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The Ascot App – A Plant Tracking Smartphone Tool for Field-based Community Science

Urban tree planting efforts have accelerated globally, but systematic monitoring of planted trees, particularly of survivorship and growth, lags behind. To help address this challenge, we developed and implemented the Ascot App, a free, mobile-based tool designed to streamline citizen science data collection in urban habitat restoration projects. Deployed at a Miyawaki-style microforest in Ascot Hills Park, Los Angeles, the app enables volunteers with minimal training to scan QR-coded tags on seedlings and submit standardized, timestamped plant health data via an intuitive interface. The app reduces user error through simplified prompts and integrates directly with a web-based administrative portal for data export and management. Over the reported 14-month period, more than 2,100 monitoring entries were contributed for the 250 targeted seedlings representing 32 native California species. We estimate ~150 volunteers used the app and contributed to these data. Furthermore, plant survivorship was 96% and plant height increased 3-fold, with variation among species. Although we did observe instances of user errors (e.g., misidentification of deciduous trees as dead), the regular monitoring enabled longitudinal data validation. We also share lessons learned from our deployment, challenges with training modality, and analysis workflow. Ultimately, the app proved effective in democratizing data collection, reducing the time burden on researchers, and increasing consistency in field observations. The Ascot App demonstrates how smartphone-based tools can expand the scope and rigor of urban tree monitoring by leveraging the enthusiasm and contributions of the local community.

Keywords

citizen science, habitat restoration, microforest, mobile app, urban trees

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INTRODUCTION

The appreciation of trees in the urban landscape continues to grow as we become an increasingly urban populace. Approximately 80% of the U.S. population and 55% of the global population now lives in urban areas, with the proportion increasing another 10% by 2050 (CSS 2024, Richie *et al*. 2024). The role of the urban tree has shifted and changed in tandem with the urban landscape. Early American settlements leveraged trees for provisional properties, establishing cultivated woodlots along their outskirts for harvesting timber & building materials (Dwyer *et al*. 1991). Through the 1700s and 1800s, as settlements grew into towns and then cities, urban trees became valued for their aesthetic purposes, used to line streets and enhance public green spaces. By the mid-1900s, urban trees were progressively recognized for their social, economic, and ecological benefits (Dwyer *et al*. 1991). The field of urban forestry evolved from the need of cities to not only plant new trees but also manage and ensure mature trees were maintained to be compatible with other urban infrastructure (Vogt 2024). Planting new urban trees remained the priority, exemplified by marquee initiatives like the Sacramento Million Tree Initiative in 2000, Los Angeles's Million Tree Initiative in 2006, MillionTreesNYC in 2007, TreeBaltimore in 2007 and TreePhilly in 2011. Perhaps the most ambitious is the UN Decade of Ecosystem Restoration pledge to conserve, restore and grow at least 1 trillion trees by 2030 (UNEP 2020). These initiatives have tracked with a global trend that has seen the number of tree planting organizations increase by over 280% since 1990, having planted an estimated 1.4 billion trees across 74 countries (Martin *et al*. 2021).

Monitoring to track survivorship of the new urban trees lags far behind the effort of tree planting initiatives. A review of 174 tree planting organizations revealed less than 1/5 included mention of monitoring new tree plantings, and only 5% explicitly mentioned measuring tree survivorship (Martin *et al*. 2021). Some mortality among any planting effort is expected, with several studies revealing observed patterns for urban trees. Mortality of newly planted urban trees can range between 5% and 39% (Gilbertson and Bradshaw 1990, Roman and Scatena 2011), with a mortality rate as high as 12% reported in just the first year (Roman *et al*. 2016). Generally, most tree loss occurs in small, young urban trees (Roman 2014), with monitoring of at least several basic metrics serving as good predictors of growth rates that can inform future planting efforts (Holl *et al*. 2018). These data may also improve modeling to estimate the long-term ecosystem service benefits of urban trees and to report back returns on public investment in planting initiatives (Roman *et al.* 2016).

