Continued Phytoremediation of the Union Bay Natural Area at Ravenna Creek

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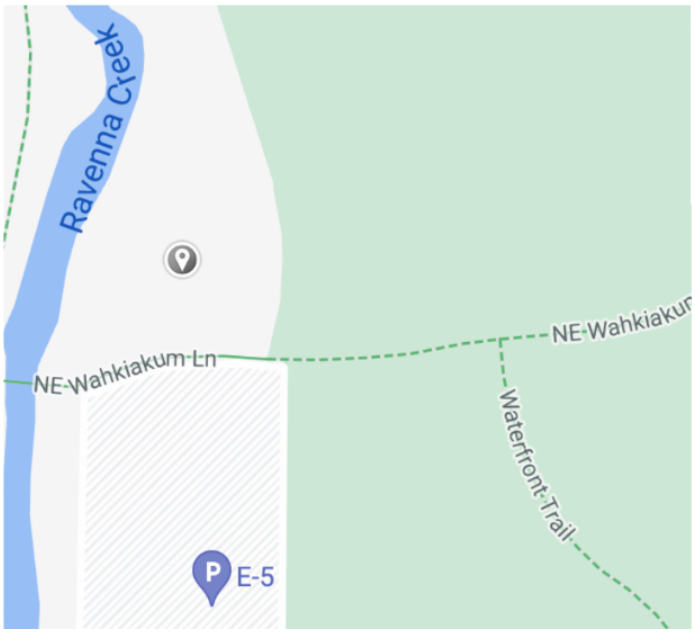
Background

Today, the Union Bay Natural Area (UBNA) is a protected wildlife zone located along Lake Washington, adjacent to the University of Washington campus. It hosts an assortment of native wildlife, with a full trophic breakdown from birds of prey and coyotes all the way down to detritivorous insects. The place is flush with diverse plant life that serves as an abundant habitat for all of these organisms. Walking through the site today, one might assume that UBNA has always been this way. But, in fact, the riparian ecosystem there is barely one hundred years old.

(History Link)

In 1916, Lake Washington was lowered 9 feet following the construction of the Lake Washington Ship Canal known as the Montlake Cut, joining Lake Washington to the Puget Sound (Ott, 2012). The receding shoreline created a marshland at the edge of the lake where, for 40 years, local residents would routinely dump personal waste, creating an unzoned landfill.



While the landfill was operational, there was little to no government oversight or enforcement of waste disposal regulations, and no detailed records were kept regarding the specific use and contents of the dumpsite (Caldbick, 2013). In 1966, the landfill was closed and the city capped it with a layer of clay, gravel, and sand. However, researchers at the University of Washington had taken a special interest in the site. Naturalists had been recording wildlife establishing in the exposed marsh since the water level first receded. The exposed marshland had become host to an

assortment of native flora and fauna. This begged the question, could people restore this wetland that had once been a toxic dumping ground to presettlement levels of biodiversity?

For the last sixty years, people have been working hard to turn UBNA into a reflection of natural Pacific Northwest marshland. Native grasses and trees were planted, and native plants were encouraged to establish. Local wildlife moved in, and now UBNA has become a refuge from the urban sprawl for native insects, amphibians, birds, and mammals. However, as the process has continued, some concerns have been raised about whether the site is safe for the long-term.

The main concern revolves around the capping process for landfills. As mentioned previously, capping covers landfills in a layer of sediment that can vary in permeability depending on the thickness and makeup of the sediments used. Typically, the thicker the better, and the more clay that is used reduces how well water filters into the stored waste. Unfortunately, the closer the site is to a body of flowing water, the higher the risk of eroding the cap and leeching potentially toxic waste into the surrounding ecosystem (*Community Guide to Capping, n.d.)*. Since UBNA is a riparian ecosystem running adjacent to Ravenna Creek and Lake Washington, the risk of cap erosion is higher than usual. Unless other strategies are used, a lot of hard work that went into restoring UBNA could be wasted should the cap fail.

