Wetland Food Forest: Restoration Project Proposal

ER412/ES471

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Abstract

This project aims to research methods in creating a system that encompasses both a wetland ecosystem and a productive food system. The proposed site is located on the property of the Galiano Conservancy in an area that is zoned for agriculture, but also hypothesized to be a wetland historically. Wetland ecosystems have historically been drained for the use of European agricultural practices. Drawing inspiration from Indigenous practices such as the Forest Garden, our goal is to create a system where wetlands and agriculture co-exist. We offer a series of structural designs that would benefit wetland agricultural plants in order to meet the goals of this site as expressed by the Galiano Conservancy Association. Our recommendations are based on the methods used to determine the site's ability to support a wetland ecosystem and agricultural practices. The methods used range from researching historical data, on-site observations, soil tests and more. Our proposed design includes a variety of ideas and techniques to not only increase various types of food production but to also encourage biodiversity and the ecological integrity of the site. This project proposal discusses different techniques that can be used to support food and material production such as tree grafting, coppicing, cultivation of native plants, and the use of chinampa style agriculture. The proposed design aims to meet the goals of the project, which addresses the need for increasing water retention on the site, exploring methods and designs that promote both food production and wetland ecosystem functioning, and coming up with ideas for creating an accessible space for harvesting together and sharing knowledge.

1.0 Introduction of Wetland Ecosystems

Wetlands and riparian areas are ecologically valuable landscapes as they transform, filter pollutants and store various nutrients while simultaneously providing crucial habitat to support wildlife and biodiversity (Hook, 1993). Despite the countless benefits that wetlands provide, they are continually disappearing from many Canadian landscapes. Over time, wetlands have become vulnerable areas and "one of the world's most threatened natural resources" (Benalcazar et al, 2019). In fact, historically, the agricultural industry is responsible for destroying up to 50 percent of wetland ecosystems across many regions in Canada (Ahmed, 2020). Up to 70 percent of historic wetlands have been degraded or lost in Canada mostly due to drainage, 84 percent of this loss is attributed to drainage for agricultural land. According to Ducks Unlimited Canada, the provinces of Manitoba and Saskatchewan lose up to 6-8 hectares of wetlands each day (Benalcazar et al, 2019).

1.2 Background of Galiano Island and the Galiano Conservancy Association

Galiano Island, located on the west side of the Strait of Georgia between Vancouver Island and the west coast mainland of Canada, was no exception to this destruction of wetlands. The island was once largely used for agricultural and forestry practices which led to the removal of many key wetland ecosystems. Despite the fact that active forestry is no longer a significant factor on the island, the legacy of agricultural and forestry-related drainage of wetland and wet forest ecosystems persist (Huggins, 2021). In 2012, the Galiano Conservancy Association (GCA) purchased a 76-hectare (ha) parcel on the central west coast of the island to establish the Millard Learning Centre (Higgs and Park, 2018). The watershed at the Millard Learning Centre has been heavily modified by human activities including drainage, logging, soil compaction from machinery, grazing by cattle and sheep, agriculture, road and dam construction and more (Huggins, 2021). The conservancy has been working to restore native forest and wetland ecosystems through the land's watershed to improve the land's ability to absorb freshwater and sequester carbon. Some successful strategies used to restore the learning centre's watershed was the creation of wetland ecosystems and the implementation of the Galiano Community Food Forest.

1.3 Background of Sustainable Food Systems in Ecological Restoration

The Galiano Community Food Forest was a successful project that works as a sustainable food production system that feeds visitors and staff, provides educational opportunities and donates food to the local community (Higgs and Park, 2018). A food forest is known as a "multistorey, perennial polyculture" system that is designed to function as a self-sustaining forest. This has been done for millennia and can be seen in forest gardens stewarded by Indigenous Peoples in the Pacific Northwest (Armstrong et al., 2022). They are typically composed of a high diversity of native and/or non-native plants to promote key ecological components (Park et al., 2017). A goal of the Galiano Conservancy is to create a space where agriculture can coexist with other ecosystems. The Food Forest "emphasis is placed on restoration of ecological processes and conservation of native species" (Park & Higgs, 2018). This Food Forest is not irrigated or intensely managed but it is fenced which allows for certain native species such as camas, ocean spray and nootka rose to grow in a natural system. The success of the Food Forest project led to the conservancy's proposal of restoring a wetland ecosystem that acts as a similar productive self-sustaining food system. In this proposal, we explore ways in which a successful wetland food forest can be attained through different restoration methods.

1.4 Background of the Project's Goal

The goal of this project is to support the creation of a wetland ecosystem that is also a productive agricultural area on a site at the Galiano Island Conservancy Association (GCA). The integration of these projects could create a sustainable method of producing food where the garden is hydrologically dependent on the wetland and would require no additional irrigation.

Our goal as students is to do research to create a basis of information that could help the GCA in their future with this site. Information on wetlands and agriculture have been collected through speaking with local wetland designers and GCA staff members. Physical surveying of the site, photopoint monitoring, test pits and soil samples are all aspects of our project which can help inform the goal of creating a Wetland Food Forest.

1.5 Wetland Restoration with Food Production

This Wetland Food Forest will be an important development for sustainable food production and ecosystem services in the future. Climate change is creating drastic weather changes of both flooding and droughts which can impact crop production, a wetland is a very effective combatant against these problems. Wetlands act as natural sponges, absorbing excess water during heavy rains and floods, thereby reducing the risk of flooding in surrounding areas. During droughts, they release stored water, maintaining groundwater levels and providing a critical water source for crops. Additionally, wetlands improve water quality by filtering pollutants and sediments, enhancing soil health, and supporting biodiversity, all of which contribute to more resilient agricultural systems (Erwin, 2008).

1.6 Background on Chinampa-Style Agriculture

Several stakeholders involved in this project mentioned the possibility of incorporating a chinampa-style agricultural design in this project to help meet the food production goals. Chinampas are a traditional pre-Hispanic lacustrine agricultural system originating from the peri-urban area of Mexico City (Guibrunet et al, 2023). Chinampas have been greatly studied in the field of sustainable agriculture as they do not require an artificial irrigation system. The first chinampa style agriculture practice was located on a wetland that formed a network of shallow canals and rectangular island composed of layers of branches, rocks, aquatic decaying vegetation and sediments from the lake. After several layers of the materials listed, a new landscape pattern was created to form an island or "chinampa" (Rey-Hernandez and Bobbink, 2022). Traditional practices also involved the use of willow trees bordering the area to retain soil and maintain the structure (Guibrune et al, 2023). The chinampas were companion planted which were beneficial for pest control, pollination, providing habitat, and increasing crop production (Vera, 2017). Utilizing chinampas as a feature in this project can help increase the food production of root vegetables such as carrots, turnips and beets.

1.7 Site Location and History

The proposed site for which this restoration plan will take place is located on the northwestern part of the Galiano Conservancy's Associations property (Figure 1). This area is situated below the other food forest and there is potential for extending the fence and connecting the two food areas. This part of the property falls within the area zoned for agricultural use, however, it is also at the bottom of a slope and has shown seasonal wetland characteristics during the winter. This has led the Conservancy to the idea of creating a wetland habitat area that also supports food production.

