Documenting the Māla Lā‘au Project using a Community Science Tool

by

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April 27, 2023

Masters project submitted in partial fulfillment of the requirements for the Master of Environmental Management degree in the Nicholas School of the Environment of Duke University

EXECUTIVE SUMMARY

Understory Alliance is a non-profit organization located on the island of Kaua‘i, Hawaii. Our client, Sari Pastore, is the founder and executive director of the organization. By increasing empathy, equity, and inclusion, Understory Alliance encourages all learners to cherish and strengthen their connection with the natural world (*Understory Alliance*, n.d.). We will focus on Understory Alliance’s Māla Lā‘au Project, an initiative to develop a community forest garden on Kaua’i. This public space aims to encourage a deepened emotional connection to nature and offers free access to native Hawaiian and culturally significant plants as well as non-invasive food trees.

The site location for the Māla Lā‘au Project will be in Kapa'a, the largest town on Kaua’i. The forest garden will be planted on the Kaua’i Animal Education Farm, as it is easily accessible to the Kapa’a community. The Māla Lā‘au Project was developed to address the need for interconnectedness between people and nature, which is an important part of Hawaiian culture. The goals are for the forest garden to improve community mental health and address the issue of food insecurity, which will allow the community to better adapt to the climate crisis (S. Pastore, personal communications, October 2022).

Hawaiian culture places importance on its people having a reciprocal relationship with nature. ‘Ōiwi is an indigenous Hawaiian perspective on how different elements of the environment interact, how people and the environment should interact with each other, and how people should interact with one another (Kurashima, N. et al., 2018). All three relationships are crucial for biocultural resource health, as these concepts serve as the foundation for their stewardship in restoration management. Citizen science tools, such as mobile apps, can engage public stakeholders in environmental management efforts through features like real-time uploading of citizen-collected data (Tang et al., 2017). They can also reinforce habits of mobilizing learners into action and advocacy (Buchanan et al., 2018).

As consultants on the Māla Lā‘au Project, our main objective was to prototype a community science tool for engaging future forest garden visitors. The community science tool should present relevant information to communicate with diverse stakeholders, gather data from forest garden visitors to paint a picture of project success, and assess future opportunities for growth and collaboration, in part by incorporating visitors’ feedback.

We developed a Google Site as a prototype of the community science tool. Components of the Google Site include a homepage for the tool, a plant catalog, and tabs to communicate educational materials as well as gather data from forest garden visitors. A homepage was created to guide users in the community science tool and within the forest garden. Users are met with a series of descriptors on the homepage that direct them to different content and resources based on their reason for visiting. The plant catalog allows users to identify different species, and learn more about practical and cultural uses for the plant. To develop content for the community

science tool and the prototype, we separated desired materials into (1) data to gather from forest garden visitors and (2) educational materials to provide. Within each category, we created overarching questions to organize the content integral to the project.

A community survey was created to gauge interest and receive feedback on the forest garden. The results will influence the plant and tree species found on the property, and the types of events offered once doors open to the public. Platforms for developing the community science tool were selected and evaluated based on a list of criteria developed by the MP team. The top three ranked platforms were Ionic, Titanium, and Google Sites. We also established relationships with the SuperBetter Company and the graduate computer science department at Duke as potential collaborators in the tool development phase.

We recommend our client use Ionic, Titanium, or Google Sites to create a unique community science tool for Kapa'a residents in Kaua'i at a relatively low cost to Understory Alliance. As our client considers next steps upon the conclusion of our partnership, we recommend remaining in contact with the SuperBetter Company and the Duke graduate computer science department. Both groups have expressed an interest in fostering relationships. The former in hopes of connecting the importance of being in nature with alleviating mental health and addiction illnesses. The latter in hopes of offering the development of the forest garden community science tool as a graduate-level project and professional development opportunity. We also recommend sharing our prototype with future developers of the community science tool.

Offering community outreach via a citizen science tool can facilitate the connection between humans and the natural environment, engage the community in evaluating forest garden success, and improve the likelihood of sustained visitor involvement. This master's project has offered a multidisciplinary, hands-on experience that enhances both our academic and professional experience. We learned about the importance of Hawaiian culture in environmental management. Upon doing so, we were able to produce a prototype of a community science tool that will help community members navigate their time spent in a culturally significant and aesthetically pleasing forest garden.

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1.0 Introduction

The Māla Lāʻau Project was initiated by our client, Understory Alliance, who is working to develop a forest garden that best serves residents on the island of Kauaʻi, Hawaii. Forest gardens are comprised of wild and cultivated food producing plants that resemble a natural forest or woodland ecosystem (Wiersum, 2004). In the hopes of engaging stakeholders, our team has prototyped a forest garden community science tool. The community science tool should present relevant information for diverse stakeholders, gather data from forest garden visitors to paint a picture of whether the project is successful and identify opportunities for growth and collaboration, in part by incorporating visitors' feedback. Our prototype guides the structure and content for the community science tool. Key questions we considered while developing the prototype included (a) what data should we gather and share with stakeholders to get them involved in monitoring the forest garden, (b) how can we best evaluate the health of the forest garden, and (c) how can we make the tool welcoming and accessible to all forest garden visitors? We have also initiated the process of finding a suitable platform for the community science tool and finding potential partners for the tool development phase.

1.1 Client and Project Significance

Understory Alliance is a 501(c)(3) non-profit organization working on increasing the health and resilience of ecosystems, communities, and individuals to mitigate and adapt to our climate crisis (*Understory Alliance*, n.d.). These objectives are addressed by strengthening the reciprocal relationship between people and nature. Emphasis is placed on offering inclusion, empathy, and equity, empowering all learners to cherish the natural beauty around us. Understory Alliance's philosophy is "when we have easy, free **access** to healthy natural places, when we are invited and expected to participate in such places actively, and when we have a physical **connection**, our emotional connection deepens. Then, we can be open to the **observation** and **education** needed to make the necessary **changes** to thrive in our world" (*Understory Alliance*, n.d.). The organization is currently working in multiple capacities: (1) supporting volunteer partnerships such as the Kauaʻi' Climate Action Coalition, (2) mentoring students enthusiastic about environmental education and science communication, (3) offering consultation to various related institutions and programs, and (4) designing biocultural landscapes for community engagement (S. Pastore, personal communications, February 2023). Sari Pastore, the founder and executive director of the organization, has years of experience in environmental education and now works with global and local communities to design programs and service-learning curricula that focus on conservation efforts.

A major initiative within the organization is creating easily accessible forest gardens populated with native Hawaiian plant species, noninvasive food trees, and culturally significant plants. The Māla Lāʻau Project on the island of Kauaʻi is an example of one such effort. This pilot project aims to improve climate equity and environmental justice through access to nature, biocultural diversity and function, and food security (S. Pastore, personal communications, February 2023).

Research has found that being in nature reduces anxiety and stress, feelings of isolation, and other health issues (Kurashima, et al., 2018). It is also known to increase self-esteem, improve immune system functions, and lead to a more positive mood. As a community that experiences food insecurity, the forest garden will allow Kauaʻi to better adapt to the climate crisis by offering easily accessible native Hawaiian plant species, appropriate noninvasive food trees, and culturally significant plants. This free, pocket-sized forest garden offers a green space that should easily weave into the community's everyday lives (*Understory Alliance*, n.d.).

Our client has tasked us with developing a prototype of the community science tool to engage stakeholders in the forest garden. The forest garden has not been established yet, so we will offer our findings on a community science tool in anticipation of what the establishment will look like and how the residents will make use of the space.

