A Bouquet of Benefits: Floriculture and Ecosystem Gifts in an Urban Industrial Zone

Elizabeth Housley

A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Landscape Architecture

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Committee:

Catherine DeAlmeida

Ken Yocom

Program Authorized to Offer Degree:

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Abstract

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Chair of the Supervisory Committee:

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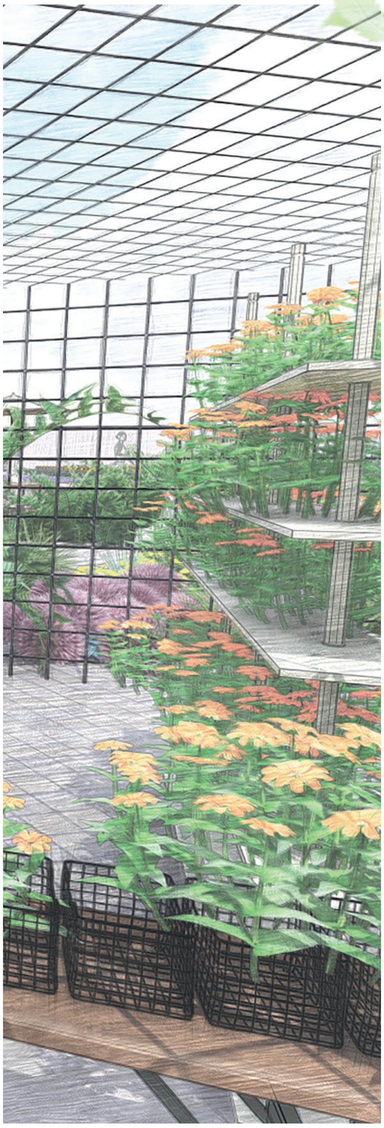
The floral industry is at once global and personal. Humans have shaped the landscape to create the simple gift of a cut-flower for thousands of years. Although regional floriculture in the western U.S. is robust, the US. imports over 75% of cut-flowers, contributing to global carbon emissions and landscape contamination. Local-based solutions can reduce environmental impact, provide an experience of place, and connect consumers to local flora. Many flowering species possess the ability to filter pollutants (phytoremediation) in contaminated soil and some of these species can continue their lives as cut-flowers, essential oils, or waste byproducts. This proposal investigates suitable floral species for a phyto-to-market system, appropriate urban floral farm and garden sites within existing networks of production, and the flow of production at the scale of a local, industrial "Flower District" in Seattle's Georgetown neighborhood.



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Floriculture and Ecosystem Gifts in an Urban Industrial Zone

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Keywords:

Phytoremediation, Byproduct, Industrial Ecology, Flowers, Gift, Urban Agriculture

Related Topics:

urban community gardens, urban farming, landscape aesthetics, urban markets, globalization, materiality, living machines, industrial districts

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Content

Image 1. A collection of global and personal floriculture images, with attention to material and aesthetic qualities. Source: Top row center, Google Maps. All others by Elizabeth Housley.

Context

"...the idea of a flower market is not in keeping with the grime and grit of urban life"

(Stewart, 2007, 4).

In the U.S., the cut-flower industry is typically regarded as a luxury product. However, this billion dollar industry materializes in everyday relationships and events. Cut-flowers are mediators, negotiating fraught relationships or acting as a stand-in when one misses an important event. Flowers are bought, gifted, and experienced during U.S. and global cultural celebrations such as weddings, funerals, religious offerings, graduations, anniversaries, and birthdays. They convey cultural meaning, provide texture and color, and in doing so provide income for millions of people across the world.

Before being cut, shipped, and gifted flowers grown in open fields play a significant role in food production by attracting and sustaining insect populations needed for pollinating staple fruits and vegetables. For the non-human world of pollinators, flowers signal opportunity and sustenance. Thinking about these larger roles opens up what is meant by giving cut-flowers, extending to sustainable use of water, decrease in carbon emission and pesticides, pollinator habitat, soil remediation, local economic growth, and color in our everyday landscape. As an initial study of the cut-flower industry, or "floriculture", I researched the journey cut-flowers take from growth to gift, and the major advances and statistics of this global industry. This initial study revealed opportunities for exploring a "bouquet" of social, economic, and environmental benefits within a productive floral landscape.