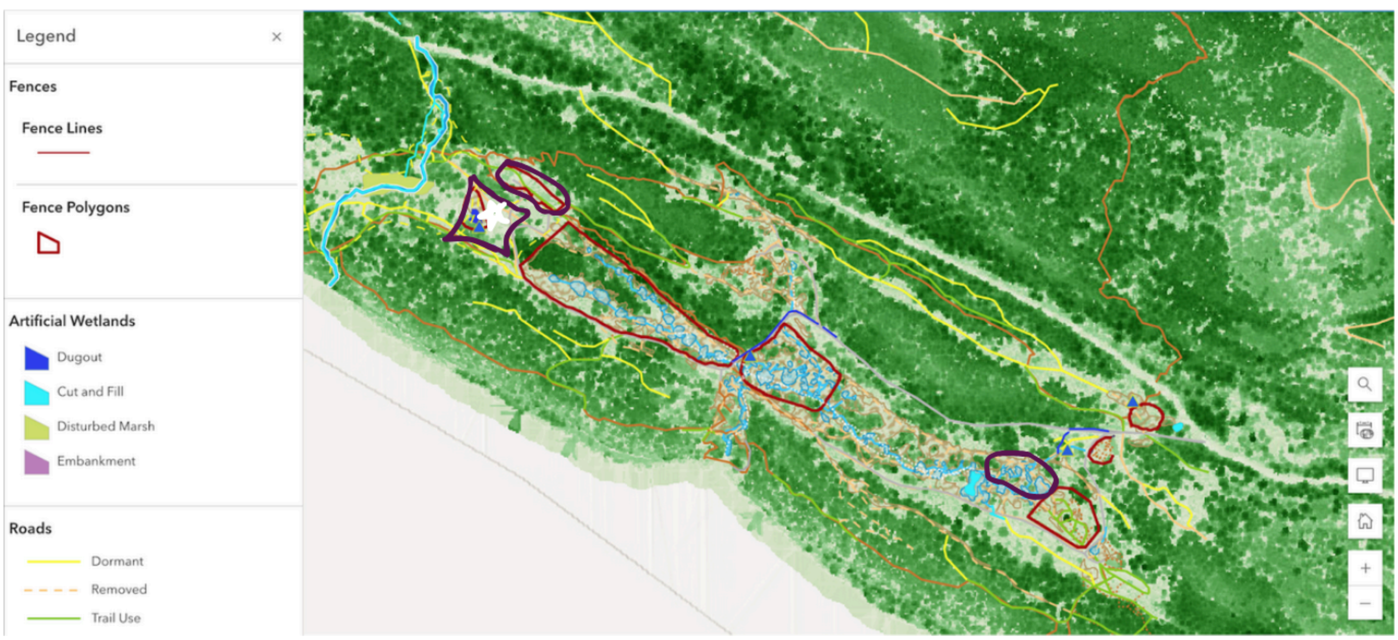

Figure 1. This map displays the site of the Wetland Food Forest relative to the rest of the property and other food areas. Food areas are outlined in purple, the one closer to the south east part of the property is the Forage garden. The existing dryland Food Forest is above the Wetland Food Forest which is denoted by an additional star. Retrieved from Galiano Conservancy's ArcGIS server.

Based on the earliest sourced aerial photo from the 1930s (Figure 2), it appears that this site was one of the first areas to be cleared on the property. It is presumed that the site was used for

European style agriculture, which is supported by the widespread distribution of invasive agricultural grasses. There are two main hypotheses we worked from in thinking about what this site may have resembled historically. One theory is that it was a forested area that was cleared. This is likely the case for at least part of the area, especially on the high northern slope, as there are scattered remnants of old stumps. However, it is also possible that this area may have always been more open, as it is suspected to be a swamp type wetland that was likely drained for the use of agriculture. Evidence for this is the large number of ditches and old roads that surround the site (Figure 3.), which theoretically would have altered the hydrology and lowered the water table. Despite this, it is clear through observation that the area is still seasonally inundated with water during the winter and has a higher water table at lower elevations even into the summer. About five years ago the Conservancy dug a pond and well, as a backup reservoir for the food forest up the hill (pers comm Adam Huggins). This exposed the water table and is a sign that it may be possible to extend and retain water in the lower elevations across the site.

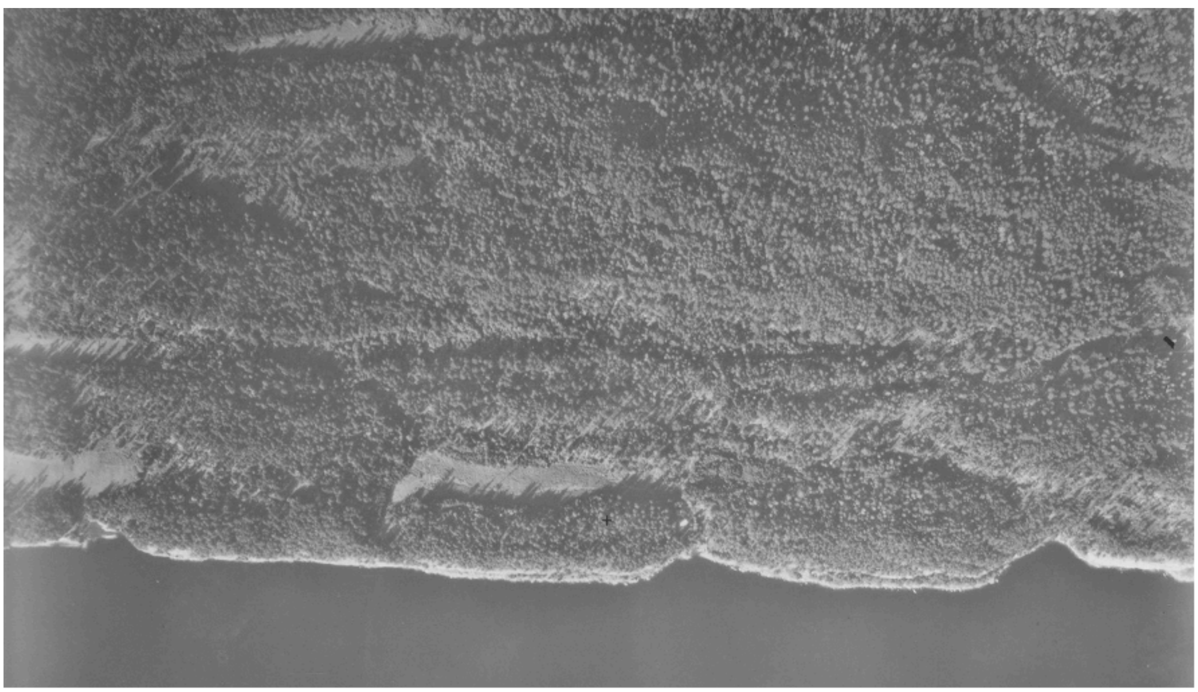

Figure 2. An aerial photo of the Galiano Conservancy Property taken in the 1930s. The cleared area in the middle is the site of our proposed wetland food forest. Source: BC Provincial Archives retrieved from research completed by former Galiano Field Course student, Jon Weller.

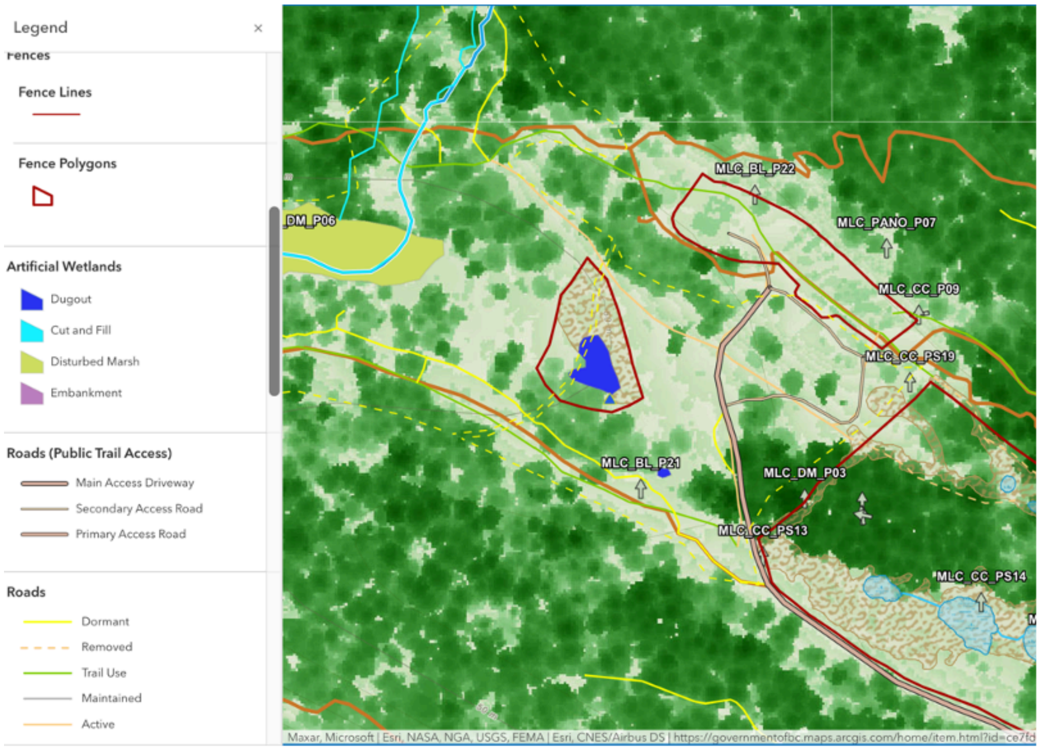

Figure 3. This is an aerial map showing the project site and some of the alterations that have occurred on and around the area. The legend denotes the different features such as old roads and fencing. Retrieved from Galiano Conservancy's ArcGIS server.

Evidence that supports this site as previously being a wetland, can also be found in the area's natural characteristics. From a topographic soil map it shows that Brigantine soils cover the majority of the site (Figure 4). These can be characterized as soils that do not completely drain and typically have around 30 to 100 cm of rock free sand and clay. Brigantine soils typically experience seasonal fluctuations in the water table, becoming saturated in the winter and allowing seepage through the subsoil throughout the rest of the year. This often results in drought-like conditions in the summer, with up to a 75 cm drop in the water table from the surface. This matches the moisture regime that is observed through the seasons on this site, and explains the wetland like tendencies in the winter (pers comm Adam Huggins).