1.2 Project Location

The Māla Lāʻau Project's community forest garden will be located in Kapa'a, a town on the island of Kaua'i. The marshy landscape of the town was changed in 1877 when Captain James Makee and King Kalakaua jointly purchased a sugar estate and established the Makee Sugar Company. A decade later, the plantation employed over a thousand workers, and they were producing 5,000 tons of sugar each year. Kapa'a's population grew due to the number of immigrants moving into the area for employment. Laborers traveled from countries such as the Philippines, China, and Japan. The plantation closed in 1946, putting a lot of people out of work and greatly impacting the community (Saito & Campbell, 2004).

Today, approximately 85% of the island's food is imported, and this reliance on importation has led Kaua'i to be dependent on out-of-state sources of food (Chirico & Farley, 2015). This places residents at risk of food shortages in the event of natural disasters, changes in the economy, and/or local climate changes. This historical context emphasizes the importance of Kaua'i having the capacity to be food self-sufficient, and forest gardens offer a means of increasing food self-sufficiency. The Māla Lāʻau Project is being constructed on the Kaua'i Animal Education Farm, as it is easily accessible to the Kapa'a community. The location is important because it allows for natural space to grow in balance with the people. The flora is also unique because of the history of the community's people.

Figure 1. Location of the Māla Lā‘au Project on the Kaua’i Animal Education Farm*

*The forest garden will be located on the eastern side of the island.

Figure 2. Community Buildings Near the Forest Garden*

*The Kapa’a Middle School is located near the Māla Lā‘au Project property, offering a convenient opportunity for teachers to facilitate place-based educational activities on the nearby farm/forest garden.

1.3 Project Scope and Objectives

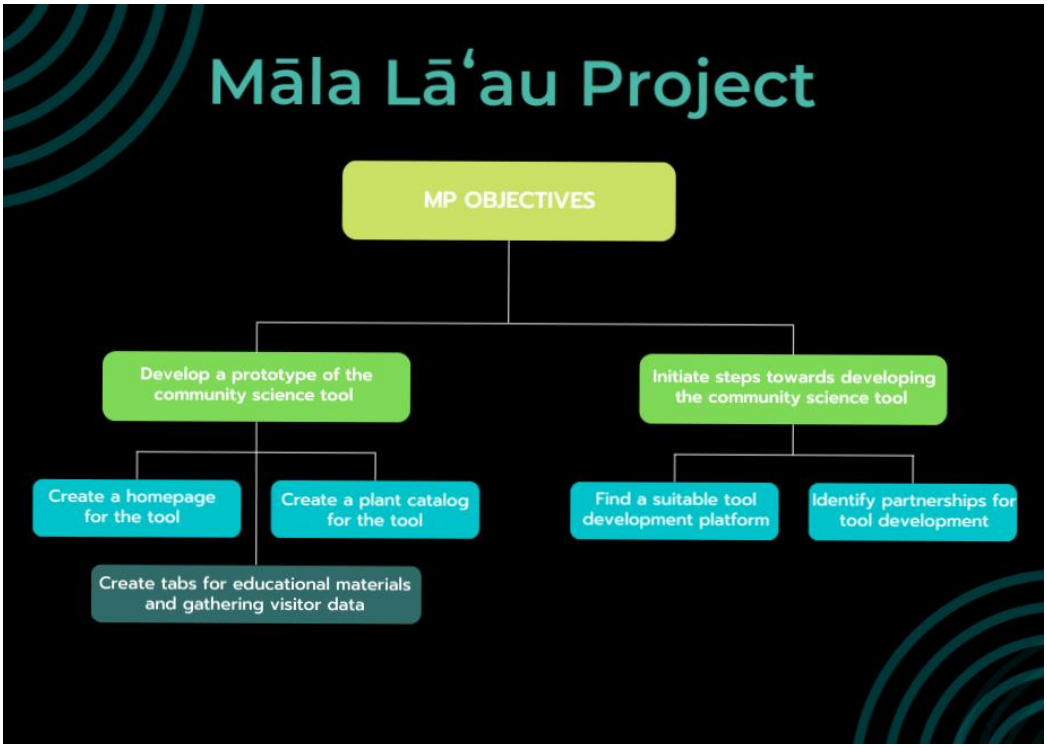
This project is unique to the Kapa'a community, as it has been tailored to their specific needs of increasing food security and improving mental health through nature connectedness. To understand the community's needs, we engaged in long, thoughtful conversations with our client and discussed the questions that would frame the objectives we set for the project. Our main question was how can a community science tool best document, share, and assess the success of the Māla Lā'au Project within the Kapa'a community? We address this question by investigating how the tool can best serve forest garden visitors while also informing Understory Alliance on how they can adapt and improve forest garden management.

Sub-questions included:

(1) What data is most pertinent to collect from the forest garden and how can we involve community members in that process?
(2) How can we ensure the community science tool evaluates the health of the forest garden, the frequency of forest garden use (e.g., tracking volunteer numbers and hours), and whether we are meeting the needs of the community?
(3) How can we make this platform user-friendly, welcoming, and accessible to different types of learners?

These questions offered a starting point for brainstorming how to accomplish our master's project objectives described in the figure below:

Figure 3. MP Objectives for Developing the Māla Lā'au Project's Community Science Tool



We were tasked with developing a prototype of the community science tool. We were also tasked with finding a suitable platform for tool development and finding potential partnerships for creating the tool.

1.4 Literature Review

We conducted a literature review to inform our approach for addressing project objectives. This section provides context on Hawaiian culture and how a community science tool may help a community like Kapa'a connect with their natural roots and address climate issues.

1.4.1 Historical Hawaiian Culture

Hawaiian culture places importance on its people having a reciprocal relationship with nature. ʻŌiwi is an indigenous Hawaiian perspective on social institutions. This perspective emphasizes the importance of a reciprocal relationship, as it is necessary for ensuring the health and well-being of ʻāina (land). ʻŌiwi incorporates three concepts: how different parts of the environment interact with itself, how people interact with the environment, and how people interact with each other (Kurashima, N. et al., 2018). These relationships serve as the foundation for their stewardship in restoration management, which is important for biocultural resource growth. Therefore, the maintenance and incorporation of indigenous institutions, such as those derived from ʻŌiwi, are required if restoration of biocultural resources are to be managed successfully (Kurashima, N. et al., 2018). By acknowledging the connection between people and nature, there may be an improvement in the community's reliance on research, engagement, education, resource management, and policy (Cadiz, Kapono, and Chong, 2018).

It is also important to address pre-contact agriculture and how Western contact changed Hawiian ecology. The 1770s marked the first point of Western contact, and their presence changed the land ecologically through the introduction of invasive species and land-use manipulation. As a result, native ecosystem loss has accelerated over the last two hundred years (Gon III, Tom, and Woodside, 2018). Inadequate biosecurity is one of Hawaii's biggest challenges to biocultural restoration and sustainability. Unfortunately, Western contact has caused issues that Hawaii will unlikely be able to reverse. However, we can recapture the pre-contact social-ecological system with the combination of traditional ecological knowledge, indigenous values, and the latest science. Such efforts can help restore native biological diversity (Gon III, Tom, and Woodside, 2018). For this reason, it is important that the design of ecological institutions considers the historical context of social-ecological systems. The Konohiki system, a system of resource management, emphasizes community-based collaboration and caretaking through informal co-management. This allows communities to self-organize and set their own goals and objectives. Community-led management has the potential to move towards more effective conservation solutions as it builds a more collective leadership that incorporates tradition (Montgomery and Vaughan, 2018).