Citizen science, also known as community science, is one approach that enables volunteers to contribute to scientific and environmental data collection efforts (Hognogi *et al*. 2023). Collaborative citizen science projects help scientists by expanding the spatial and temporal reach for data collection beyond what the scientists could do alone, while the volunteers gain greater familiarity to the research process, to scientific knowledge, and an opportunity to contribute to science in an impactful way (Finch *et al*. 2022). A major obstacle in citizen science, however, is the technical skills required to use subject-specific measuring tools and equipment. In the case of urban forestry, traditional ground-based tools including tape measures, calipers, clinometer, *etc*. are regularly used to assess the survival and growth of trees. Although using these tools can be learned with modest training, they do need to be purchased or obtained and may be intimating for a layperson unfamiliar with field research. The recent and

ubiquitous availability of mobile smartphones in the U.S. (91% of U.S. adults, Sidoti and Dawson 2024) and parallel rise in software applications, or apps, has created an increasingly accessible approach to opening scientific and environmental monitoring. For example, Schweizer *et al*. (2024) identified 42 available smartphone apps that support forest restoration monitoring, including those that support tracking of seedling planting and survival, estimate plant growth, calculate canopy openness and inventory tree density along a digital belt transect. Schweizer *et al*. (2024) also trialed several apps, concluding that although the apps generally did not improve labor efficiency, they did enable more cost-efficient monitoring, particularly by alleviating the need to purchase specialized tools. Furthermore, each app presented strengths and weaknesses, emphasizing the need to carefully consider application features and project objectives when selecting or developing an app for forest monitoring (Schweizer *et al*. 2024).

Here we describe the Ascot App – a free, user-friendly app designed specifically to facilitate the tracking of the survival, growth, and phenology (i.e., flowering, seed production) of newly planted tree seedlings as part of an urban habitat restoration project in northeast Los Angeles. The app uses a guided data collection approach that enables briefly trained volunteers to contribute in-field observations without requiring extensive experience or time commitment. By using QR-coded tags and a fixed set of question prompts about each tree, we aimed to streamline monitoring while reducing user error. Further, time-stamped data is uploaded immediately without storing any information on the user's device. Lastly, we provide a use case study that has employed the Ascot App for 14 months in tracking 250 tree seedlings at the Ascot Hills Park microforest project between June 2024 and July 2025.

APPLICATION DEVELOPMENT

We developed the Ascot App with the primary objective of aiding regular and systematic monitoring of 250 QR-code tagged tree seedlings within the Ascot Hills Park microforest. Anticipating the app could be useful in other environmental and ecological monitoring studies that may also leverage citizen science, we considered best practices in citizen science technology in our design (Freitag *et al*. 2016). The Ascot App was built using React Native (front-end), NodeJS (back-end), and connected to GCP's Firebase for data storage. Building the app with React Native allowed us to deploy the app to the Apple App Store and Google Play Store. Furthermore, we applied human-centered design to allow volunteers to collect consistent, high-quality data with minimal training and tools. Upon scanning the QR code tag affixed to each tree, the app screen would automatically retrieve the associated plant common name, scientific name, and 4-letter, 4-digit code. An example QR code scan would yield, 'Coastal live oak, *Quercus*

agrifolia, QUAG_0001' and populate the app screen accordingly (Figure 1).

Figure 1. The Ascot App log-in screen (a), the Ascot App plant health data entry screen (b), dimensions and design of the QR-coded tags (c), and an example QR-coded tag attached to a Sambucus nigra plant within the Ascot Hill microforest (d).

Eight prompts to assess plant health can then be responded to by either selecting a check box or moving a slide bar, an intentional design feature to eliminate typographical errors and reduce frustration and confusion about appropriate response (Figure 1b). All submitted data are securely stored in Firestore, with role-based user authentication managed through Firebase to protect data integrity. This use of user authentication in Firebase was selected to guard against any unwanted read or write operations that may severely damage data integrity and validity. Furthermore, the app was designed to support offline data entry and CSV export for downstream analysis.

