hosted a yearlong bioblitz on iNaturalist where members and their families were encouraged to observe and record wild animals and plants across the state, beginning with a training session to launch the event (Osborne 2021).

Short-term programming

Another mechanism for Extension programming is hosting a one-off event that focuses on documenting biodiversity of a given place in a specified time frame, commonly referred to as a bioblitz (Meeus et al., 2023; Parker et al., 2018). A bioblitz is an intensive survey of all living species in a designated area, involving experts and the public in a collaborative effort. It is an increasingly popular method for raising awareness about biodiversity, collecting valuable data, and engaging the community in conservation efforts. For example, Conservation Florida and Duke Energy collaborated to host three bioblitz events, inviting participants of all ages and backgrounds to document plants and wildlife in public preserves and parks across Florida. These events included guided tours and hands-on activities to engage attendees in conservation efforts (Conservation Florida 2022).

Quantifying the impact of facilitated programming

Evaluating the impact of an event, either short-term or longer-term, can be like that of traditional evaluation methods for natural resource Extension programming (e.g., Workman & Scheer, 2012). However, our focus is on providing metrics that evaluate the impact of a program which complement traditional pre and post questionnaires. Although we differentiate between longer-term and short-term programming, we believe the metrics are similar as they both center on the presence of an 'event' which an extension professional has facilitated. Here we provide four metrics (Figure 3) to evaluate and quantify the impact of these events on individual engagement (the participants) and natural resource management (the place).

- ***Number of participants*** measures the total number of individuals who attended and participated in the event. It provides a direct indication of the event's reach and popularity within the community. A higher number of participants typically suggests greater community engagement and interest in biodiversity and conservation activities.

- ***Percentage increase in number of observations before and after the event*** assesses the change in the volume of observations recorded in the targeted area before and immediately after the event concludes. By comparing these observations, extension professionals can understand the immediate impact of the event in motivating participants to actively engage in biodiversity documentation and the value for natural resource management.

- ***Percent of biodiversity documented before and after the event*** evaluates the diversity of species recorded in the area before and immediately after the event. The percentage is calculated by comparing the number of different species documented at the event location to those recorded all-time within a 50 km radius of the event location before and after the event. A higher percentage of documented biodiversity post-event suggests improved participant knowledge and data available for natural resource management. For repeated events, this can be complemented with the number of 'new species' documented in that site to reflect knowledge gain for natural resource management (Figure S1).

- ***Percent change in engagement level of participants*** quantifies the impact of an event on an individual participant's engagement level with biodiversity. Initially, this metric measures the immediate change in the frequency of participants' contributions to iNaturalist before and after the event. For a more comprehensive analysis, this metric can be extended to track participants’ engagement over a longer period, offering insights into sustained behavioral changes. This approach allows for assessment of both short-term and long-term impacts, providing valuable longitudinal data on participant engagement and the effectiveness of extension activities (see Appendix B for more details).