Management should also be grounded in honoring the place, the culture, and the understanding that we have a shared responsibility to protect and conserve our environment. The idea of a reciprocal relationship between people and nature can build trust among a community, allowing it to grow its network (Cadiz, Kapono, and Chong, 2018). Place-based solutions are crucial for effective resource management because every location is privy to its unique set of issues. This is particularly important in Hawaii because locally sourced food is both socially and culturally important to the community. Food systems are vulnerable to land-use change and climate change impacts (Montgomery and Vaughan, 2018). Food is an important part of Hawaiian culture. Pre-contact, cooking was considered a sacrificial practice and eating an act of worship. Food has bonded people together and created an environment that celebrates sharing a meal and being friendly with one another. Over the decades, Hawaii has become reliant on food imports, which makes food security an issue if there were to be a shortage. To return to a more self-sufficient system, Hawaii needs to call on their indigenous values and knowledge. Breadfruit, for example, is a Polynesian crop that provides holistic and practical solutions to Hawaii's food security issues, environmental degradation, and public health issues. It can be grown sustainably, restoring ecosystems and helping increase food production (Langston and Lincoln, 2018).

1.4.2 Hawaiian Natural Resource Management

Ahupua'a is a traditional resource management framework that recognizes the connection between land- and marine-based natural resources. Land and sea are dependent on one another for ecological function. The island of Kaua'i has a highly connected ecosystem in which the health of the forest influences the health of the ocean, and vice versa. For example, nesting seabirds' excrement (guano) acts as a natural fertilizer that benefits land ecosystems (S. Pastore, personal communications, October 2022). The guano also fertilizes nearshore marine systems, which adds to the density and diversity of marine species. When fish populations are suffering, these birds have to change their migratory pattern, which means the land and sea are not receiving the seabirds' benefits of nesting in Kaua'i.

The interconnectedness of the island's ecosystems makes it important for there to be effective resource management and stewardship. By involving the community, the people of Kaua'i can become a part of the interconnectedness and foster a more reciprocal relationship with nature. A community science tool can act as the catalyst, getting the community involved in monitoring the health of the island's ecology.

1.4.3 Community Engagement and Community-Based Natural Resource Management

Community engagement begins as soon as the community is approached to gauge their interest in project participation (Dyer et al., 2014). At the initiation of a community engagement project, one should consider what will make the process successful and have a clear understanding of how outcomes will be assessed. In an *outcomes-based evaluation* of community engagement, components of a successful participatory process might include equity, trust, learning,

information exchange, empowerment, ownership, influence on outcomes achieved, and improved decision quality and acceptance. In a *process-based evaluation*, early engagement, efforts to represent all relevant stakeholders, clear and agreed upon objectives, continual engagement, context-relevant methods used for engagement, strong facilitation, use of scientific and local knowledge, and open communication of meaningful information are some useful evaluation criteria. Meaningful community engagement requires a participatory process of defining 'community', effective communication, mutual respect, and clear roles and responsibilities.

In the field of natural resource management, community engagement is a term used to describe the mechanisms for involving communities in the management of their own environment and the resulting implementation process (Dyer et al., 2014). Community-based natural resource management is becoming more common around the world (Prager & Vanclay, 2010). It is recommended that such initiatives include an understanding of reasonable expectations for volunteers, involvement of all relevant stakeholders, identification of issues relevant to the community, diverse funding availability to increase group autonomy, sufficient funding for project and stakeholder expectations, good communication among group members, and adequate staff training to effectively provide a professional service.

1.4.4 Building Community in Environmental Education through Mobile Tools

Mobile citizen science tools may have several positive impacts on community engagement. A 2021 study determined that a mobile scavenger hunt app not only increased the level of attachment to the place, but it created an awareness among neighborhood residents, encouraged app users to seek new experiences, and offered a platform to reflect on personal memories and community events (Knearem et al., 2021). Mobile platforms have become increasingly important channels for citizens to send and receive information (Tang et al., 2017). With mobile tools available for collecting real-time data, citizen science can contribute to environmental management efforts such as air and water quality monitoring as well as biodiversity conservation. Notably, both online and offline activities should be promoted for successful public engagement in environmental management.

Citizen science projects should offer a means of two-way communication between practitioners and participants, with such communication tools supporting social learning, sharing, and community building (Luna et al., 2018). Online interaction can provide social proof that an activity is perceived as worthwhile since a community is engaging in the activity. Community building can be driven by community activities being publicized. It can increase social presence in dispersed communities, and a communication plan is vital for participants to frequently hear back from project implementers. Community building on an online platform can be enhanced by clearly defining your purpose, offering gathering places, developing up-to-date member profiles, encouraging appropriate etiquette when interacting on the platform, and addressing the needs of

newcomers without alienating the regulars (Kim, 2006). It is suggested to allow space for the technology platform to evolve, adding depth and complexity as members' needs change. Engagement can be enhanced by integrating community leaders to greet visitors, answer questions, and deal with troublemakers hurting the platform's welcoming environment. Additionally, offering regular events can deepen relationships and develop a loyal following.

Using mobile tools for environmental education offers a new way of engaging stakeholders in environmental stewardship. The tool can connect learners to collaborate virtually about scientific inquiries (Buchanan et al., 2018). For example, the app QuestaGame can be used for teams working together to take and upload photos of various species, with rewards given for correct identification of the organism. Online tools are shown to positively reinforce mobilizing learners into action and advocacy. In a study of 11 eco-apps for educating and engaging adult learners, big environmental changes and actions were documented, including 90 million pounds of waste being diverted from landfills through recycling, reusing, and composting practices (Typhina, 2015). Traditional environmental education methods include websites, tour guides, and brochures. However, feedback on app store pages indicated a preference for these engaging platforms compared to traditional methods, with the benefits of location-specific content, community sharing, and gamification. Being able to share your work was considered more fulfilling as it could now be shared and made readily available around the world through the app.

2.0 Methods

2.1 Design of Initial Framework

Before diving into brainstorming components for the community science tool, the team first established a unified purpose, visualizing an ideal end product and creating actionable steps towards reaching this goal – all the while, keeping in mind that the creative process is imperfect and will require some flexibility from everyone involved. To get team members on the same page, the team created a "Guiding Light" document that describes the Why, the How, the Who, and the What of the project. In the preliminary weeks, this document was filled out with thoughts from all team members.

Having harmonized a team mental model, we began to discuss relevant components for the community science tool while considering the project's importance for our client's community. We determined there would be three main components to the prototype: (1) developing a homepage that serves to guide users through different parts of the forest garden, (2) creating a comprehensive plant catalog with forest garden species, and (3) finding ways to incorporate data collection and shared education content within the community science tool.

We also wanted to ensure the community science tool documented both environmental gains and societal benefits of the project. We brainstormed additional ways for the tool to achieve this goal, although not all of these components are included in the current prototype:

- Geospatial mapping of forest garden
- Plant inventory
- Photo identification feature to accompany plant catalog
- Workshop summaries
- Tracking of forest garden volunteer hours

2.2 Content Development

We went through a content development phase to determine what data should be gathered from forest garden visitors and what educational materials should be shared. The data collection items were sorted and broken down into relevant questions Understory Alliance may use to engage visitors in the community science tool (see Appendix A). While drafting what data should be gathered from forest garden visitors, a main consideration was how to hold the project accountable for meeting the needs of the community. The team brainstormed ways to address this consideration, including plans to inquire visitors whether forest garden maintenance plans are being followed and if so, whether these plans have been effective or require revisions. The community science tool may also allow visitors to document their observations of the forest garden. For example, offering a tab on the community science tool where people can upload pictures of traditional crafts made from forest garden materials, share recipes using ingredients from the forest garden, or share how they have spent their time caring for the forest garden.