One way to address the problem of leaking contaminants is to create a system that continually purifies the soil around the cap itself. Obviously, doing so manually would be extremely expensive and time consuming. But, luckily, many plants have evolved over hundreds of millions of years to survive in extremely toxic environments. Since the 1990s, a lot of research has been done assessing the ability of plants to phytoremediate soils. Phytoremediation is the process whereby a plant, in acquiring minerals through its root systems, also fixes and breaks down compounds such as heavy metals, ammunition wastes, halogenated hydrocarbons, or concentrated organic pollutants (Tripathi, 2020). Metabolic processes in certain plants can fix these substances in their cell walls, deposit them in the soil as inactive chelated compounds, or store them in vacuoles (Saier, 2008). Through oxidation and reduction reactions that take place during uptake and metabolic cycles, plants can turn harmful compounds into useful sources of nutrients that can be cycled back into the environment (Saier, 2008). This process is also sometimes referred to as phytoextraction (Saier, 2008). Plants can even release these compounds directly into the atmosphere in a process called Phytovolatilization, where inert toxins are released with water vapor through the stomata (Saier, 2008). Poplar and willow trees have both been observed to effectively uptake contaminants from the soil due to their high rate of biomass production (Legault, 2017). Also, both species are relatively easy to propagate from cuttings and are indigenous to the Northwestern United States. Phytoremediation of UBNA's topsoil would mean planting poplar and willow saplings along the areas most vulnerable to erosion, such as riparian zones along the banks of Ravenna Creek and the lakeshore.

On top of cleaning the soil, growing poplar and willow trees along the bank of Ravenna Creek will create a riparian buffer zone. With poplar trees taking root by the water, they will stabilize the soil as they grow, forming a wall of biomass both above and below ground. This

filters runoff flowing into the creek from UBNA and limits how much the creek erodes the bank, easing the transition from forest to wetland (USDA). Riparian buffers also provide habitat, creating areas of shade where fish or other aquatic organisms can rest or conceal themselves from predatory birds. Over time, a riparian buffer will adapt and change with the path of the waterbody it is adjacent to. So, as the bank of Ravenna Creek naturally shifts and becomes less fixed, the riparian buffer will adjust as the poplars propagate and grow. The bank of the creek will slowly become more structurally heterogeneous, increasing biodiversity as more species find suitable habitat.

The site our team is working on is located right on the bank of Ravenna Creek, in one of the last places in UBNA to be opened for restoration. Due to its proximity to flowing water channels that lead into the Puget Sound, careful monitoring of chemicals applied to the surface of our site is necessary, to prevent runoff from contaminating the entire local ecosystem before the trees can do that job for us.

Purpose

The ultimate goal of this project is to incorporate a particularly polluted region of UBNA into the surrounding ecosystem by creating a riparian buffer zone and clearing invasive species. We hope that by planting poplar and willow trees, the soil covering the landfill cap will be purified of inorganic pollutants and the riparian zone along Ravenna Creek will become a more suitable habitat for local flora and fauna and increase biodiversity in UBNA. This also means removing invasive species such as Himalayan blackberry and non-native weeds that would outcompete native plants if left unchecked.

On a smaller scale, the site has to serve as an adequate nursery for the new saplings and as a recreational space. Making sure the poplar and willow plantings are adequately cared for, watered, fertilized, and protected from foraging wildlife before they can establish and phytoremediate the soil is extremely important to the ultimate success of the project. Creating signage that outlines the site's purpose and maintaining trails that allow access to natural spaces in UBNA will also help highlight the value of the project to the public. Our hope is that we will increase public engagement with the restoration underway in UBNA using social media, crowdfunding, and work parties.

Original Methods

Our capstone project is the third installment of landscaping, wildlife management, soil analysis, and tree propagation to take place on this site. Restoration began in Autumn of 2021 when Sharon Doty acquired the right to use the plot for her phytoremediation research at the University of Washington. Doty began by clearing invasive species—mainly *Rubus armeniacus*—to make room for poplar and willow plantings. Through to the spring of 2022, *Salix spp.* branches were coppiced and planted in a spoke formation in the center of the site, with each stalk about one foot apart and six inches deep. The plantings were pruned of dead branches to

promote new growth, and more were planted more densely as the trees began to establish. Once the team was confident the willows were secure, they began building the riparian buffer by planting *Populus spp.* along the bank of Ravenna Creek. Work parties with SER-UW helped clear invasive species and keep the plantings from being outcompeted.