To complement the field data collection process, a web-based administrative portal, the Ascot App Admin, was developed using React.js (front-end) and NodeJS (back-end) with use of Firebase. This administrative interface allows authenticated users (e.g., the project lead), to view, manage, and export plant survivorship data in real-time. We applied a modular architecture, creating hierarchically organized source directories and reusable React components which support easy portal maintenance and expansion. Data exports are facilitated through CSV conversion tools, and user authentication includes secure login, registration, and password recovery workflows. Styled with Tailwind CSS and designed for accessibility, the Admin portal provides intuitive navigation between multiple datasets and projects. Notably, at this time all data comes from regular data collection efforts at the one project, the Ascot Hills Park microforest. To encourage future development and improvements, The Ascot App source code is freely available under the MIT License, permitting use, modification, and distribution with attribution; and is available upon request to the corresponding author.

USE CASE

Site

Ascot Hills Park (AHP, (34°04'14" N, 118°11'26" W) is an open space urban park in northeast Los Angeles, California, United States. The park is in the El Sereno neighborhood where park need is high (TPL ParkServe, 2020), and over a decade of local, volunteer-driven habitat restoration efforts have worked to bring back native plant communities (Siglar and Willette, 2025). A growing number of adaptive management approaches are being used at AHP to identify & use effective restoration techniques (Wilson and Willette, 2022; Mestesky *et al*. 2024). Given Los Angeles' Mediterranean-type climate, and examination of local, relic plant communities, restoration efforts at AHP have followed a low-density tree configuration to reduce perceived competition risks and match natural Mediterranean ecosystem forests (Sanchez-Gonzalez *et al*. 2015, Schneider *et al*. 2023).

The AHP microforest was established in January 2024 and represents an innovative application of the Miyawaki microforest method (Miyawaki 2004) in a Mediterranean-type climate, a method that is typically applied in temperate or tropical climates. A total of 850 1-gallon seedlings of 32 different native California plants were installed within the 930 m^2 (10,000 ft^2) plot. The plants were organized by the following four growth forms: canopy tree, tree, sub-tree, and shrub (Supplemental Materials 1). Seedlings were planted with a semi-regular distribution. Canopy trees were planted first at 3 m intervals, with trees, sub-trees and shrubs planted among the canopy trees at a spacing of 1 m from any other plant. Effort was taken to avoid planting the same species next to each other. The microforest site was covered with ~8cm of wood mulch and a 1.5 m perimeter fence installed to reduce herbivory pressure. The entire site was watered 6 times between January and December 2024 (~6 hrs. per event), with only rainfall supplementing watering to date.

QR Coded Tags

Stainless steel 50mm x 29mm x 1.5mm metal tags were created with the 4-letter and 4-digit code and corresponding QR code for each of the 250 monitored plants (Figure 1c) and manufactured by LogoTags (Mount Vernon, NY). Each tag was attached to the base stem of the plant using flexible coated wire (Figure 1d) in June 2024.

Monitoring Protocol

Nearly monthly monitoring began in June 2024 and is scheduled to continue through January 2026. Here, we report data between June 2024 and July 2025, with the exception of November 2024 due to low volunteer turnout and January and February 2025 due to local wildfire conditions. Monitoring commenced with local volunteers being provided a 10-minute tutorial on how to download the free Ascot App from the Apple App store, create a unique user login and password on the app, then practice scanning a sample QR coded tag and entering sample data. Efforts were made to clearly explain each plant health prompt and volunteers were also provided with a user guide for reference, which included a list of the target plant species, plant sketch, diagnostic features, and counts (see Supplemental Materials 2).

We found that monitoring worked best in teams of 2-3 volunteers, with one or two volunteers searching for the next tagged plant, and one volunteer responsible for scanning the found tag and entering the plant health data. A data consistency check with a lead researcher was performed with each team on their first plant, and additional plants at their request, to ensure data accuracy. Volunteers would often work collaboratively to reach a consensus on entered plant data (e.g., if the plant was 3 ft or 4 ft tall, if there were any signs of herbivory, *etc*.) and quickly became comfortable with the data collection process. Most monitoring events had eight to 12 volunteers, thus forming approximately four teams who would each be assigned one plant species. Each species had between 10 and 59 plants (31.3±15.9 Avg, SD) and would take a team of two volunteers approximately 30-60 minutes to locate, scan, and enter data. Faster teams or those with a fewer number of plants to locate would be assigned a second or third species. In total, monitoring of all 250 plants with 12 volunteers took approximately two hours from introduction to completion.