The educational materials table lists the cultural and environmental context that should be shared with the community (see Appendix A). Educational outreach materials will include information on the native Hawaiian plant species and noninvasive food trees found on the property. During content creation, an emphasis was placed on making the educational materials engaging for different types of learners. For example, it was proposed to provide images of significant species found on the property for visual learners. Once all ideas for potential data collection and education sharing items were documented, the exhaustive list was trimmed to include only the most prevalent questions for visitors. Once the community science tool is launched, our initial content structuring format can be built upon following community input.

The community science tool will include a homepage where individuals can indicate what they are visiting the forest garden for, and clicking on a provided response will take them to another landing page that may have some educational material or ask visitors to document their visit using text, graphics, pictures, or videos. We outlined a list of questions that serve to guide community science tool users during their time in the forest garden (see Appendix B). These

questions helped us structure what content visitors may access from the homepage. The community science tool will allow stakeholders to be an active part of the forest garden management process because their input will serve as a data source for the staff. We formatted some of the brainstormed content in a Google Site that serves as a prototype of the community science tool.

2.3 Platform Selection and Development of the Community Science Tool

To provide our client with a robust set of possible formats for developing the community science tool, we evaluated 10 tool development platforms, 8 of which were suggested by our client and 2 by external advisors. In this project, a platform is defined as a framework of services that Understory Alliance can utilize to build and deploy the community science tool. Included below is the list of prototyped platforms:

- AppSheet
- Task Manager
- KoboToolbox
- Mighty Networks
- Titanium
- Ionic
- Google Sites
- ArcGIS Survey123
- Metabase
- SuperBetter

We tested the platforms by inputting different pieces of information from our content development phase to see how they would function and be displayed in the community science tool.

We engaged in conversation with our client to determine a set of criteria that would evaluate each platform in a way that assessed how easily users could navigate the platform. After using the criteria to analyze each of the platforms, we can choose platforms that best address the goals and objectives of the project. Each platform was evaluated according to the following criteria:

- Which platform will result in an **accessible and easily navigable** community science tool?
- How easy is it for forest garden management to **edit and update** the community science tool?
- How can we utilize a platform's **aesthetic capabilities** to engage and retain community member use?
- Does the platform have the **capability to display data** in a visual way that is easily understandable?

- Does the platform have the **capability to analyze data** within the community science tool?
- What is the **cost of use and/or development** of the platform?
- How **relevant** are the features of each platform in accomplishing the goals and objectives of the Māla Lāʻau Project?

We also reached out to the computer science departments, both undergraduate and graduate, at Duke University to discuss a collaboration on community science tool development. Such a collaboration would serve as a professional development opportunity for other students and allow our team to outsource the task of building the community science tool.

2.4 Community Survey Development

After outlining the information we wanted to share with and collect from forest garden visitors, we determined that the distribution of a community survey would prove useful (see Appendix C). This survey would help the team better understand the community's existing knowledge of forest gardens, gauge their interest in establishing such a destination in their community, offer foresight into how the community might interact with the space, and incorporate community needs into forest garden development plans.

While drafting the survey, diligent phrasing of questions was a top priority. The survey language was intended to be welcoming, not off putting by testing community knowledge levels. Our main objective was to provide supportive and inclusive background information. Respondents will be given the opportunity to express their concerns and offer open ended feedback on the community project.

The MP team was asked to develop the survey but not administer it, as the client will distribute the survey to community stakeholders. Survey results will help establish an initial impression of future stakeholders and what they are hoping to get out of the forest garden. Our client may also use the results for her own intended purposes. The survey development process has reinforced our efforts to make communications in the community science tool engaging for different types of learners, which is reflected in the content presented on the prototyped Google Site.

3.0 Deliverables

3.1 Content Structure

Appendix A shows the questions developed to sort what data will be collected from forest garden visitors and what educational content will be shared in the community science tool. In Part I of Appendix A, four overarching questions were used to categorize the type of information we want to gather from community members:

- Is the forest garden thriving or unhealthy?
- What are the impacts on the people that visit?
- How are people interacting with the space?
- Are there ways we could be better serving the community?

Although not listed as a question, we want to ensure that the educational content is displayed in diverse ways, engaging different types of learners. In Part II of Appendix A, overarching questions for sharing educational materials include:

- How can we help the community feel welcome and mindfully orient themselves?
- How will the community establish a sense of place?
- How can we help deepen relationships and ties with the land?
- How can we provide a culturally appropriate experience for the community?

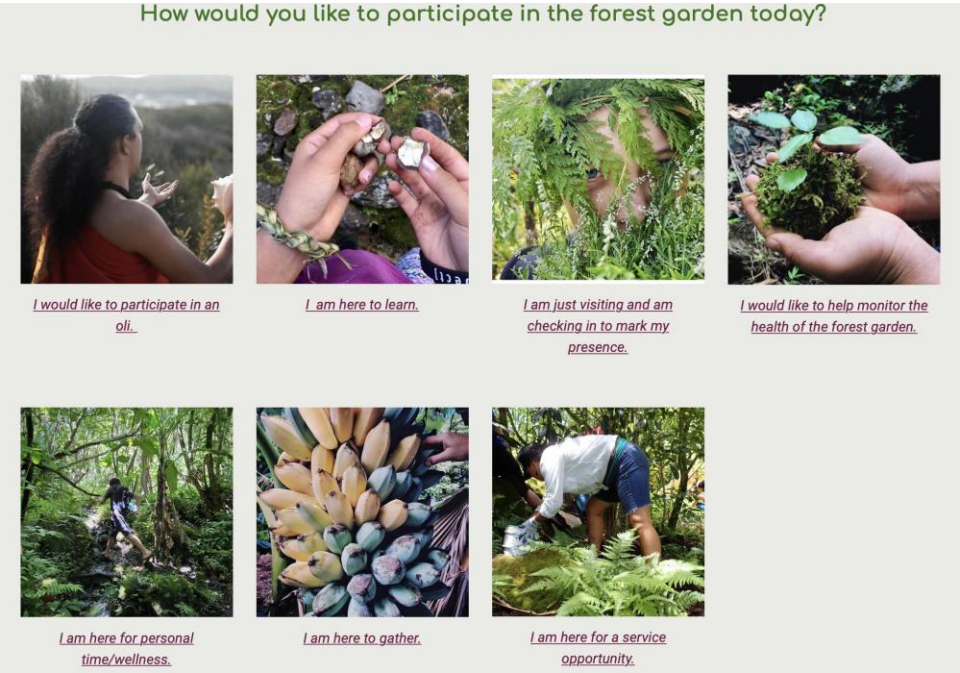
3.2 Prototype of the Community Science Tool

We developed a Google Site as a prototype of the community science tool. It serves as a guide on what content and formatting to use in the finalized end product. It is a compilation of relevant components we have developed, and its purpose is to assist in the future development and advancement of the community science tool. The main components of the prototype are:

- A homepage with descriptors of activities to participate in throughout the forest garden
- A plant catalog for identification purposes
- Webpages for gathering data from forest garden visitors and sharing educational content.

The homepage includes a series of descriptors that serve to guide community members throughout their time in the forest garden. The descriptor that visitors click on will indicate how they plan to use the space, which in turn will inform their intended contributions to forest garden management.