In the fall of 2022, a new capstone team was introduced and they continued the work of maintaining the site. They cut down Himalayan blackberry and competitive grasses with help from SER-UW. They also used a technique called “sheet composting” to encourage the success of the poplar and willow trees. The process involves cutting down grass around the base of the young tree, then covering the base with wet cardboard, and placing fertilizer on top. The cardboard, as it slowly decomposes, will keep faster-growing grass from shading out the developing tree and nutrients can still be carried to its roots during watering as the compost filters down through the soil. From what we’ve observed, this method has proven effective and given the trees time to grow taller than the grasses, reducing the amount of maintenance needed to keep the trees alive.

In the winter of 2023, the team also carried out a soil analysis to identify any potentially harmful compounds and get an understanding of its nutritional makeup. Samples were taken from four different spots in the site, two in the middle of each plot, one on the edge of the plots, and one by the creek. Three samples were collected from each spot. They also performed a water-quality analysis using samples from the top and bottom of the creek, the pond towards the Eastern side of the site, and surface water from a puddle. These initial measurements will inform how well the trees were able to extract certain compounds from the soil and which ones they added.

(The four blackberry piles from spring of 2023)

Observations

Our current team visited the site in late March of 2023. Upon first inspection, the stand of willow trees dominated the middle, and looked the most cared for. However, the borders of the site were still overgrown by Himalayan blackberry and grasses. Three discard piles of blackberry brambles were lying between the bank and the willow stand. We knew they would eventually begin to take root again. From the previous group we learned the species makeup of this section of UBNA. Prevalent plant species include red osier dogwood, Oregon ash, cottonwood, and of course poplar and willow. We learned that the area just south of our site that reaches to the bank of Lake Washington was previously a parking lot, and underwent extensive restoration efforts recently. By comparison, the Southern site has significantly less Himalayan blackberry, and is much more biodiverse than our plot. Since our site was left untouched by both restoration efforts and development since the landfill was capped, primary succession was much more of a free for all among native and invasive species, which is why the Himalayan blackberry could spread so extensively. Since our group wanted to plant many more trees, especially along the bank and by the trail, we knew that removing the brambles would be an important aspect of our labors here.

Aside from vegetation, we were also warned about the nuisance of foraging rabbits and beavers. Some of the plantings had obviously been eaten—some missing branches and some gnawed down to the stub—and it was obvious that fresh plantings would be a prime target for local herbivores. We knew that if we were going to continue to plant trees, we would have to find a way to ward off the beavers and rabbits.

New Methods

The fundamental goals of our project were as follows: clear invasives to make room for new plantings; raise money for fences, equipment, saplings, signage, and compost through scholarships and GoFundMe; and use TikTok to make engaging and educational videos about our site to raise awareness about our project and increase involvement for work parties.

(Our SER-UW workpart to remove blackberry and plant saplings)

Clearing the blackberry brambles was the most straightforward if the most labor intensive part of the project. Thankfully, a work party made up of volunteers from SER-UW and Doty's ESRM 201 class helped tremendously. By the end of our first work party, we had cleared a massive cluster of Himalayan blackberry at the northern edge of our site and planted dozens of new trees from cuttings in UBNA. However, our victory was short-lived. Overnight, it seemed, almost all of our new plantings were decimated by beavers. Most were either chewed down to the base or missing entirely. The ones that survived were further away from the water. This experience taught us not to underestimate the appetites of the local fauna, and to prepare more carefully for our next planting. In preparation for our next work party, we bought 100 feet of chicken-wire fencing, cut them into cylinders and held them together with twist-ties to be easily placed around the saplings. We made sure to fence the saplings that the beavers had spared immediately, holding them in place with metal stakes so they couldn't be pushed over. For our second attempt, we had to purchase two hundred willow and fifty poplar saplings from a nursery in Bellingham. We stored them in one of our teammates' yards until the work party, when we managed to get all two hundred and fifty saplings planted in the ground, watered, and most of them fenced in the same day. Through the heat wave, we watered the trees as often as we could, and the majority are establishing quite well.