In terms of food production purposes brigantine soils are quite acidic with a pH between 5.1 and 5.5, causing seeds to germinate slowly in the spring.. The top layers of the soil do not hold moisture very well and have a low fertility, although this can be boosted by improving water retention. However, brigantine soils support many of our native trees and understory shrubs including *Thuja plicata* (Red cedar), *Alnus rubra* (red alder), *Pseudotsuga menziesii* (Douglas fir), *Polystichum munitum* (Sword fern), *Gaultheria shallon* (Salal), and *Pteridium aquilinum* (Western Bracken fern). Additionally, it supports fruit trees quite well (Agriculture Canada, 1989).

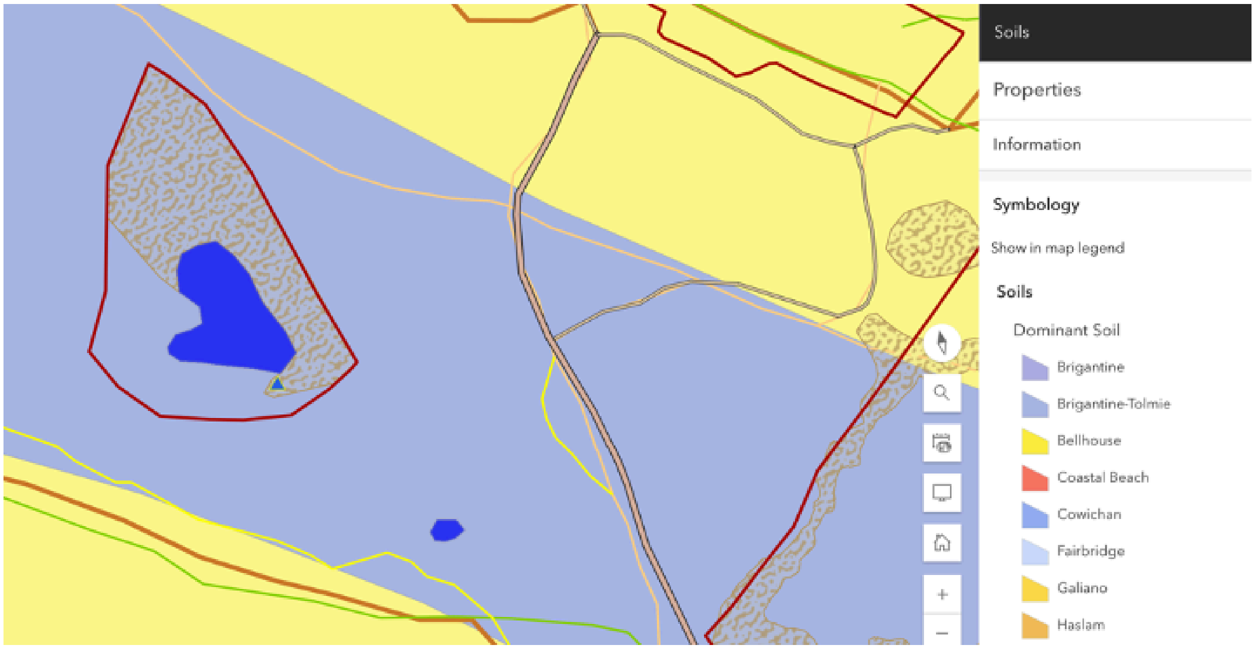

Figure 4. Map showing different soil composition on the site. See legend for the different colors denoting soil type. Brigantine (purple) is the dominant soil on this site. The stippled areas represent rough n' loose soil. Retrieved from Galiano Conservancy's ArcGIS server.

Natural characteristics of the site that support its history as previously being a forested area include some of the tree coverage that remains. A LIDAR map of the site (Figure 5) shows a patch of high tree coverage on the south west side of the pond. This area is an intact stand of well established *Thuja plicata* (Western red cedar) with an understory that becomes seasonally swampy. Tree coverage will be an important factor to consider in the design of this project. Higher tree coverage can provide more shade, decrease sun exposure, increase moisture, and change soil composition, which will seriously influence the types of plants that will grow in that area. High canopy coverage will be crucial for supporting our native shade loving species. The area behind the pond is one of the only intact spots with large trees left on the site, and it is intended that they stay.

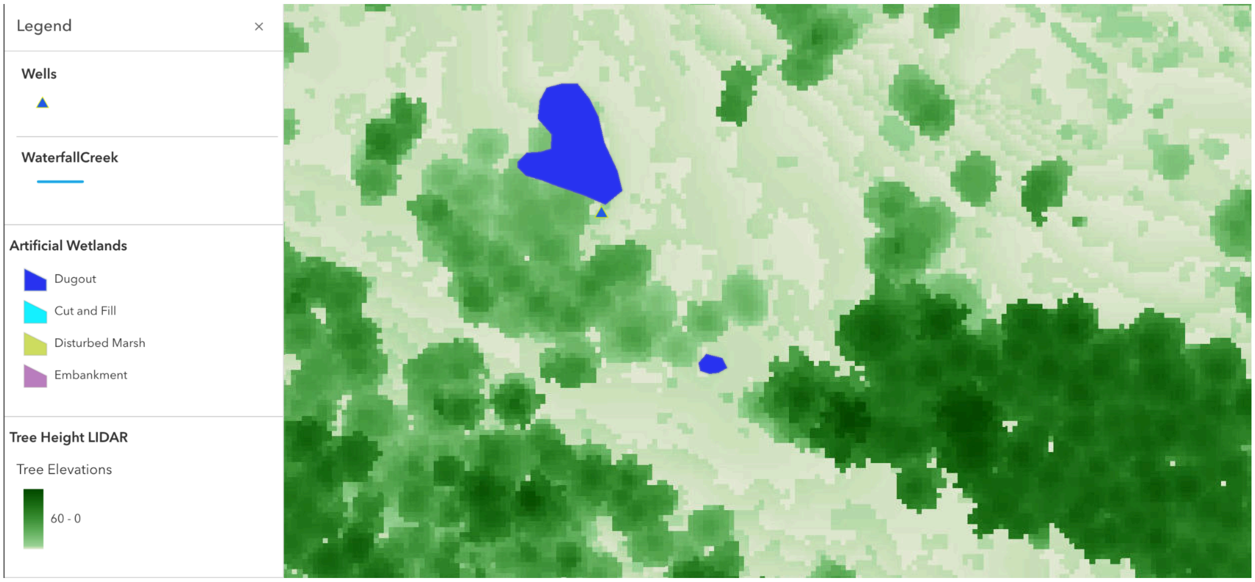

Figure 5. LIDAR map showing tree heights of the site. Dark green denotes the taller trees[EH1]. The blue areas on the map represent exposed standing water. This can be used as a proxy for moist shaded areas as taller trees create a better canopy. Retrieved from Galiano Conservancy's ArcGIS server.

1.8 Overview

The conservancy's proposed idea of restoring a potentially historic wetland site into a food forest seems probable through the research done thus far. This proposal examines the properties of the site including soil, water retention and tree cover to provide suggestions that would increase the success of this project. Our main goals of this project are to explore the hydrology of the site, explore methods that can increase the site's food and material production, research design techniques and discover ways to add elements of educational and cultural purposes. Each goal is sectioned with our proposed methods and suggested next steps for the conservancy.

2.0 Goals and objectives

Project Goal: The overarching goal of this project is to help with the preliminary research and groundwork to see if it is possible to create a wetland food forest at the proposed site on the conservancy's property. The conservancy's goal is to actually create a wetland that also supports a food production system and we are going to help them prepare for that by attempting to achieve the following goals and objectives:

Goal 1: Explore the hydrology on the site and figure out techniques that can be used to increase water retention

Objective 1: Learn about the current state of the hydrology during the summer by conducting site observations and methods such as test pits.

Objective 2: Analyze the soils in the test pits to figure out their composition.

Objective 3: Make note of the ditches and roads around the site that may be responsible for altering the hydrology and lowering the water table.

Objective 4: Compile information on different techniques of water retention through research and speaking to knowledge holders.

Goal 2: Explore methods that can support the site's food and material production.

Objective 1: Research techniques on increasing fruit production through grafting onto native water loving rootstock.

Objective 2: Explore Chinampa style agricultural methods and techniques.

Objective 3: Researching what types of root vegetables and tap root plants would do well.

Objective 4: Looking into plants and coppicing methods that would provide basketry weaving materials.

Objective 6: Exploring different techniques of native berry cultivation.

Goal 3: **Look into methods of how to design the site so that both food production and wetland biodiversity is supported**

Objective 1: Preserve the current intact areas like the cedar swamp, but enhance the understory with harvestable swamp loving species.

Objective 2: Research native plants that would thrive in a wetland ecosystem and provide ecosystem services and harvestable material.

Objective 3: Explore ways of incorporating design aspects from chinampa style agriculture.

Objective 4: Look into the best ways to design a native berry patch and material production so that optimal growth and accessibility is acquired.