Floriculture Context

The floral industry is a global landscape of production. The US. imports approximately 64% of cut-flowers for the floral industry from Colombia and Ecuador, and the European market imports mainly from Kenya. A 2012 estimate of the industry suggests a global economic value of 300 billion USD (Chandler and Sanchez 2012). Within the United States, California and the Great Lakes Region produce the majority of domestic floral products. Although regulations and enforcement are improving, this industry is notorious for global carbon emissions, water pollution, and pesticide use (Stewart 2007). The floral industry is responding by implementing international regulations, supporting local urban agriculture, shifting to alternative economic models, and technological advancements (Image 2). This design proposal investigates how local-based solutions in the Seattle industrial neighborhood of Georgetown can reduce soil contamination, provide an experience of place, and create an industrial floriculture ecology.

Global Market

The majority of U.S. imports come from Colombia and Ecuador. In 2018, the USD value of cut-flower imports from Colombia was $912,039,000; Ecuador-based imports were valued at $323,373,000 (Trademap, 2018). The process of importing approximately four billion flowers from Colombia each year consume 114 million liters of fuel and release 360,000 metric tons of CO_2 on their flights to Miami alone (Graver 2018).

On Valentine's Day alone, 90% of the total 250 million yearly roses are imported into Miami from South America. This consumes roughly 6.4 million liters of fuel and releases 20,250 metric tons of carbon dioxide —about as much as the CO_2 emissions from 4,300 passenger vehicles (Graver 2018). This estimate does not include the energy involved in transporting flowers from the Miami airport to their final point of sale, water usage during growth and transport, or the energy cost of keeping them under constant refrigeration.

Some estimates warn against assuming imported flowers use more energy than domestic ones. Although domestic blooms do not require international shipping, they must be grown in temperature-controlled greenhouses. A lack of data in the floral industry makes it difficult to conclude which process is more efficient. (Doughty 2019). Environmental impact data calculating the rate of floral waste—the amount that die in transit or arrive too damaged to sell, is lacking. But, some estimates suggest 15% waste from supermarkets and 20% from wholesalers. A small study on Dutch and Kenya waste provided carbon footprint estimates for Image 3. (Swinn 2017).