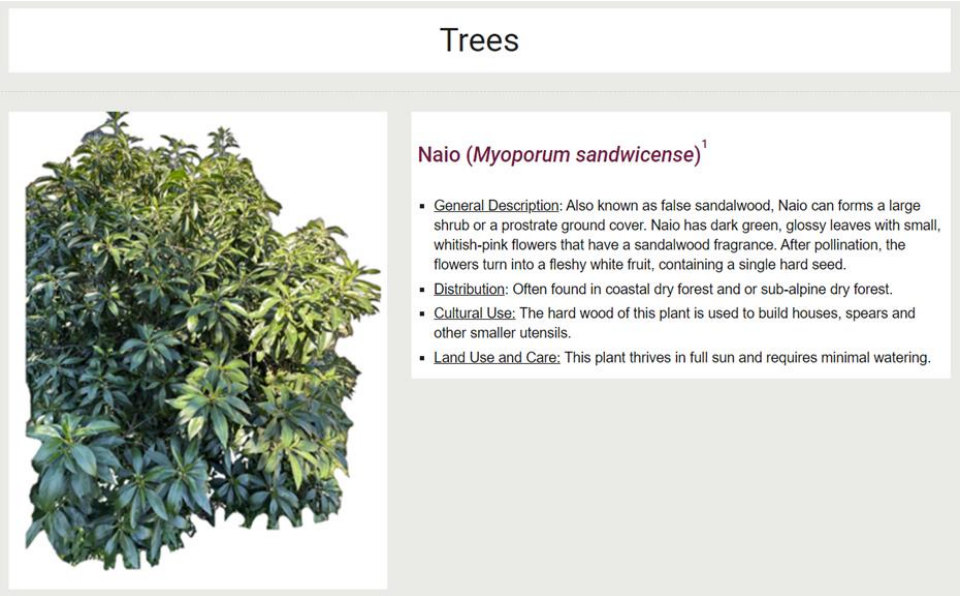
Figure 4. Screenshot of the Homepage



A major goal for educating forest garden visitors includes providing background information on native Hawaiian and culturally significant plants. The plant catalog we developed will help deepen visitor's cultural understanding and ties with the land. It may be embedded within the community science tool to help users identify various plants throughout the forest garden. Photos are provided in the prototype to help identify plants. Once identified, the user is provided with a general plant description, planting tips, and historical and cultural information as it pertains to the species. The plants in the forest garden have been chosen thoughtfully based on the climate, cultural traditions, and community needs.

Figure 5. Screenshots of the Plant Catalog

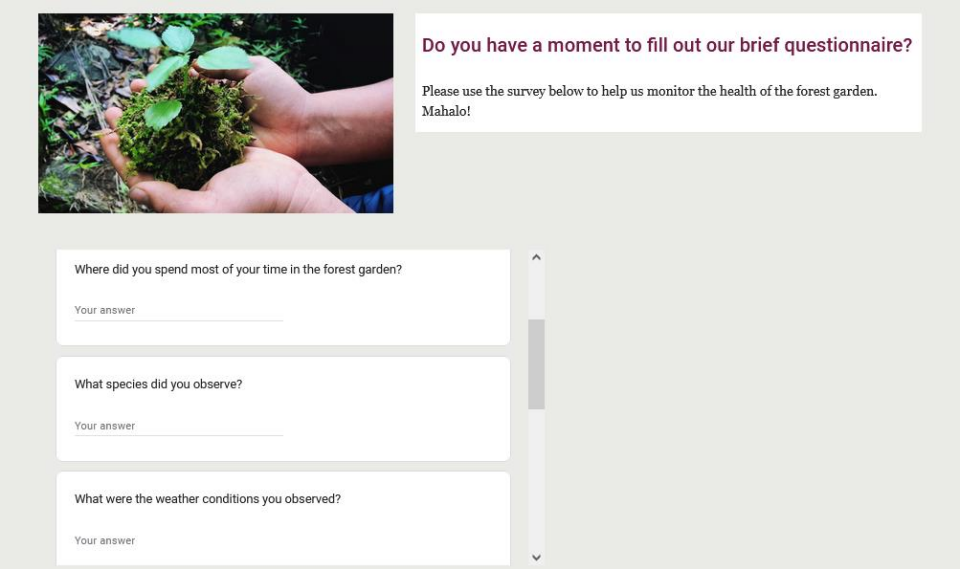
A. Tree Example



B. Shrub Example

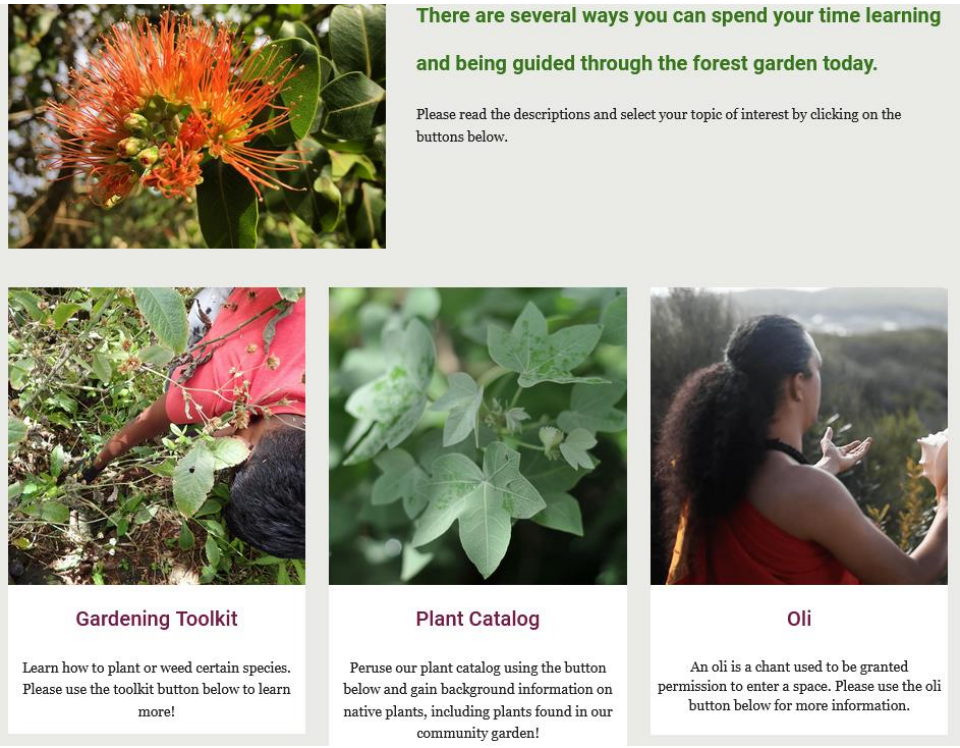
The forest garden management tab allows us to gather data about the health of the forest garden. Visitors can share where they spent time in the garden and use guided questions to assess the health of the vegetation around them.

Figure 6. Screenshot of the Forest Garden Management Tab



Visitors can click on the learning tab and select a topic of interest to dive into.