Goal 4: Incorporating ideas for educational and cultural purposes.

Objective 1: Select areas of the site to incorporate educational signage.

Objective 2: Explore designs for accessibility and education.

Objective 3**:** Propose ways for the conservancy to connect with the Penelakut Peoples**.**

3.0 Site considerations

3.1 Field observations

While walking the site we were able to get a better understanding of the area and its current state. Key features that we noticed surrounding the site include dirt roads used by vehicles, ditches, and fenced in areas from prior restoration projects. These are suspected to have altered the hydrology on the site, potentially lowering the water table, however, the exact blocking point has not been discovered. Many landmarks from human activity were also found on the site. Some of which were left by the Conservancy during the construction of the pond. The most apparent includes the large mound of clay that was scooped out of the pond and placed to the side as a large berm. Due to its composition of nearly 100% clay not much has been able to grow out of it, and it is available to be distributed around the site. There are also many scattered ditches and holes on the site, some of which were dug to test where the water table was prior to the pond construction. Other things to note include an old road that runs along the top of the site that has compacted the soils and left large ruts. This is important to consider as soil compaction can have negative effects on plant growth by making it difficult for water and nutrients to penetrate into the soils (Lowery & Schuler, 1991)

Some of the natural characteristics that were important to note on the site include native plants such as *Gaultheria shallon* (salal)*, Holodiscus discolors* (oceanspray), *Pteridium aquilinum* (western bracken fern), and *Rubus ursinus* (trailing blackberry). The open part of the site offers full sun exposure, with an aspect that faces approximately south, making the conditions ideal for food production (see Figure 6). However, this has allowed most of the open area to be dominated by invasive agronomic grasses (Figure 7. A). Around the pond there is also *Alnus rubra* (red alder), *Cornus sericea* (red osier dogwood), and *Salix scouleriana* (Scoular's willow) that is looking healthy (Figure 7. C and D). These are all established species that we could keep to provide basketry making materials. However, a stand of *Phalaris arundinacea* (Reed canary grass) is dominating on one side of the pond.

Around a third of the site is quite intact and has not had recent disturbance. This includes a stand of well established *Thuja plicata* (western red cedar) south of the pond. The understory is quite bare, and it gets much wetter in the winter (Huggins, 2024). Behind this in the southwestern corner is a well shaded, moist area that has canopy coverage from alders and adjacent cedars (Figure 7. B). This shaded area already has established *Gaultheria shallon* (salal) and *Rubus ursinus* (trailing blackberry), and *Polystichum munitum* (sword ferns) and would be perfect to support the introduction of more native berries.

Figure 6. Showing the overall current condition on the site. This was one of our photopoint monitoring spots that captured most of the site. Taken from the northern slope facing approximately south. This photo will be referenced as a baseline for the project. This was taken by our group in June, 2024.

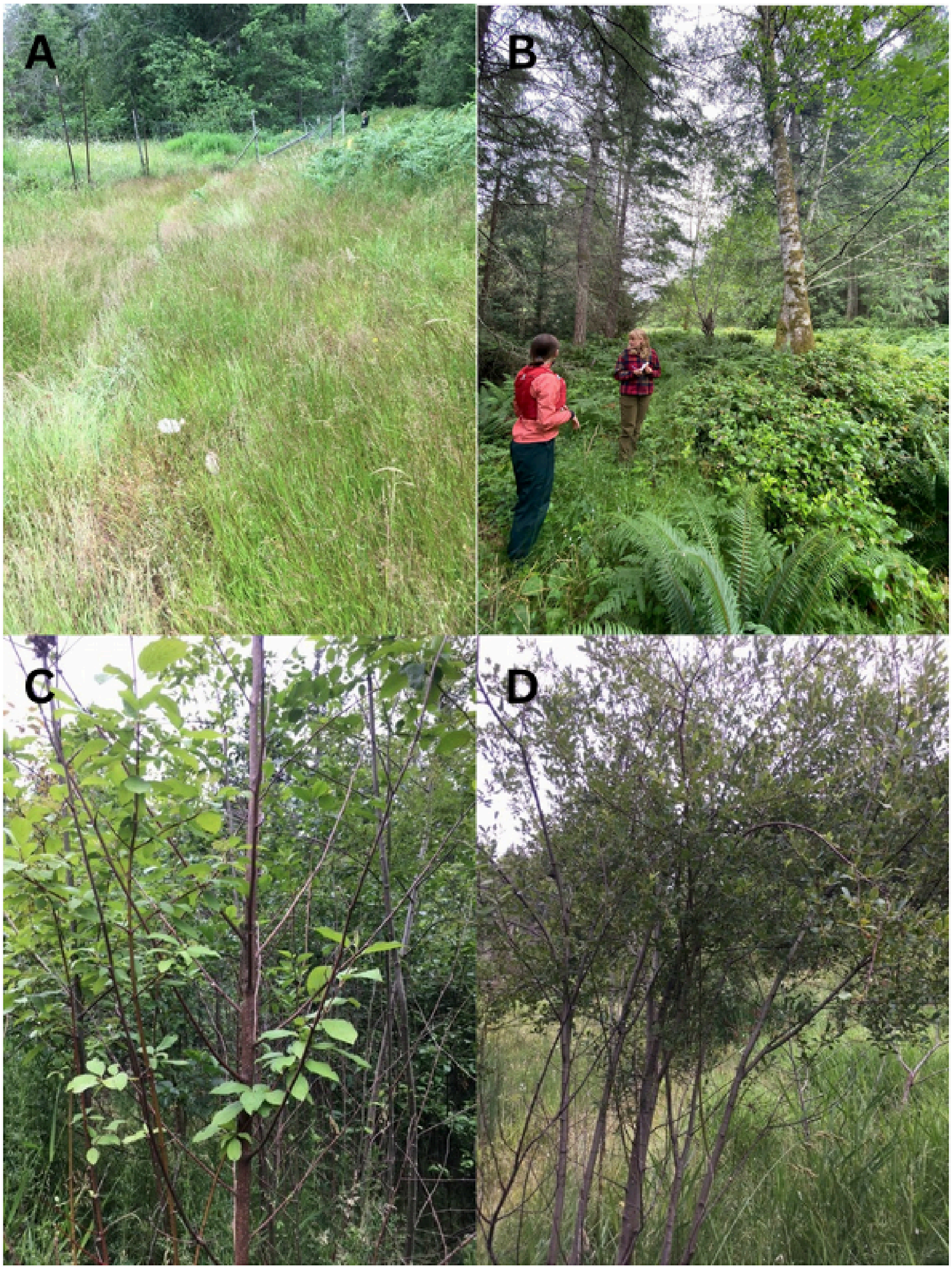

Figure 7. Panel A shows the main composition of the site, with widespread agronomic grass cover. Panel B is the shaded, moist area in the back behind the cedar swamp; there are already some established *Gaultheria shallon* (salal), *Rubus ursinus* (trailing blackberry), and *Polystichum munitum* (sword fern). Panel C is a young *Cornus sericea* (red osier dogwood) found beside the pond. Panel D is a bunch of *Salix scouleriana* (Scouler’s willow), also pictured beside the pond.

3.2 Stakeholder Knowledge

An important method of compiling information was speaking directly to GCA staff. The Restoration Coordinator Adam Huggins expressed the importance of restoration of this area into a wetland and the possibility for new innovative methods of water retention. The Sustainable Agriculture coordinator Cedana Bourne, voiced the importance of this land being used for producing food, as it was originally designated for Agricultural Land Reserve by the Province of British Columbia. Both GCA staff agreed on the need for these two visions to coincide, which has guided this project. Additionally, we met with Peter Bickle Janes, a wetland farmer using innovative designs and experiments on his own property and shared his views on best practice for this site. He explained that having clay soil can be positive for water retention and that our site may be a good spot for the project we are proposing.

Adam Huggins has connected us with Robin Annschild, who is an expert in wetland restoration and has provided valuable insights. Based on the soil results from the test pits, she explains that the clay substrate is thick enough to be impermeable to water. This ensures that whether the water comes partly from the ground and partly from the surface, or mainly from the surface, there is sufficient winter rainfall to fill many ponds. Further, she offers the idea of using core trenches for this site based on the theory that surface water currently flows downhill through soil pores and fractures. By digging basins or trenches, we could block these pathways, causing water to pool and be retained on the slope long enough to support targeted plant species growth (Robin Annschild, 2024).