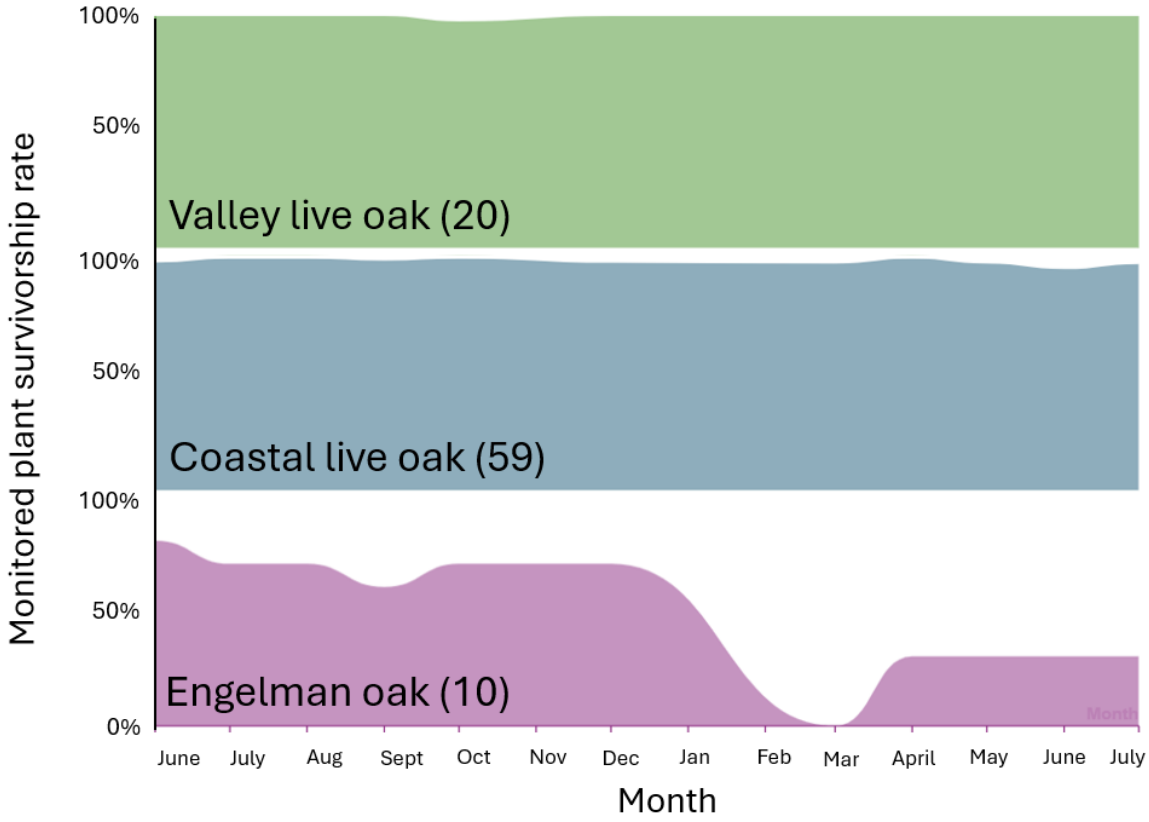

Figure 2. Survivorship rate by month between June 2024 and July 2025 for three representative plant species, Valley live oak (Q. lobata), Coastal live oak (Q. agrifolia), and Engelman oak (Q. engelmanni). Number of tracked plants in parentheses.

Monitoring Results

The purpose of this paper is to describe the development and use of the Ascot App with the monitoring results to be reported as part of a forthcoming comprehensive report on the Ascot Hills Park microforest project. Notwithstanding, we provide the following findings as proof of concept and utility of the Ascot App.