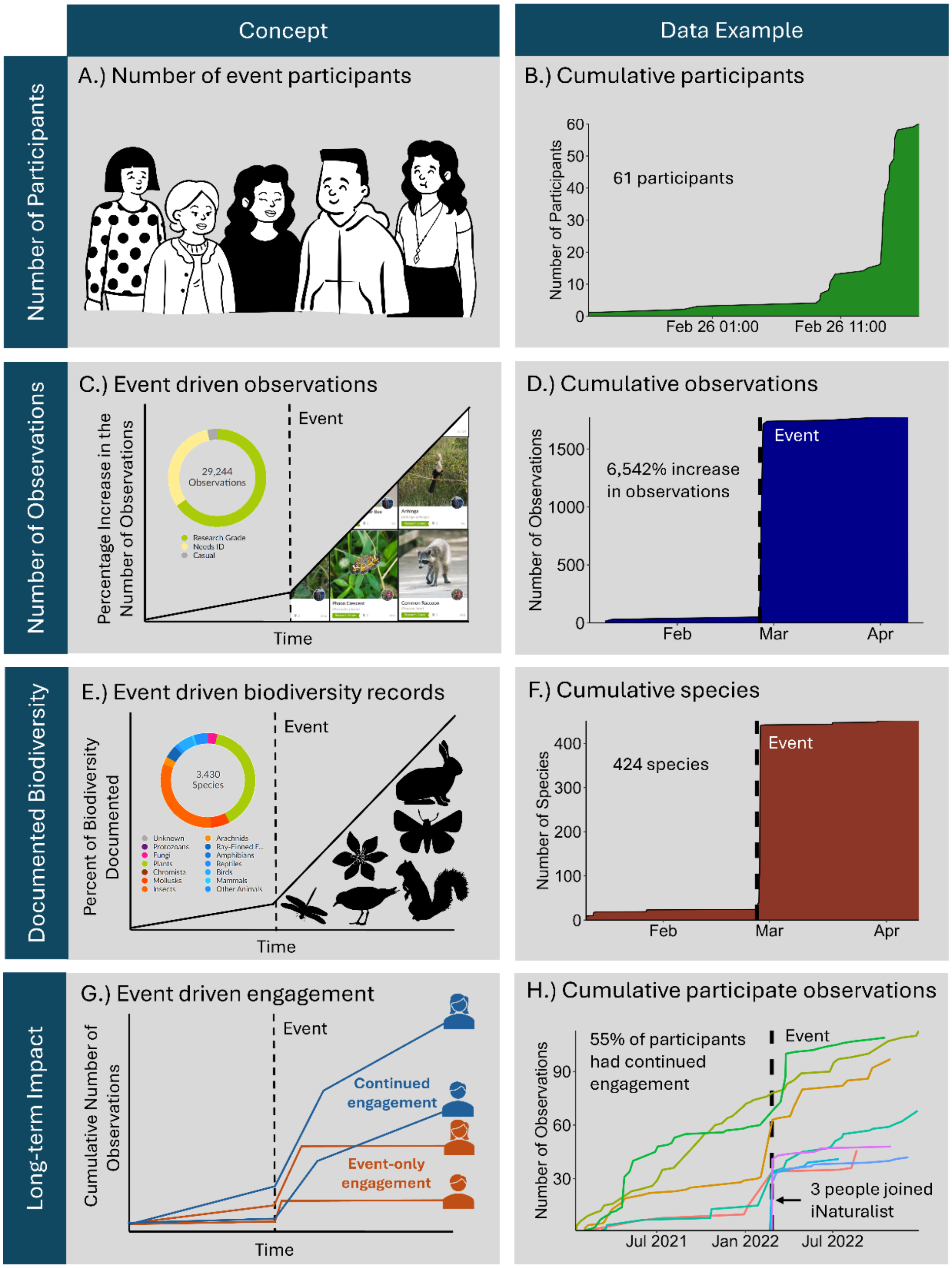

Figure 3. Four Methods to Quantify the Impact of Facilitated Programming. The left panel describes the concept and the right panel provides a real data example. (B) displays the cumulative number of participants during an event. (C) displays the cumulative number of

observations before and after the event. Similarly, (D) displays the cumulative number of species before and after the event. (H) displays the cumulative number of observations by bioblitz participants before and after the event to show long-term impact.

Conclusions and future outlook

iNaturalist is an increasingly popular citizen science platform that is currently under-recognized and under-utilized in formal Extension programming. Here, we provide some novel ways in which we are using iNaturalist as a formal part of our Extension program. Future work should continue to investigate how to evaluate short-, medium-, and long-term impacts of participants of iNaturalist (Figure 1) and could include, for example, quantifying the monetary value of the participant contributions to natural resource management. Other avenues of future research include integrating quantitative metrics, as described here, and qualitative metrics to comprehensively document impact of Extension programming that leverages iNaturalist.

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Appendix A: Justification for Volunteer Hour Calculation

To calculate volunteer hours, we define 30 observations as 1 volunteer hour. This assumes that each observation takes an average of 2 minutes. There are various methods to create and upload observations. Some users may take observations directly in the application on their smartphone, while others may take photos to upload later via the application or website. In some cases, users may spend time post-processing images. Additional factors that influence the time required to capture an image include the number of images taken for the observation and the ease of capturing the image (i.e., a moving butterfly is harder to capture than a stationary plant). Further, time is required to add meta data such as identification of the organism and ensuring the date, time, and location are complete. Given all these considerations, we believe that 2 minutes per observation is a conservative estimate of the average time it takes users to create an observation.

Appendix B: Further Possibilities to Leverage the Percent Change in Engagement Level of Participants

The metric “percent change in engagement level of participants” offers a powerful tool for extension professionals to evaluate the impact of their programming. In addition to measuring immediate changes in activity levels, this metric can be extended into a longitudinal analysis, providing a deeper understanding of participants’ engagement over time. By tracking long-term trends, professionals can identify patterns of sustained engagement or disengagement, allowing for targeted interventions to maintain interest and involvement. Additional metrics, such as the diversity of species observed, the geographical spread of observations, and the number of new identifications an individual makes, can further enrich this analysis (Figure S2). By leveraging these data points, extension professionals can refine their programming to better support community engagement and biodiversity conservation, ensuring that educational efforts translate into meaningful, lasting impacts. This approach not only enhances the effectiveness of extension activities but also contributes to the broader goals of fostering a scientifically literate and environmentally conscious public.