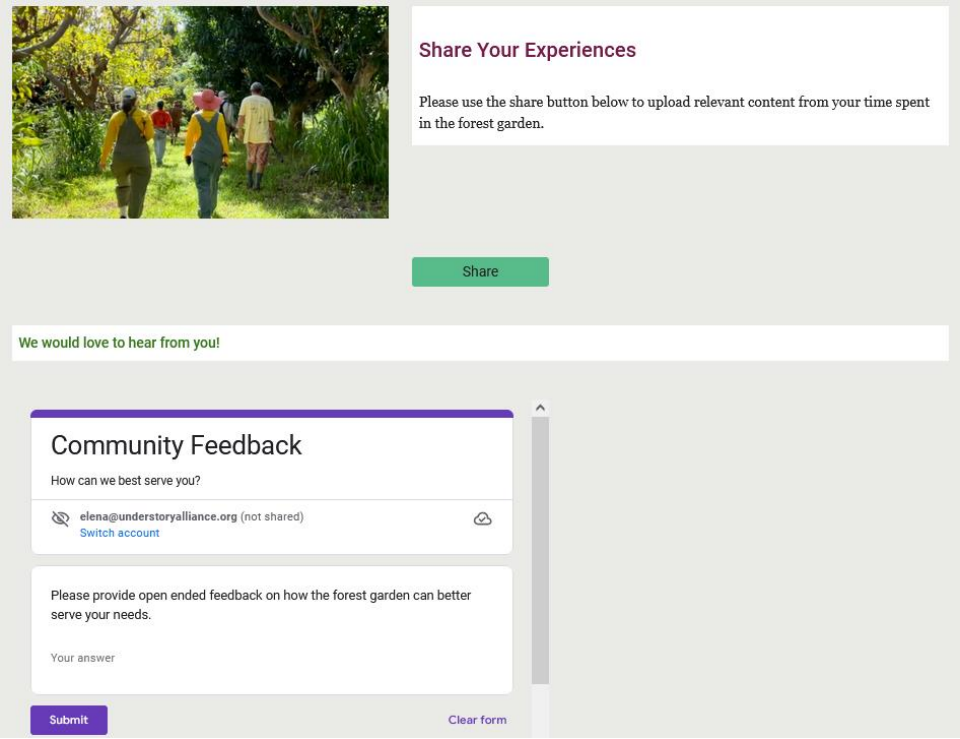
Figure 7. Screenshot of the Learning Tab



The communications tab allows visitors to document their experiences in the forest garden. People can click on the green button (displayed in the figure below) to upload content they would like to share with the community, such as pictures of traditional crafts made from forest

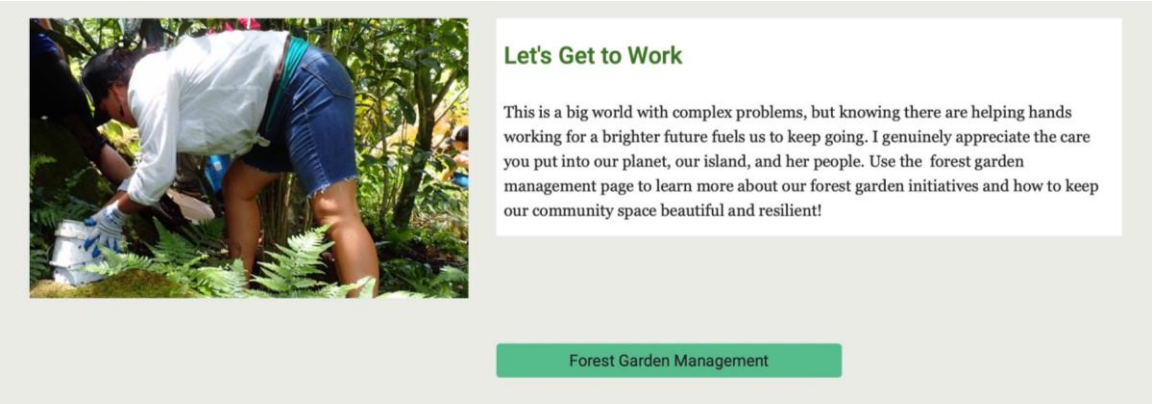
garden materials. This is also where visitors can go to provide open ended feedback on how the forest garden can better serve their needs.

Figure 8. Screenshot of the Communications Tab



On the volunteering tab, the green button in the image below allows visitors to explore the forest garden management tab, which is a useful resource for many volunteering efforts. This page also allows visitors to check in and track their volunteer hours, and a calendar is displayed on the volunteering tab so visitors can stay up to date on upcoming events in the forest garden. The calendar is also available on the homepage.

Figure 9. Screenshot of the Volunteering Tab



3.3 Platform Ranking for Tool Development

We developed a set of criteria to analyze different features of potential community science tool platforms. The criteria include ease of use, ease of edit, overall aesthetics, data analysis and visualization capabilities, and cost of use and development. All criteria were weighted equally. We ranked the ten chosen platforms based on this criteria in Table 1 below.

Ionic and Titanium require basic coding experience. However, they have the capacity to design a unique community science tool that fits the specific needs of Understory Alliance. Ionic works in tandem with GitHub, which operates a software package to develop a secure and functional software on Ionic's dashboard. It provides instructions on how to build, deploy, and automate the community science tool. Individuals can code for specific data visualization and analysis functions. Titanium works the same way as Ionic, but requires a bit more coding knowledge than Ionic. Titanium alone is free, but depending on certain features included in the development process, the pricing can be discounted for individuals or new organizations with an annual revenue of funding under a certain limit. Both Ionic and Titanium utilize API, an application programming interface that provides the instructions and requirements that allow a mobile community science tool to use features of other platforms. API is another expense to be considered. Both platforms can operate with iOS and Android. Based on the criteria, Ionic and Titanium are highly ranked at the first and second position.

Google Sites is a mobile platform that works on a variety of devices such as PCs, phones, and tablets. The platform allows for the development of easily accessible and editable sites. There are a variety of templates available to achieve aesthetic goals. There is no cost to publish. However, there are limits to what you can do within the platform in terms of the available features. SuperBetter is a gamified mental health tool that promotes personal growth through challenges that inspire resilience and strength (*SuperBetter*, n.d.). Although the mental health aspect would satisfy the goal of assessing how the community is connecting with nature, it does not have other capabilities needed to analyze data or record observations. Rankings below 4 are platforms that cannot accomplish much without encountering additional costs or only cater to specific features.

Based on our analysis, we recommend that Understory Alliance use one of the top three ranked platforms. These include Ionic, Titanium, and Google Sites. Each platform offers the opportunity to create a unique community science tool for the Kapa’a community in Kaua’i at a relatively low cost to Understory Alliance. For the time being, we used Google Sites as the prototyped platform because it comes at no cost. Understory Alliance can continue to utilize this platform until money has been allocated for more extensive community science tool development.

Table 1. Prototyped Platform Ranking.

	Criteria (ranked 1-5; 1-worst and 5-best)								
Platform Name	**Ease of Use (for user)**	**Ease of Edit (for management)**	**Aesthetic**	**Data Visualization Capabilities**	**Data Analysis Capabilities**	**Cost of Use & Development**	**Relevance to Goals of Project**	***Score (avg.)***	**Overall Rank**
Ionic	4	4	4	5	5	3	4.5	*4.29*	**1**
Titanium	4	4	4	5	5	3.5	4.5	*4.21*	**2**
Google Sites	4	4	4	3.5	3	3	4.5	*3.57*	**3**
AppSheet	3	3.5	3	3.5	4	2	3	*3.14*	4
ArcGIS Survey123	3	3.5	3	4	4	2	2	*3.07*	5
Metabase	2	3	2	4	3.5	3	3	*2.93*	6
SuperBetter	4	3	3.5	1.5	2	2	3.5	*2.79*	7
Task Manager	3	3	3	2	3	2	1	*2.50*	8
KoboToolbox	2	3	2	3	2.5	3	2	*2.43*	9
Mighty Networks	3	3	4	2	1	2	1	*2.29*	10

3.4 Community Survey

Survey data was not available prior to the completion of the prototype of the community science tool. However, formulating the questions gave our team the opportunity to consider the forest garden from the perspective of future visitors. For example, it has offered clarity on potential mental and physical benefits community members may experience from spending time in the forest garden. We have provided the final survey to be distributed to community stakeholders in Appendix C.