By the end of the quarter, we had accumulated four large piles' worth of discarded blackberry brambles, adding to the three left over from the previous group. Many had been there so long that they were resprouting again at the edges of the piles, and we knew their roots were spreading underground as well. We had to get rid of the piles, so we contacted UW Center for Urban Horticulture and corresponded with one of their landscape specialists. They agreed to help

us truck the piles offsite, and we held another work party with SER-UW to help us load them onto the truck. For onsite composting, we chose a spot at the Northern edge of our site to lay down four wooden pallets with a layer of cardboard between them and the soil.

In order to afford all of the fencing, wire cutters, and compost, we had to rely heavily on crowdsourcing. We set up a GoFundMe page that told the history of our project and its current goals. We regularly updated the website with photos of our restoration progress (pictured above), and managed to raise $1,425. Sharing the project's details on social media, especially Facebook, made it easy for friends and family with disposable income to donate. Videos we shared on TikTok also displayed our progress restoring the site, as well as showcasing the different types of wildlife that make up UBNA's growing ecosystem. Using our funds, we also purchased two wildlife cameras and attached them to some mature trees in our site. We were able to capture videos of foxes, beavers, and of course a lot of humans and dogs, including one individual who had set up a tent on our site. We were able to incorporate these images into the promotion of our project, but it also gave us a better understanding of the environment we were working in, and what sort of organisms make it a home.

(UBNA, 8/18/2023)

As spring transitioned abruptly into summer, our focus shifted from planting saplings to keeping them alive as they were buffeted by heat waves. Early on after our second planting party, we would water all the trees at least three times a week, sometimes consecutively, checking up on them as often as we could As their roots became more established, waterings did not need to be as frequent. However, heat waves persisted, and a number of the trees appear to have perished—although there is hope that some will bounce back in the fall. On the other hand, the poplars planted along the edge of Ravenna Creek were close enough to the water table that they never dried out completely. Their leaves stayed consistently green. All of our plantings on the Northeastern side of our site also appear to be doing well as they are also located near the bank of part of UBNA's wetland system. The site with especially thin and rocky soil, nearest to the main road on the Southern end of our site, saw the most severe desiccation.

Our equipment for watering was rather rudimentary, consisting of buckets and plastic jugs, the structural integrity of which was often compromised. Lifting the water out of the creek was also physically challenging, and the bank was slippery and eroding. To remedy this, we built two wooden platforms coated in waterproof paint to stand on while we collected water. They kept our feet dry, but once the water level of the creek receded, the pallets became less useful as we had to bend lower and climb down the bank to the water level to fill our containers. We brought in a water pump at one point in the hopes of speeding up the process, but the manual pump mechanism was too weak and the hose too short to make the labor worthwhile. More efficient water pumps were also too costly of an expense for the resources of this project.

One to two times per week, we would spend about two hours first watering the saplings and then clearing the blackberry that was growing up around them. We grubbed the roots as well as we could with shovels and gloves. For especially tangled, more established brambles, we clipped them with garden shears and raked as much of the tangled branches out as we could. This made it easier to access and dig up the main blackberry stumps.

Discussion

In the near future of this project, the trees will need to be watered at least once or twice a week until the heat waves subside and the fall rains return. The students who inherit this project in the fall of 2023 will continue the work of invasive removal and fundraising. We have purchased new watering equipment for them and two pairs of garden shears, which will hopefully make their work easier. We have also left them a How-To document that has helpful tips to aid in management of the site, as well as all our contacts in UBNA and the CUH to help with transporting blackberry piles, putting up signs, and acquiring fertilizer.

In the far future of this project, similar cycles of labor to ours will be taken by the groups that inherit it. Invasive removal will be followed by tree planting and the watering and maintenance necessary to ensure they survive. As the trees acquire more biomass, analysis of their tissue samples and the soil around them may show insight as to the effectiveness of phytoremediation. We may cross analyze them with the samples taken by the first group and, depending on the results, we will learn whether adjustments to our practice are necessary to

improve the effectiveness of our phytoremediation. Hopefully, within a few more years' time, analyses of the soil will show a marked improvement in its health and nutritional makeup. Until then, consistent care and attention from future capstone projects will see this site become a dense stand of healthy trees that may be enjoyed by park goers and native wildlife for years to come.

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