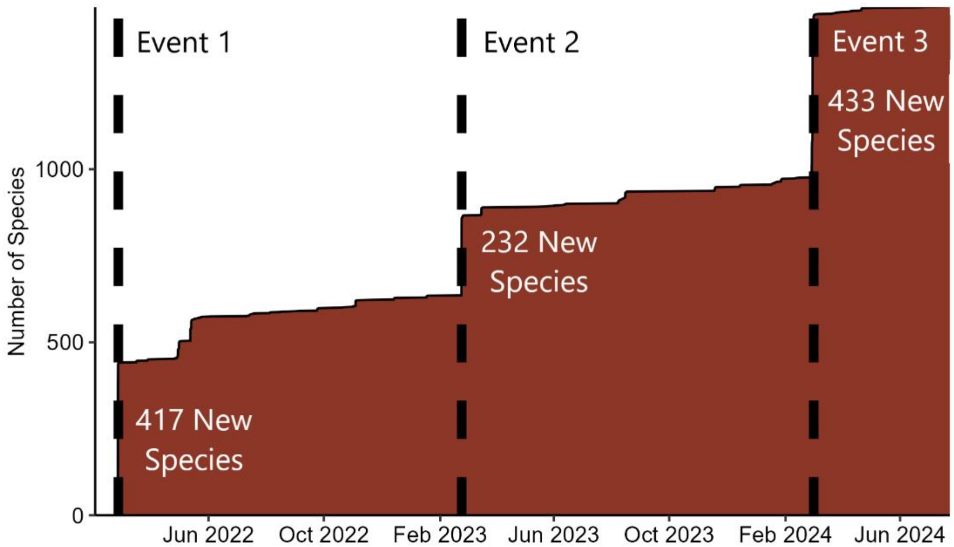

Figure S1. Number of New Species Observed as a Result of Three Bioblitz Events Illustrating Increased Data Availability for Natural Resource Management.

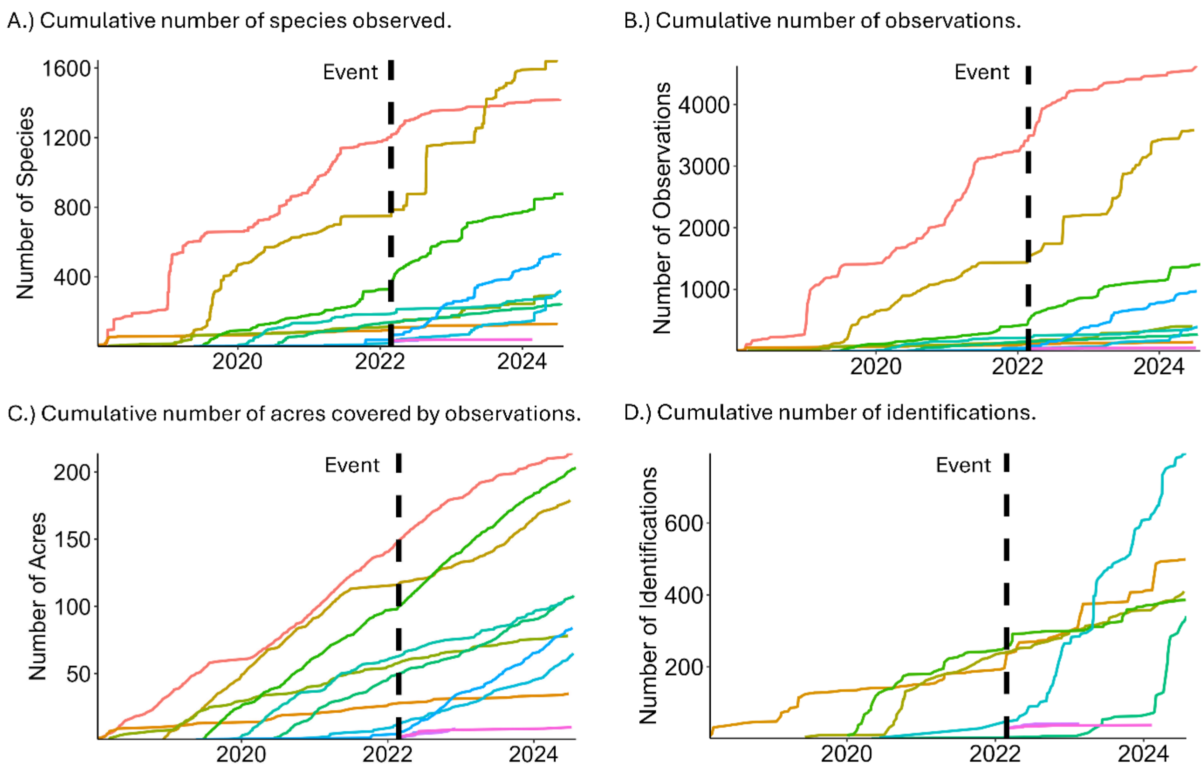

Figure S2. Metrics That Can Be Used to Examine Long-Term Trends of Programs, Either Short-Term or Longer-Term Events. In Figure 3G we cover simply number of observations, but other metrics, such as those described in Figure 2 could also be used to analyze user activity over time in relation to an event facilitated by an extension professional. This graph shows cumulative user metrics before and after an event. If an event had a positive impact on a user's metrics, a steeper slope is expected in the short- or long-term. As an example, the individual illustrated by the blue line in panel D clearly has increased their identifications after participation in an event, highlighting the longer-term impacts on that individual's engagement with biodiversity and the value for natural resource management.