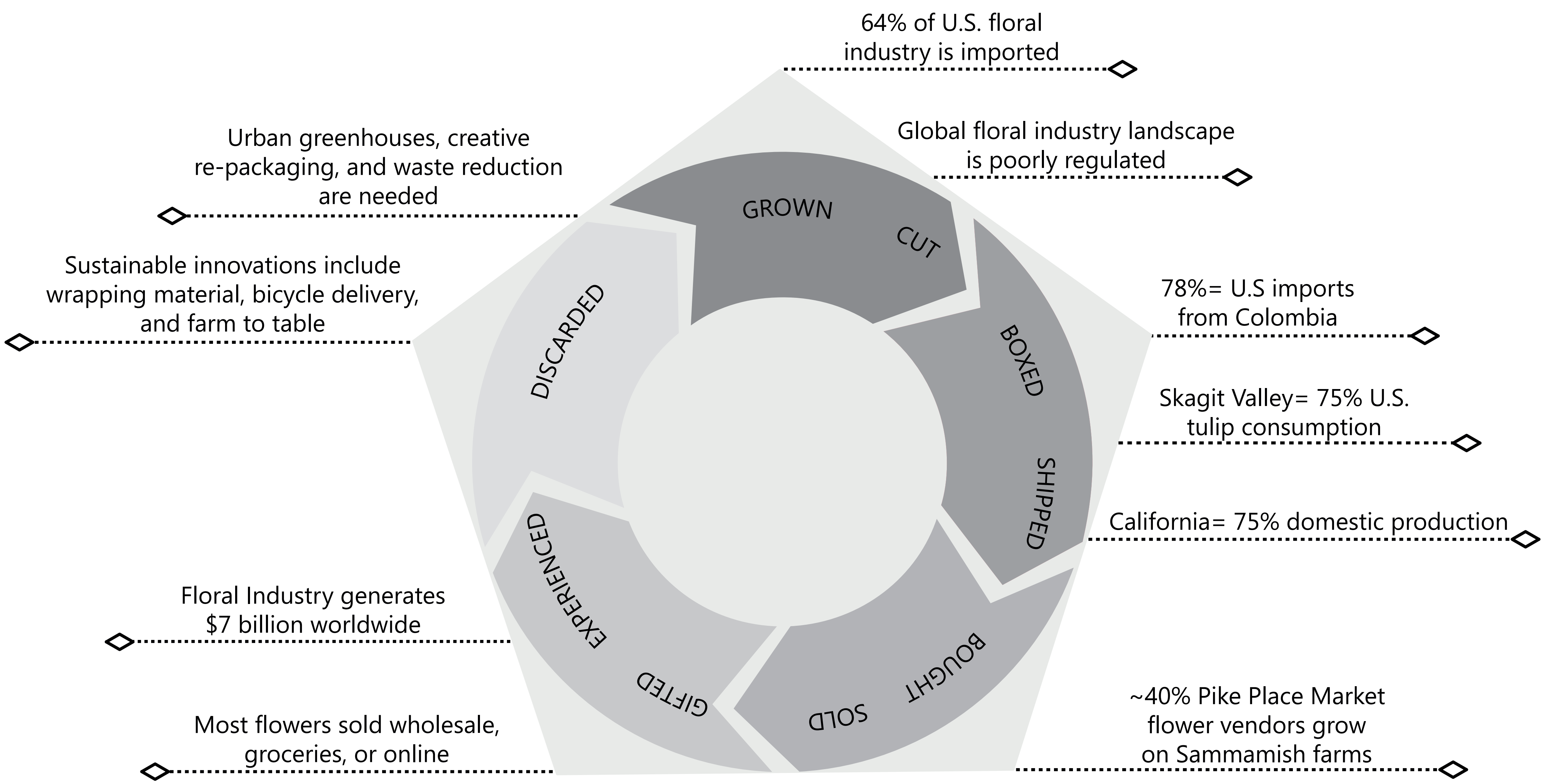


Image 2. Floral Industry Diagram.