3.5 Future Collaborations

We have established relationships with the SuperBetter Company and the graduate computer science department at Duke University. SuperBetter is focused on building resilience and recovery from mental illness and addiction through online gamified challenges (*SuperBetter*, n.d.). They have proposed linking the community science tool with their own application and have offered to create a gamified challenge customized to Understory Alliance's mission, which would reinforce the benefits of spending time in nature for mental well-being. The graduate computer science department at Duke has offered to include developing the forest garden community science tool as a project for masters students or for their Code+ summer program. As Understory Alliance considers next steps, we recommend they remain in contact with both groups for potential future collaborations. Additionally, we recommend sending along our proposed prototype to future partners in the community science tool development phase.

4.0 Conclusions

As the Māla Lāʻau Project continues being developed, Understory Alliance can integrate our findings to best serve the needs of the community. Our prototype exemplifies one way of formatting the desired content for the community science tool. This prototype was created keeping in mind that the forest garden will best thrive with sustained involvement of Kapa'a and other Kauaʻi residents. As an example, the prototype offers a means of tracking the frequency of forest garden use. Additionally, community participation may be retained by incorporating their input as the project evolves. The community science tool should request feedback from visitors to identify project areas in need of refinement, potential development of new project areas, and opportunities for future collaborations. Feedback will also be gathered on whether we are meeting the needs of the community. Integrating this feedback will be integral for solidifying the commitment of involved community members.

Understory Alliance aims to improve the connection between humans and the natural world, and getting the community involved in caring for the forest garden may enhance progress towards

reaching this goal. The Google Site exemplifies ways to make the educational content on the tool accessible for different types of learners, to establish a welcoming, user-friendly, virtual environment, and to actively engage visitors in caring for and sharing their knowledge of this communal outdoor space. The community science tool should offer ways for visitors to evaluate and document their observations of the health of the forest garden. The plant catalog may also encourage visitor curiosity and exploration, providing ways to identify and learn about a plant's significance.

Working on the Māla Lāʻau Project has provided us with a multidisciplinary, hands-on experience that may enhance both our academic and professional careers. A partnership with Understory Alliance has allowed us to expand on our existing professional skill sets while also giving us the opportunity to develop new ones, such as community science tool research and development. We immersed ourselves in Hawaiian culture through resources provided by our client and relevant literature to truly understand the place-based relationship between humans and nature. Upon doing so, we were able to produce a prototype of a community science tool that will help community members navigate their time spent in an aesthetically pleasing forest garden. This may help strengthen community ties and teach the community about the importance of biocultural restoration.

5.0 References

Buchanan, J., Pressick-Kilborn, K., and Maher, D. (2018). Promoting Environmental Education for Primary School-aged Students Using Digital Technologies. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*. https://doi.org/10.29333/ejmste/100639.

Cadiz, E., Kapono, L., and Chong, U. (2018). Na Kilo Aina: Visions of Biocultural Restoration through Indigenous Relationships between People and Place. *Sustainability*, 10, 3368. https://doi.org/10.3390/su10103368.

Chirico, J. and Farley, G. (2015). Thinking Like an Island: Navigating a Sustainable Future in Hawai'i. University of Hawai'i Press. https://books.google.com/books?hl=en&lr=&id=E1kEEAAAQBAJ&oi=fnd&pg=PT38&dq=food+insecurity+in+kauai&ots=PtsU_ByEoZ&sig=LufGaF_EnxuGTtnNySM55p2tzNk#v=onepage&q=food%20insecurity%20in%20kauai&f=false.

Dyer, J., et al. (2014). Assessing participatory practices in community-based natural resource management: Experiences in community engagement from southern Africa. *Journal of Environmental Management*, *137*, 137-145. https://doi.org/10.1016/j.jenvman.2013.11.057.

Gon III, S.M., Tom, S.L., and Woodside, U. (2018). ‘Aina Momona, Honua Au Loli Productive Lands, Changing World: Using the Hawaiian Footprint to Inform Biocultural Restoration and Future Sustainability in Hawai’i. *Sustainability*, 10, 3420. https://doi.org/10.3390/su10103420.

Kim, A. J. (2006). *Community building on the web: Secret strategies for successful online communities*. Peachpit Press.

Knearem, T., et al. (2021). Seek and Reflect: A Mobile Scavenger Hunt to Develop Community Engagement. C&T '21: Proceedings of the 10th International Conference on Communities & Technologies - Wicked Problems in the Age of Tech.

Kurashima, N. et al. (2018). Aina Kaumaha: The Maintenance of Ancestral Principles for 21st Century Indigenous Resource Management. *Sustainability* 10, 3975. https://doi.org/10.3390/su10113975.

Langston, B.J. and Lincoln, N. (2018). The Role of Breadfruit in Biocultural Restoration and Sustainability in Hawai‘i. *Sustainability*, 10, 3965. https://doi.org/10.3390/su10113965.

Luna, S., et al. (2018). Developing Mobile Applications for Environmental and Biodiversity Citizen Science: Considerations and Recommendations. In *Multimedia Tools and*

Applications for Environmental & Biodiversity Informatics (pp. 9-30). Springer International Publishing. https://doi.org/10.1007/978-3-319-76445-0_2.

Montgomery, M. and Vaughan, M. (2018). Ma Kahana ka ‘Ike: Lessons for Community-Based Fisheries Management. *Sustainability*, 10, 3799. https://doi.org/10.3390/su10103799.

Pastore, S. (2022, October). Personal communication [Personal interview].

Pastore, S. (2023, February). Personal communication [Personal interview].

Prager, K., & Vanclay, F. (2010). Landcare in Australia and Germany: comparing structures and policies for community engagement in natural resource management. *Ecological Management & Restoration*, *11*(3), 187-193. https://doi.org/10.1111/j.1442-8903.2010.00548.x.

Saito, D., & Campbell, S. (2004). Lihue Plantation Company History. University of Hawaii at Manoa Library. https://www2.hawaii.edu/~speccoll/p_lihue.html.

SuperBetter. (n.d.). https://www.superbetter.com/.

Tang, Z., et al. (2017). Developing an Interactive Mobile Volunteered Geographic Information Platform to Integrate Environmental Big Data and Citizen Science in Urban Management. In *Springer Geography* (pp. 65-81). Springer International Publishing. https://doi.org/10.1007/978-3-319-40902-3_4.

Typhina, E. (2015, 2015-11-01). Designing eco-apps to engage adult learners. 2015 International Conference on Interactive Mobile Communication Technologies and Learning (IMCL).

Understory Alliance. (n.d.). https://www.understoryalliance.org/.

Wiersum, K.F. (2004). Forest gardens as an ‘intermediate’ land-use system in the nature–culture continuum: Characteristics and future potential. *Agroforestry Systems*, 61, 123-134.

6.0 Appendix

Appendix A: Content Structuring Process

I. Data Gathering

Overarching Questions	Project Goals	Measureable Sub-Questions
Is the forest garden thriving or unhealthy?	Ensure health and function of the forest garden	
		What is the survival rate of each species?
		How healthy are the plants?
		How healthy is the soil?
		Are plants coexisting with neighbors? Or outcompeting?
		Are the plants fruiting?
		Are we seeing a diversity of plants?
		Are the plants free of diseases?
		Where in the garden did you observe the plant?
		Are the species getting enough sunlight?
		Are the species getting enough water?
What are the impacts on people that visit?	Provide health and wellness benefits for Kaua'i residents	
	Provide food security	What food are you gathering and for what health purpose?
		What food is absent that residents would like to gather?
		How many individuals are you feeding with the food gathered?
	Provide psychological benefits	How are you connecting with the space?
		Anxiety/stress levels when you entered the garden? When you exited?
		How are you recreating/decompressing in the space?