3.3 Photographic Monitoring

We set up three different photo monitoring locations across the site. These fixed points were placed on landmarks that were unlikely to change over time and also marked with flagged rebar for easy relocation in the future. The locations were chosen to showcase the landscape from different angles so that change to the site can be captured and recorded over time from these exact points. The first step in capturing the photo was to set up the Fuji XT-4 camera using a Fuji 30mm lens on a tripod stand. To make it easier for the photo to be replicated in the future, before each picture was taken we recorded the height of the camera lens, the azimuth of the camera direction, and tried to include semi-permanent objects on the edges of each shot. The pictures were taken horizontally with a wide angle, and each point tried to capture the landscape in 3 shots with a 20-30% overlap. This allowed us to create a panoramic view through piecing together the three photo angles (Fgure 8. C). One of our photo points was in the center of the site. To set this up we took four photos, one for each azimuth facing exactly north, east, west, and south (Figure 8. B). We were also able to use a photosphere camera to capture a 360º view from our first photopoint site (Figure 8. A). All of these photos will form the baseline data for this project as it progresses into the future.

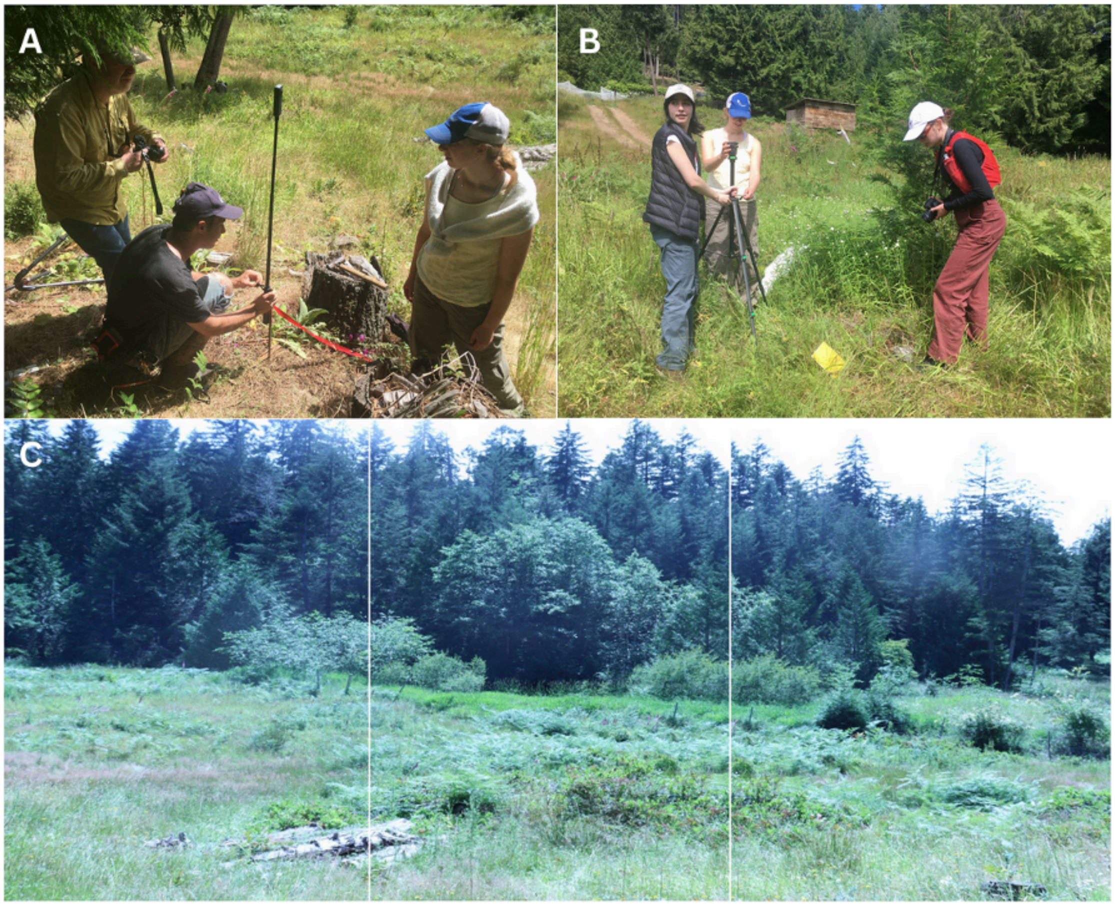

Figure 8. Panel A shows the setup of the 360º Photosphere camera with Eric Higgs (left), Adam Huggins (middle) and Maddy Hopkyns (right). Panel B shows the setup of one of our photopoint spots from the center of the site, Kara Mullin (left), Maddy Hopkyns (middle), and Erin Owens (right). Panel 3 is three photopoint photos side by side to show the general baseline condition of the site, taken in June 2024. This is a view of the cleared area full of invasive agronomic grasses with the pond (not readily visible) in the center. Taken from the Northern slope of the site facing approximately South West.

3.4 Soil test pits

A step taken on July 5th 2024, was the physical digging of test pits in locations of higher elevation than the pond on our site. The objective of these test pits is to determine whether the groundwater table is visible around the site. Two test pits were dug (Figure 9) and no water was initially found, which means the water table is deeper than predicted. However, there was an interesting discovery within these test pits which revealed a dense quantity of clay beneath layers of sand and dirt.

Soil samples were collected from the test pits and subjected to a jar test to analyze the soil horizons (Figure 10). The soil jar test is a simple method used to analyze soil composition by separating it into its different components: sand, silt, and clay. Small samples from each distinct layer of soil in the test pit were placed in a jar filled with water. After shaking the jar to thoroughly mix the contents, the soil particles were allowed to settle. This process visually reveals the soil profiles within the jar, allowing for the observation of different layers. By examining the settled layers, we can determine the percentage of various soil components, such as sand, silt, and clay, within the soil.

These tests confirmed that the soil composition is mostly finer sand and clay, free of rocks and other coarse material. This is important to consider, as finer textured soils have greater water holding capacity and ability to retain nutrients compared to coarse-textured soils (Maietta et al, 2020). Consequently, this has led us to the understanding that the water in the pond previously dug on the site was not displaying groundwater, instead, it is hypothesized that it may be catchment of annual water flow and rainfall.

Figure 11. Soil horizon jar test conducted by GCA staff on July 5th, 2024. [*A layer* = loam (53% sand, 36% silt, 11% clay). *B layer* = sandy loam (80% sand, 5% silt, 15% clay). *C layer* = clay (24% sand, 76% clay) (Huggins, 2024)]

On July 28th, 2024 there were two days of patchy precipitation. The following day, July 29th it appeared that in pit #1, four inches of water was caught and retained, and in pit #2, there was six inches of water. Ten days later on August 8th, water can still be seen in test pit #2. It is difficult for us to determine whether this is the captured rain water, or groundwater.

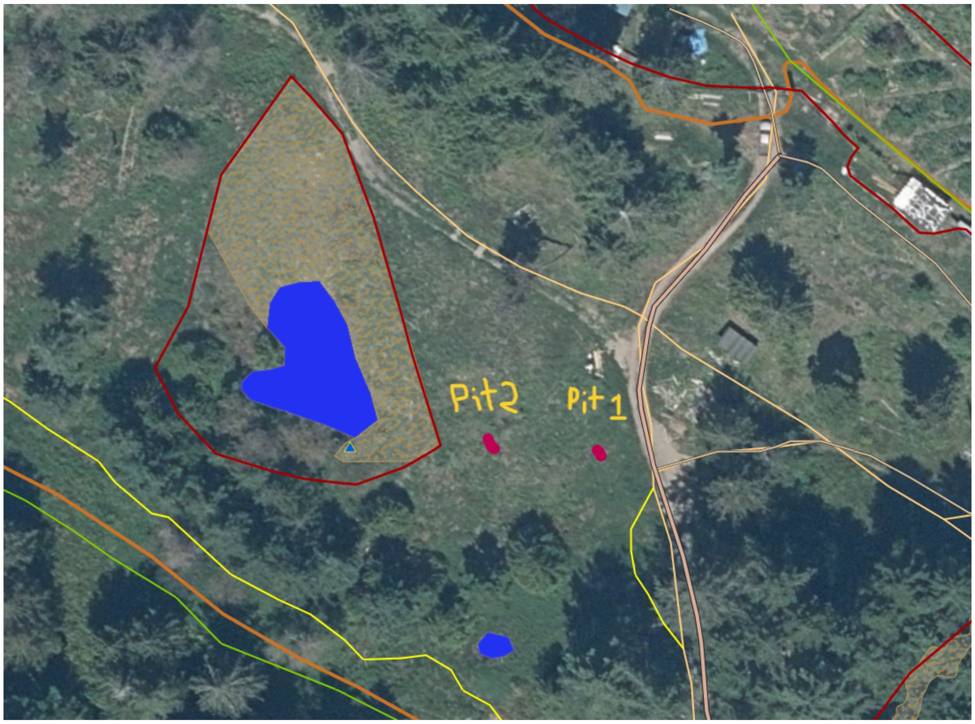

Figure 9. Map showcasing the locations of where test pit #1 and test pit #2 were dug on the site. Map provided by Adam Huggins, 2024.