Between June 2024 and July 2025, a total of 67 users submitted 2,156 unique monitoring data entries. As nearly all monitoring was conducted in teams of 2-3 volunteers, we conservatively estimate 150 volunteers contributed to this use case. Starting with the premise that all 250 plants were alive when QR coded tags were attached in June 2024, the overall survivorship rate of monitored plants as of June 2025 was 96%. Survivorship varied by species, with all species at 95% or higher survivorship except *Q. engelmanni* with a survivorship of 30% (3/10 original seedlings). We attribute this oak's performance to the very small size and poor quality of the initial seedlings when planted. Survivorship of the three oak species is illustrated in Figure 2, with *Q. agrifolia* and *Q. lobata* maintaining a rate, whereas *Q. engelmanni* had an initial loss of 30% of plants by December 2024, followed by an additional 40% loss by March 2025. The unusual dip to 0% then recovery to 40% between March to April 2025 is attributed to volunteers mis-reporting oaks that had dropped leaves as dead. We also observed this seasonal decline then recovery in survivorship for *J. californica* and *S. nigra*, both deciduous species that drop leaves in the winter season. Here we can appreciate the value of longitudinal monitoring which enables the validation of entered data month to month as a type of accuracy check.

Among the other plant health metrics, plant height was relatively easy for volunteers to measure and report, as indicated by the submitted data entries. The Ascot App uses a sliding bar at 1 ft intervals for volunteers to estimate plant height (Figure 1b). Had volunteers failed or forgotten to measure height, submitted data would have included the default height of 1 ft for all plants. Rather the data illustrates a trend of increased plant height over the study period, with a notable bump in late spring 2024 and spring 2025 (Figure 3). Again, the exception was *Q. engelmanni* which was consistently measured at 1 ft in height, the minimum height option.

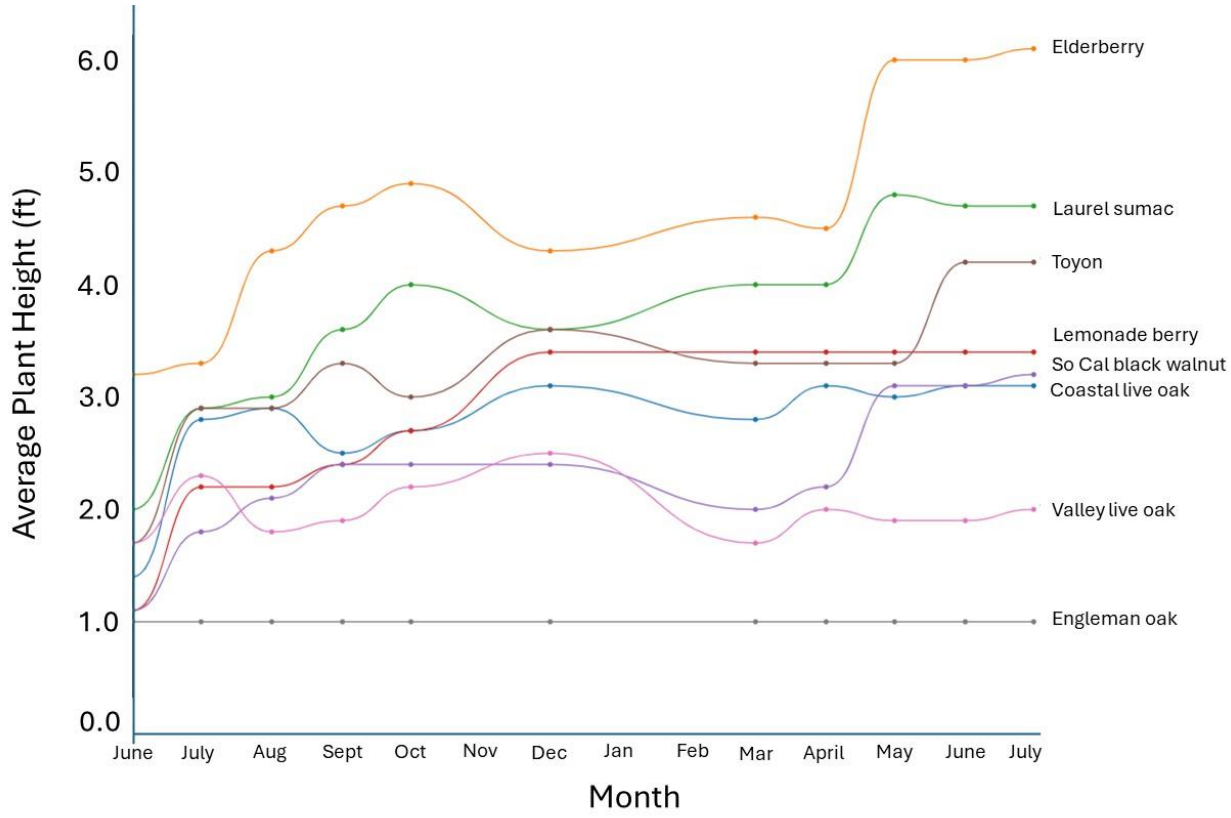

Figure 3. Average plant height of eight monitored plant species based on volunteer reported heights using the Ascot App and associated plant height estimate sliding bar tool. Variation is inferred as varying perceived height estimate by different users over different months.