		What effect has coming to this space had on you?
		How are you getting in touch with the present moment in nature (mindfulness)?
How are people interacting with the space?	Ensure the space is meeting multiple community needs	
		What are cultural practices that take place in natural spaces (e.g., oli, spiritual practices (hula), and Na Kilo Aina)?
		What cultural foods are being eaten with gathered ingredients?
		If gathering, what purpose are you gathering for?
		How would you like to participate?
		Are there any projects you're interested in pursuing in the garden?
		How long did you stay for your visit?
		How many hours did you spend volunteering?
		Who did you spend time with in the garden?
Are there ways we could be better serving the community?	Offer means for community to provide feedback	
		Do you have any open ended feedback to share with the Māla Lāʻau Project team?
		Are forest garden maintenance plans being followed?
		Have forest garden maintenance plans been effective or do they require revisions?

II. Education Sharing

Overarching Questions	Measureable Sub-Questions
How can we help the community feel welcome and mindfully orient themselves?	
	How can the community practice being present with surrounding nature?

	How can the community learn more about the plants they are seeing?
	How will the community know which plants to eat and how to prepare them?
	How will the community know which plants can be used for medicinal purposes?
	How will the community care for the plants in the forest garden?
	How can we make people feel safe to participate?
	How can people be invited to participate?
How will the community establish a sense of place?	
	How does the location and plant community coincide?
	What is the historical context of the land we are on?
	Who are the people who first lived their lives here?
	Who joined the first arrivals/took over?
	What grounding techniques will you practice today to immerse yourself in the present moment and tune into your senses?
How can we help deepen relationships and ties with the land?	
	Where is the water coming from?
	Where are we?
	What are our ancestral ties to this land?
	Who made use of this land before us?
How can we provide a culturally appropriate experience for the community?	
	What can the community do upon entering the space to acknowledge their culture?
	How can people get more personalized questions answered about the forest garden?
	How can the community connect with each other?

Appendix B: Designing the Initial Framework

This appendix shows the questions that community science tool users may be met with when they open and activate the tool. The questions serve to guide them through their time in the forest garden. Based on their response, they will be provided specific information or educational material. The questions are as follows:

Why are you here today?

- Would you like to participate in an oli?
  - *provide info/links to a few Olis* and history blurb
- Just visiting! Open to guided app experiences.
  - Would you like to be randomly placed into a guided experience?
- Just visiting and checking in the app to mark my presence.
  - Wonderful! We hope you enjoy your visit.
- If you have the time, take notice of the forests' health
  - Where did you spend most of your time in the forest?
    - What species did you observe?
      - Did they appear healthy?
        - Y: what color were the leaves/flowers
        - N: what made you think it appeared unhealthy/dead?
          - Did the other species close by also look unhealthy?
      - What were the weather conditions you observed?
        - Was that location receiving a lot of sun? Shade?
      - Crown Light Exposure
        - Crown is fully shaded.
        - One side of the crown is exposed to light.
        - Two sides of the crown are exposed to light.
        - Three sides of the crown are exposed to light.
        - Four sides of the crown are exposed to light.
      - What were the soil conditions? Dry or wet? Soil color?
      - Was it raining during your visit?
      - *instructional videos/step by step guide on how to upload images*
- I'm here for personal time/wellness
  - Would you want to participate in Na kilo Aina?

Would you like to participate in a meditation practice?

space for yoga/meditation pinpointed on map

Here's access to a map that guides you through the forest

I'm here to learn

Toolkit for those who want to learn how to plant certain species/weed

Educational signage and guidance on community rules within the forest

Plant inventory

Historical significance/general history of area/community

Traditional practices were banned until the 1970s

Would you want to participate in Na kilo Aina

supplies offered in locations throughout forest

nature journaling guidance

I'm here to gather natural agroforest items

Are you gathering with others?

Y: Is it with friends/family/kids?

N: *redirect to personal time tab*

What are you gathering the items for?

Food for cooking

-include recipes

Traditional cultural practices (hula, lei, etc.)

Medicinal purposes

Arts & crafts

Other (open ended response)

I'm here for a service opportunity

Interest in a community group/maintenance day in the forest?\

Bringing in a school/church group

Offer contact info for community engagement personnel

Here's access to a map that guides you through the forest

map includes species specific descriptions/cultural sig. info

-learning traditional Hawaiian words that relate to the forest

click on species and reroute to questions about forest health

Appendix C: Understory Alliance's Community Forest Garden Survey

We developed this community survey to gauge residents' interest and prior experience with forest gardens. It was created for our client to distribute and collect results:

> Before establishing a community forest garden on Kauaʻi, we want to hear from you and incorporate your needs into the forest garden plan!
>
> Duke University students are helping with this project and helped draft survey questions. However, your responses will be anonymous and only visible to Understory Alliance staff.
>
> Thank you for helping us create a forest garden that will benefit the community!

1. A forest garden is a reconstructed natural forest in which wild and cultivated plants coexist. Have you ever experienced a forest garden?
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Uncertain

2. Please rate from 1 to 5 the importance of each forest garden benefit (5: Very Important, 4: Important, 3: Neither Important nor Unimportant, 2: Unimportant, 1: Very Unimportant). *Mark only one oval per row.*

	1	2	3	4	5
A shared location to grow food	◯	◯	◯	◯	◯
A place for the community to gather	◯	◯	◯	◯	◯
A place to relax and ease anxiety	◯	◯	◯	◯	◯
A place to connect with nature	◯	◯	◯	◯	◯
A place with environmental benefits (E.g., reduced air, and water pollution)	◯	◯	◯	◯	◯
A place to volunteer and maintain the garden	◯	◯	◯	◯	◯

3. “I would be excited to have a forest garden in my neighborhood.”
Mark only one oval.

- Strongly agree *Skip to question 6*
- Agree *Skip to question 6*
- Neutral *Skip to question 6*
- Disagree *Skip to question 4*
- Strongly Disagree *Skip to question 4*

4. What has stopped you from supporting the forest garden?

5. How likely are you to visit the forest garden?
Mark only one oval.

- Extremely Likely *Skip to question 7*
- Likely *Skip to question 7*
- Neutral *Skip to question 7*
- Unlikely *Skip to question 12*

6. How likely are you to visit the forest garden?
Mark only one oval.

- Extremely Likely *Skip to question 7*
- Likely *Skip to question 7*
- Neutral *Skip to question 7*
- Unlikely *Skip to question 12*

7. Who would you bring with you when visiting the forest garden?
Check all that apply.

- [ ] My dog
- [ ] My kid(s)
- [ ] My relative(s)
- [ ] My community group
- [ ] Other: _____

8. How would you participate in the forest garden?
Check all that apply.

- [ ] I would like to visit at my leisure
- [ ] I would like to gather food or herbs
- [ ] I would like to gather materials for crafting
- [ ] I would like to participate in cultural practices
- [ ] I would like to volunteer
- [ ] I would like to attend community events
- [ ] Other: _____

9. What would you like to see growing in the forest garden?
Check all that apply.

- [ ] Native trees like Alahe'e or plants like Palapalai
- [ ] Introduced food trees like Tangerine or shrubs like Papaya
- [ ] Medicinal canoe plants like Noni or Olena
- [ ] I prefer no forest garden
- [ ] Other: _____

10. Everything has its challenges. Please identify any challenges you foresee in the forest garden.

11. What solutions do you have for those possible challenges in the forest garden?

12. Is there anything else you would like us to know?