Figure 10. Panel A shows Adam Huggins investigating soil horizons. Panel B shows the finished test pit product, no water table present

4.0 Design considerations

4.1 Design Overview

From our methods and assessment of the site, factors were found that informed our design proposal. The major site considerations that we found include:

- Pre-existing roads and ditches that have altered the hydrology.
- There are established cedars and areas with moist shady conditions.
- There are native plants and material/food producing plants around the site that could be preserved.
- The site's southern aspect will be good for food production.
- Through the initial digging of the test pits and sampling the soil it was discovered that the water table is not as high as previously suspected in the lower elevations of the site and that the main soil composition on the site is finer sand and clay.
- It was also found that the site has a dense, large layer of clay a few feet below the topsoil, which could be useful for water catchment.
- This finding has led us to the understanding that the water in the pond is not from the water table, but rather, believed to be a catchment for annual water flow and rainfall.

By taking these findings into consideration, we were able to direct our research and compile information on the best ways to move forward with the design of this project. As well, this project was guided by the goals of the Galiano Island Conservancy and stakeholders who provided us with their ideas and visions for this site. From this, we also formed our own goals and objectives to achieve our overarching goal of this project, which was to help with the preliminary research and groundwork to see if it is possible to create a wetland food forest on this site. This section will take you through a multitude of design recommendations for the wetland food forest. Some of the main ideas include techniques for water retention, Chinampa style agriculture, producing basketry materials, preserving intact areas and enhancing them by cultivating native plants and berries, ideas for increasing accessibility, education and cultural practices, and putting innovative spins on farming techniques such as tree grafting and the use of root crops. From our site assessment and time spent in the area, we have formulated a map with a rough design and proposed location of these collected ideas for the Wetland Food Forest (Figure 11.).

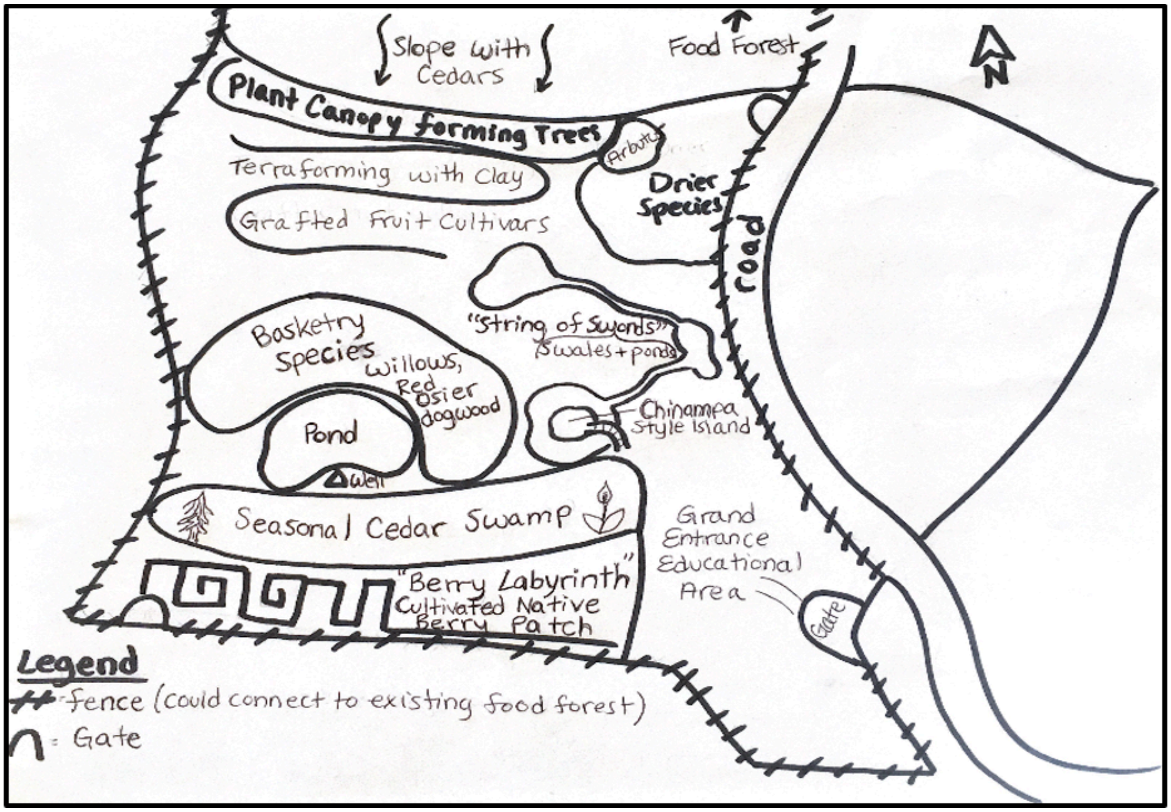

Figure 12. Aspiration Map. Our collected ideas for the proposed wetland food forest and the approximate location of these features. Drawn by Amelia Gray.

4.2 Water Retention Techniques

The overall design of this wetland site is to construct three small ponds that are connected by swales to increase water retention. Several stakeholders mentioned that the use of smaller ponds will be an easier construction method that will help meet the goals of the project. Connecting the three ponds by swales will help increase water catchment and retention as well as increase flow between areas. The area surrounding the ponds will also act as a food productive site with the inclusion of various shrubs and trees that produce fruits and thrive in the shadier, damp areas. The design also includes the incorporation of a boardwalk along the center pond. This will be used to access an area where food production will take place and can also act as an accessible point for educational use. This design does take inspiration from the chinampa style agriculture to further increase the site's food production abilities. The chinampa will support the production of root vegetables. The design also includes fencing along the entire site to prevent disruption from wildlife. The site's entrance will be located on the South East side following the road where signage will be placed to promote educational opportunities of the site.

Our recommendations for the future include to conduct further research regarding the ideal size and depth of the ponds. Better understanding the water volume of the catchment areas (three ponds) will help determine how long it will take to fill with precipitation, how long it will stay full throughout the year and determine if overflow is possible . Additionally, the water depth of the ponds will help determine which species will benefit from the wetland habitat. Other research we hope to fulfill in the future includes researching floating native plants for the water filled areas to increase habitat for native insects as well as determining the best vegetables to plant using the chinampa style agriculture.

To increase water retention on the site we have come up with several recommendations as follows:

1. Fill the surrounding ditches and old dirt roads along the wetland area.

2. Use the clay soil from the ground and the past pond restoration project for the lining of the wetland and the lining of the chinampas.

3. The design should involve smaller bodies of water that are connected by swales. (As seen on Figure 11 labeled “string of swonds”).

4. Plant willow trees along the borders of the bodies of water.

We recommend filling in the surrounding ditches and road by stripping the topsoil of the site and using it to fill in those areas to recontour the ground to its natural level. The leftover clay soil from the previous pond restoration project can be used as a liner along the bottom and sides of the pond to encourage water retention. The overall design of the three smaller bodies of water connected allows for water to flow in between them rather than off the site. Additionally, planting willow trees along the border of the ponds will provide shading around areas of the water.

4.3 Chinampa Style Agriculture

Incorporating a style of chinampa agriculture would be beneficial to this project as the materials for the construction are sourceable and the land’s features are suitable. Historically, the construction of a chinampa was done on a firm floor in a shallow canal area (Ebel, 2019). The main construction of this design involves three shallow ponds that could support a rectangular chinampa design that would be in the centre of the ponds. Chinampas are typically constructed with mud scraped from surrounding lakes or swamps (Ebel, 2019). The conservancy has an abundance of mud from prior restoration work with the construction of the pond present on the property. The existing mud as well as the mud that will be dug up with the excavator can be used for each chinampa. Additionally, the use of local willow species on the property can be used to create borders along the rectangular chinampas. The use of willow trees should also be used to border the surrounding area of the ponds to act as a protective barrier against wind and pests (Ebel, 2019).