DISCUSSION

After the first 12+ months of use, we feel the Ascot App meets the original objective of creating an accessible, user-friendly smartphone application that enables volunteers to contribute to monthly monitoring of the Ascot Hills Park microforest project. Further, it has been successful in creating an opportunity for us to leverage the eagerness and availability of volunteers to perform the monthly surveys of the 250 plants more consistently and effectively. As stated, a team of 12 volunteers requires approximately two hours to complete monitoring, whereas we have calculated it takes roughly 6-7 hours for one researcher (D. Willette) to complete. Democratizing the effort required for measuring new tree plantings lowers the barrier for incorporating regular monitoring into reforestation efforts. As the project continued, we did find it helpful to create the simple user guide (Supplemental Materials 2), which we refined and improved after trialing with several student and community groups.

Limitations and Next Steps

Here we present three limitations we discovered as part of the development and 12+ month deployment of the Ascot App - (1) modality of initial training materials, (2) quality of data entries, and (3) downstream data management.

We found most volunteers eager and excited about the opportunity to use technology alongside environmental monitoring, especially when it leverages technology they are familiar with and is readily available – a smartphone. Our diverse population of users, ranging from elementary school children to college biology majors to a local running group to retired senior citizens, brought equally diverse experiences in environmental monitoring. Our original approach of walking volunteers step by step through installing & using the app was effective, but time-consuming. Our pivot to a second modality, a paper-based user guide, helped improve training time especially when we were able to make a PDF copy available to volunteer groups ahead of the event. Improving this further will be a third modality, creating a brief 1-2 minute tutorial video which actively walks users through the process, and will be made available in the App.

A common critique of including citizen science elements into environmental monitoring is quality control and overreliance on unverified data entries (Lukyanenko *et al*. 2011, Hognogi *et al*. 2023). We acknowledge this critique and observed such patterns in this study, including the 'resurrection' of plants reported as dead one month the alive the following (Figure 2). Although ensuring high data quality requires diligence in most scientific research, we feel the current design of the Ascot App has built in aspects to reduce this concern. These include that the app is project specific and a user would likely be joining researchers in the field to access the microforest and thus would receive the above training. The Ascot App only accepts data entries initiated with a scan of one of the project's QR-coded tags and thus narrows the types of data entered and supporting data interoperability between monitoring events. Furthermore, the app uses a limited number of plant health data prompts to not overwhelm or disengage users while monitoring. We seek to further improve the prompts and user experience as we continue using the Ascot App at the Ascot Hills Park microforest and expand its use on forthcoming projects. In particular and with additional coding, the application can accommodate new prompts such as for diameter at breast height or phenology data, enabling the project administrator to customize the tool for their specific research needs. customization of prompts to allow collection of data.

Lastly, the current data output is a large CSV file downloaded from the web-based Ascot App Admin portal. The CSV file format was selected as it can be sorted, filtered and searched, as well as imported into common software programs such as Microsoft Excel. A best practice of citizen science is to include volunteers not only in the data collection phase, but in the data analysis phase (Ganzleben and Kazmierczak 2020), including through basic visualization of the collected data. Moving forward, we plan to develop a web-based dashboard, Microforest Connect, to collate, summarize, and graphically visualization of collected monitoring data. These data will also be leveraged to quantify ecosystem services and quantify their monetary value by incorporating use of the iTree Eco suite (iTree 2023), a free software application that assesses urban trees. Ultimately, we feel the Ascot App is an effective smartphone-based tool that has demonstrated a low-cost, highly accessible approach to public participation in monitoring of new urban trees and has the foundation to support citizen science involvement to improve reforestation monitoring across Los Angeles and other urban landscapes.

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