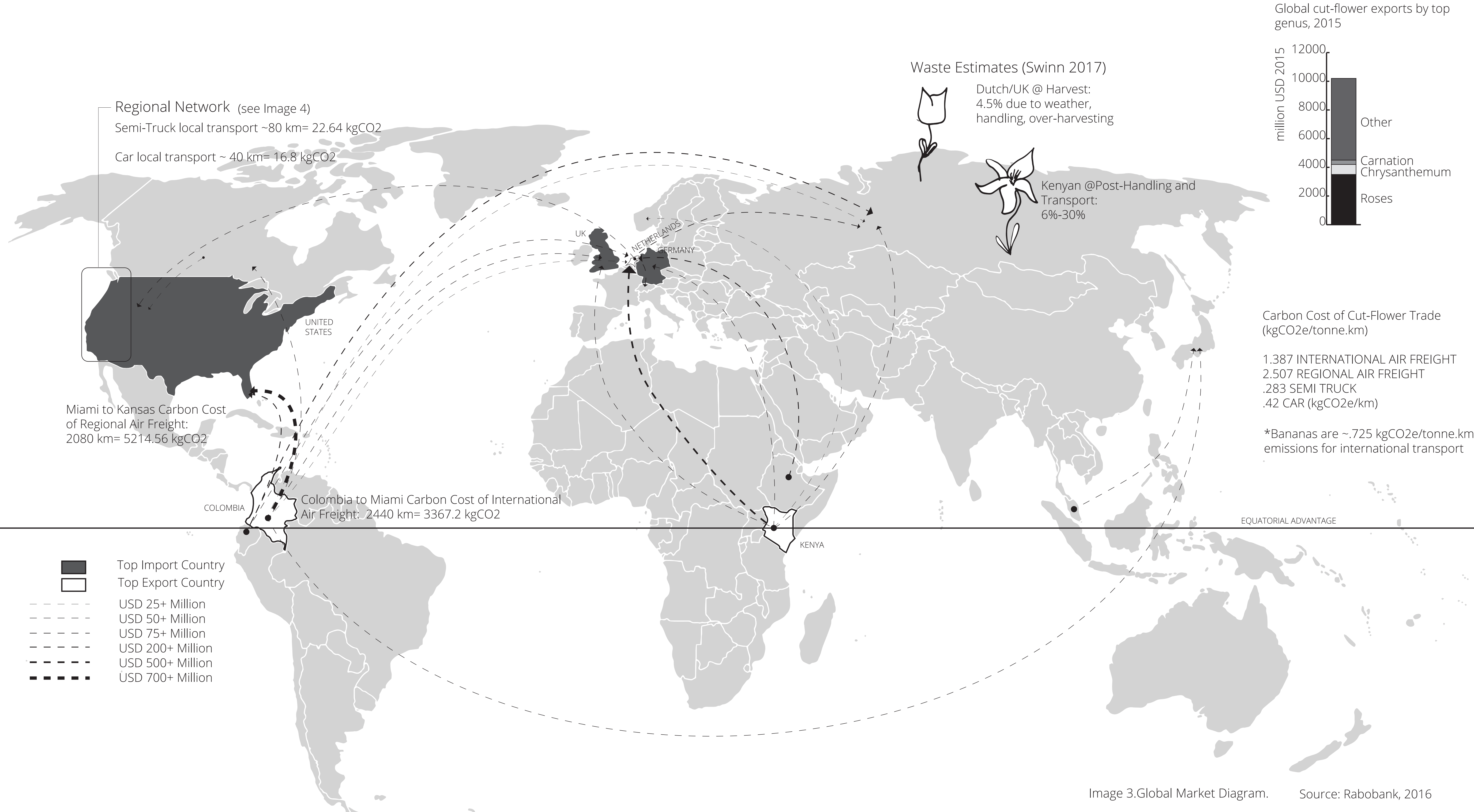
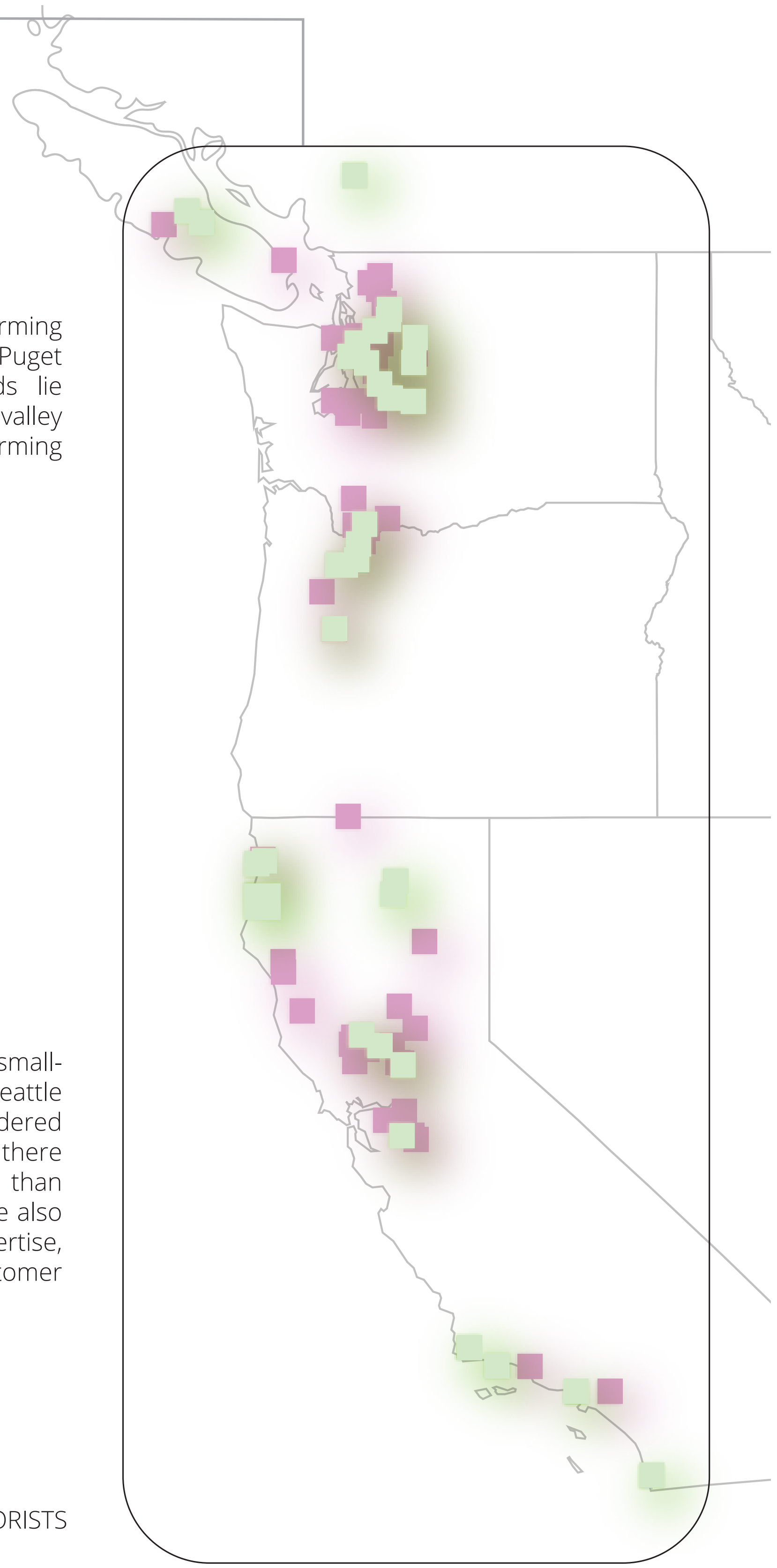