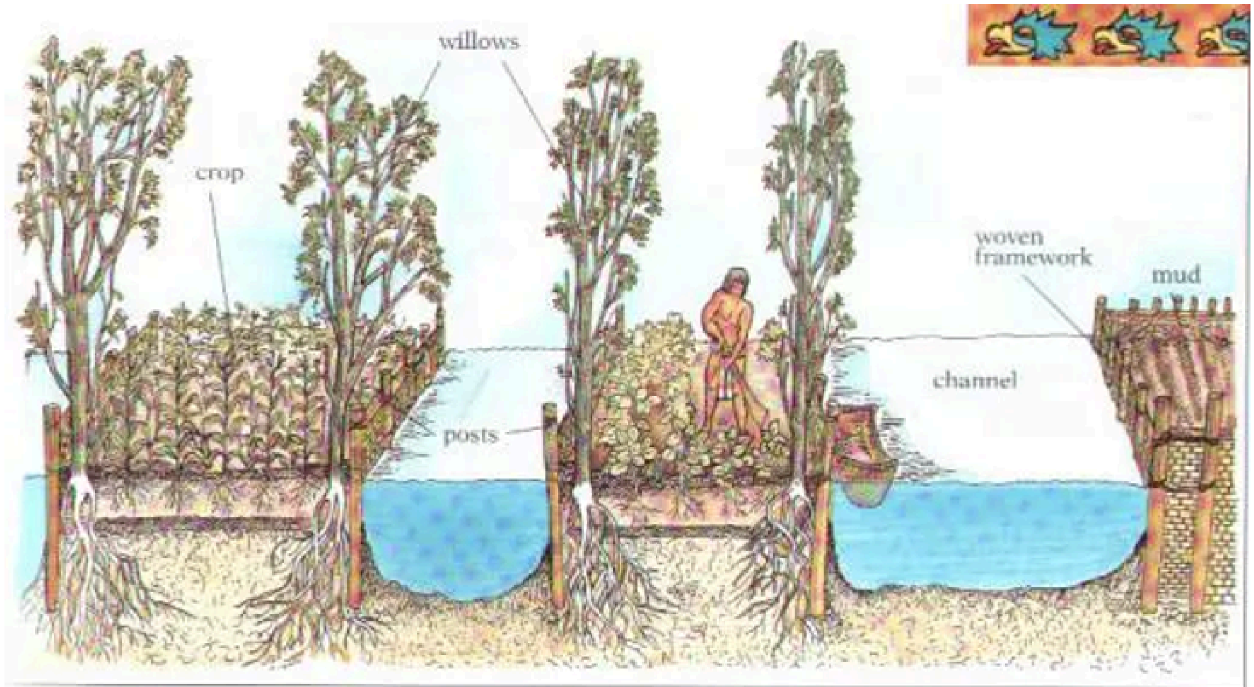

Figure 13. This figure displays the layout of a traditional chinampa style agriculture practice using posts and other natural material to build agricultural land separated by shallow canals. As seen in the figure, the plants planted on the chinampas can absorb the water along the sides and underneath the chinampa. *Chinampas gardens*. Retrieved from https://midwestpermaculture.com/chinampas-gardens/

4.4 Basketry Material

An additional objective for this site is to produce materials for basket weaving. The thin branch material used in basketry can be created through the coppicing of dogwoods, willows and hazelnut trees. Coppicing is the action of felling a tree at the bottom which allows for new growth on many smaller branches which can be harvested for basket and fence making. In the wetland area there will be a mix of coppiced trees, wetland vegetation and grafting trees. As these are all water loving trees (Wallace et al., 2021) this would be an effective support for the wetland.

Figure 14. This photo is an example of a coppicing technique. Retrieved from https://www.growingwithnature.org/what-is-coppicing/

4.5 Tree Grafting

Tree Grafting is a technique used to produce a plant cultivar that is identical to the original source by attaching the bud from the original tree, called the scion, to the stem and roots of another young tree, called the root stock. This can allow the production of a desired fruiting species to grow in an area that it may not be able to, such as a wetland, through the base being a different species. Potential trees for successful grafting in this project could include the Oregon crab apple (Malus Fusca), Italian plumb, and hazelnut trees. (Normuratov, 2021). By joining these two different plant tissues together, wetland agriculture becomes more viable, allowing the production of fruit in areas where it may not have historically been possible (Habibi et al., 2022).

4.6 Cultivated Native Berry Patch, the "Berry Labyrinth"

In the back intact area behind the Cedar swamp, we are proposing the addition of a cultivated native berry patch. There is already established *Gaultheria shallon* (salal) and *Rubus ursinus* (trailing blackberry); it would just involve planting more native species and removing some invasives. Our design layout proposal is creating somewhat of a "Berry labyrinth" or maze, by planting them in rows with lots of different pathway options in between. This would create a layout that promotes optimal growth by giving them enough space and makes them accessible for harvest. To get this area established it would take at least a few years of maintaining the paths, weeding and pruning the plants for optimal growth. Additionally, some of the berries such as *Vaccinium* Spp. prefer organic rich soils containing rotted wood, and are most often found growing out of old stumps (Barney, 2003), so creating piles of old woody debris for some of these species should be considered. Some native species that would grow best here include, *Rubus spectabilis* (salmonberry),*Vaccinium parvifolium* (red huckleberry), *Vaccinium ovatum* (evergreen huckleberry), *Rubus parviflorus* (thimble berry), and *Sambucus racemosa* (red elderberry).

Cultivation of native berry patches has already been practiced for thousands of years in the Pacific Northwest (Armstrong et al., 2022). In particular Nuu-chah-nulth peoples would steward plants like *Rubus spectabilis* (salmonberry), *Gaultheria shallon* (salal), *Sambucus racemosa* (red elderberry), and *Vaccinium ovalifolium* (oval leaved blueberries) to increase harvesting for use and trade (Armstrong et al., 2022). These are all shade loving moist forest plants that would do very well in the proposed “Berry Labyrinth" area. There is evidence of Indigenous peoples using techniques of cultivation such as transplanting, weeding, and pruning (Warren, 2016) to enhance nearby forests and food areas, and the benefits of these relationships can still be seen in many areas today (Vanier, 2022). Armstrong et al.,(2021) investigated how the functional trait diversity is higher in these tended areas near village sites compared to naturally occurring forests. This has allowed these areas to persist and withstand conifer forest encroachment even after 150 years without cultivation. It is hypothesized that the long term tending strengthened the underground processes such as soil formation and mycorrhizal associations making a more resilient system. By cultivating a “Berry Labyrinth" we could create a functional resilient system that persists into the future, providing habitat and food. This would also be a great area for harvesting together and creating a fun, educational way to interact with our food systems.

4.7 Cedar Swamp

To meet the Conservancy’s goals of restoring wetland ecosystems and preserving cedars for the next century, it is important to set aside areas for this. We propose leaving the seasonal cedar swamp intact, and enhancing the undergrowth by planting native swamp loving species that will add more habitat and have harvesting potential. Useful species that would thrive in the understory here include *Lysichiton americanus* (skunk cabbage), *Equisetum telmateia* (giant horsetail), and various fern species. Other traditionally harvested plants that are associated with cedar swamp forests include *Ribes bracteosum* (stink currant), *Streptopus lanceolatus* (rosy twisted stalk), and *Maianthemum dilatatum* (False Lily-of-the-valley) (Fenneman et al., 2021).

Many of the species that grow well in the understory of cedar swamps were harvested for medicinal purposes and other uses too. For example, *Equisetum telmateia* (giant horsetail) contains many antioxidants and silica, and can be made into a tea or tincture to benefit hair, skin and bone health (Pojar & Mckinnon, 2004). Many of these plants can be eaten as well, like the fiddleheads from ferns, and in small quantities the berries from *Maianthemum dilatatum* (false lily of the valley) and *Streptopus lanceolatus* (rosy twisted-stalk). These species can also have indirect benefits for the rest of the wetland food forest. For example, *Lysichiton americanus* (skunk cabbage) is a great species for attracting pollinators of all kinds and keeping furry pests away, due to its pungent smell (Baley, 2021).

4.8 Introduction of Native Plants

One of the main benefits of a wetland ecosystem is their ability to increase the biodiversity of an area. This can be accomplished by the introduction of native plant species in the proposed site. Biodiverse ecosystems are more resilient to change, create habitat and attract an abundance of species. An increase in species abundance and richness increases the number of genotypes circulating in an ecosystem, which creates a higher chance of them having traits (phenotype) which enable them to adapt to a changing environment. Diversity also creates the opportunity to create more habitat for various species, increasing the chance of filling a habitat niche for more species to persist in. With the increase of nutrient availability, habitat options and protection this will increase the capability to support a more biodiverse and abundant ecosystem, thus creating a rich and successful ecosystem. We hope specifically that this will attract red listed pollinators, indicator, and keystone species. Examples of such species as the red legged frog. The plants suggested to be brought into the area such as the Western Blue Flag Iris, Swamp milkweed, and the Western bog-laurel are plants known to attract pollinators and provide habitat for red listed species (Sharma and Singh, 2022). The table below suggests native plant species that would provide various benefits to the proposed site.

Table 1. Table outlining the traditional purposes, growth success, and benefits of Native plants that we are hoping to plant within the wetland food forest.

Plant: Latin name then common name	**Traditional purpose**	**Growth Success**	**Benefits within the Wetland food forage forest**
Asclepias incarnata L. : Swamp Milkweed	Swamp Milkweed attracts pollinators such as butterflies and hummingbirds.(Holmes, 2024).	Swamp Milkweed grows along the edges of swamps, stream banks and ditches and seeks sunny openings. (Holmes, 2024).	It would fit in any shaded area potentially surrounding the pond or swale (Holmes, 2024).
Kalmia polifolia : Western Bog Laurel	Traditionally, bog laurel has been used to make a medicinal drink as well as for skin ailments.	It is successful in peatlands and open wet swamp areas; it is a perennial species and has active growth during spring and summer.	Fits in soils with low pH's, and would fit in the open meadow area near swales or the pond (Brietzke & Starzomski, 2013).

Iris missouriensis : Western blue flag Iris	The Western Blue Flag Iris's rhizomes have been used to superficially treat infections and ulcer, the fibers of the plant have also been woven into nets and ropes to catch fish, and deer. The flower functions as a nectar guide bringing in pollinators such as bumble bees and various flies. (USDA, 2024).	The flag iris is successful in shaded areas and will tolerate sunny areas for a large portion of the day. The flower can tolerate periods of droughts once established but prefers to live in moist soils of meadows and hillsides. (USDA, 2024).	We think that this plant would fit into the meadow area of our site near swales, or ponds edges. It would provide useful materials for netting and rope (USDA, 2024).
Vaccinium alaskaense *:* Alaska Blueberry	Alaskan blueberries have traditionally been used as a source of food, and the leaves have been used for medical purposes.	These blueberries can survive at low and high elevations, and can often be found growing in shrubbed areas, they can survive off a range of moisture.	We think that this plant would fit into the meadow area of our site near swales of pond edges, growing alongside already established salal berries. This would provide productive berries to harvest in the wetland forage forest (Fenneman et al. 2021).
Lysichiton americanus : Skunk Cabbage	Traditionally used for the treatment of coughs and headaches.	Skunk cabbage can be found in woodlands, wetlands or near streams and ponds, preferring cool moist areas, creating its own heat.	We think that this plant would fit along the edges of swales, or the pond. It attracts pollinators through its intense smell (National Wildlife Federation, 2024).

4.9 Tap root crops and that would do well in wetland conditions

Clay soils were discovered on the Galiano Conservancy's property upon field testing. This led to further research into tap root plants that would be successful in these soils. Key characteristics are plants that are able to break up clay soil compaction and withstand dry and wet soils. Plants such as the Daikon Radish, beets, mustard plants, and snap beans are all highly successful in compacted clay soils (Deep Green Permaculture, 2024).

Raphanus sativus (Daikon radish) has long cylindrical roots which extend far into the soil. This process improves soil structure and facilitates the movement of water and nutrients deeper into the soil, making them more accessible to plant roots. The radish is edible and is often included in salads (Amy, 2024).

Brassica spp. (Mustards) contains a fibrous root system that works effectively to break up compacted soils, it additionally supply's disease suppressing action through allelopathic effects. The leaves, flowers and seeds are edible which is why it is so successful in a food forest (Amy, 2024).

Beta vulgaris (Beets) are an edible taproot with the ability to grow in clay soils. They are ideally grown in raised beds, which could potentially be ideal for Chinampa style agriculture. They are rich in iron and betaine and can be used in various recipes. The purple vegetable can be boiled, roasted, or even eaten raw. The leaf can be used similar to spinach, often eaten boiled or raw in salads.

Phaseolus vulgaris (snap beans) prefer clay soil, as they like the firm anchorage the soil provides, as well as the moisture retention of clay soils. The root is able to break through the compacted clay and grow successfully providing fruitful plants and an abundance of beans (Pleasant, 2024).

4.10 Design Ideas for Accessibility and Education

A key design feature of this project is its emphasis on accessibility and education. To achieve this, we propose creating an entrance at the south-east corner of the site intersecting the road. This entrance would lead to a pathway providing access to various areas of the site such as the Berry Labyrinth and basket weaving materials. Informative signs along the pathways and at the entrance would highlight the available food and offer ways to engage with the environment. It is also discussed in the *Exploring the potential of food forestry to assist in ecological restoration in North America and beyond* paper that "the participants underscored the value of their food forests for learning, culture sharing, and/or demonstrating of different designs (e.g. maintaining native food species" (Park et al., 2017), which supports our objective of community engagement, learning and accessibility.

When selecting educational signage for the wetland food forest it is important to consider placing signage and boardwalks in areas that do not interfere or disturb the growth of the plants. Boardwalks are a way to create accessibility for all ages and abilities and can be a useful way to minimally disturb the plants but allow for access to the land. It is important to place the signage in areas that can lead to the further knowledge of the area as well as including the cultural importance of these plants. Educational signs could be developed by students or community members, providing information about the plants and ecosystems. A large welcoming entrance sign for the Wetland Food Forest is recommended, along with smaller signs to identify species, their ecological roles, and their uses by people. There would be signage in multiple languages including Hul'qumi'num, the language of the Penelakut Peoples (Garden Walk, Garden Talk, 2014; Park et al., 2017).

4.11 Engaging with the Penelakut Nation

We suggest that the Galiano Conservancy reach out to the Penelakut Nation inviting them to collaborate in the planning and implementation moving forward in this project. Through engaging with members of the Penelakut Peoples, we can consider which types of plants they would like to include, traditional knowledge of the land, and create a space where they can connect to their ancestral lands. It is important to seek permission from Indigenous communities before planting certain species on the Conservancy's property and to involve them throughout the planning process. We also believe the Wetland Food Forest should create a safe space where cultural practices, education, and harvesting together can take place. In the future the Penelakut Nation may even want to lead workshops in basketry making and or traditional food harvest in the Wetland Food Forest. We also recommend involving Galiano, Penelakut and other Gulf Island students to participate in the creation of the Wetland Food Forest, perhaps through helping plant some of the native species. This collaborative effort could involve consulting with Elders to gather stories and traditional names of the plants. Students might also create a storybook that captures the history and cultural significance of these plants within Indigenous traditions. Involving different school classes in the long-term tasks of removing invasive species, preparing the site, planting, monitoring, and managing the area can deepen their sense of responsibility and connection to the land (Curran, 2013). The Wetland Food Forest project provides a great opportunity for strengthening relationships with the Penelakut Peoples and the land, by creating a space for sharing, harvesting, creating, and knowledge exchange.

5.0 Summary and Recommendations

5.1 Summary

This proposal highlights the history of the draining and removal of wetland ecosystems across Canada and the implications that arose and continue to arise due to the loss of this natural resource. Up to 70 percent of historic wetlands have been degraded or lost in Canada mostly due to drainage, which has been attributed to drainage for agricultural land. Galiano Island has experienced wetland loss due to poor forestry and agricultural practices in the past and still experience the legacies of these practices. Wetlands provide a multitude of benefits ranging from storing and filtering water to providing habitat and promoting biodiversity yet continue to be drained for human development purposes. The Galiano Conservancy understands the importance of increasing wetland habitats and has seen much success in their past restoration projects from building wetlands on their property. The conservancy proposed the idea of restoring an area that was once a potential wetland ecosystem back into a more natural state with the addition of food production. We explore the possibility of this project through various methods including field observations, soil sampling and the research of food production techniques.

Through our methods thus far we have determined that groundwater was not found on the site but the test pits did hold rainwater. Additionally, the soil type is mainly composed of clay soil creating a higher probability of the site retaining water. The overall tree coverage of the site is composed of some old growth allowing for partial shade in some areas to further help with water retention. Stakeholders involved also shared their opinions that the clay substrate soil is thick enough to be impermeable to water leading us to hypothesize that this site will be suitable wetland habitat.

The design methods explored involve the implementation of three small ponds that are connected by swales that will help hold and increase the flow of water on the site. The use of agricultural methods such as the floating garden beds also known as chinampa agriculture will be a useful incorporation in the ponds to increase vegetable production. Other techniques such as grafting were explored to increase fruit production on site. Additionally, the use of the existing forest ecosystem is a suitable habitat to increase berry production.

The wetland food forest is also an ideal site for educational and cultural purposes. The design of the site should include space for boardwalks and signage to encourage the knowledge of local plants and provide insight on the site design. Additionally, the creation of this site would be a great opportunity for Penelakut peoples to connect to their land and forage for cultural and medicinal purposes.

We hope that our aspirations for the project will provide a strong baseline for the Galiano Conservancy to continue this work, and help them achieve their goals of creating the wetland food forest.

5.2 Future Recommendations

Our next recommendations for the Galiano Conservancy is to further explore some of the design considerations laid out in this proposal. The main considerations we believe should be further researched include the following:

- Continue to measure the test pits for water catchment and retention.
- Develop a monitoring framework that can be utilized throughout each stage of this restoration project.
- Continue the use of camera 360 monitoring to capture site changes.
- Connect with local Penelakut peoples who are interested in working on this project to determine their aspirations for the project.
- Create a design map of the ideal structure of the wetland that includes accessibility features such as a boardwalk and educational signage.

- Discuss with stakeholders to determine which plants would be most successful on the site.
- Gather and narrow down the plants needed for tree grafting to increase fruit production on site.
- Create a design structure and potential trial of the chinampa style agriculture on site to determine its practicality in growing root vegetables.

We also propose that design methods be discussed with stakeholders and altered as needed based on the monitoring framework developed by the conservancy. We hope this proposal will serve as a useful tool for the Galiano Conservancy as they plan the next steps for the project and inspire a clear vision for the future of the wetland food forest.

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