Image 3.Global Market Diagram. Source: Rabobank, 2016

Regional Network

In Washington State, rural floral farming surrounds Seattle in the fertile Puget Sound. World famous tulip fields lie northwest of Seattle in the Skagit valley and northeast of Seattle in a farming valley known for lavender and wine.



The regional floriculture network of small-grow farms, florist-farmers, and Seattle wholesale florists could be considered robust. Along the West coast states, there are twice as many farmer/florists than solely farms. Floral farmers who are also florists typically custom grow, advertise, and sell directly to a regional customer base.

FLORAL FARMS
-PRODUCTION ONLY

REGIONAL FLORAL FARMER/FLORISTS
- DIRECT TO CUSTOMER

Image 4. West Coast Farms. Data source: Floret Flowers

Image 5. U.S. Regional Markets. Data source: USDA 2019

The number of new cut-flower companies since 2015 has increased in the Great Lakes region and California. Most other states have lost companies since 2015. Illinois now hosts 107 cut-flower producers, up from only 11 in 2015. California continues to dominate the U.S. market with 464 producers in 2018, but with less dramatic growth compared to Illinois. Expansion in Open-Ground Flower Production since 2015 occurred in sunny climates suitable to outdoor farms, such as in California and Florida (USDA 2019) (Image 5). Circle sizes in Image 5 indicate market position relative to others.

YES! Farm, Seattle

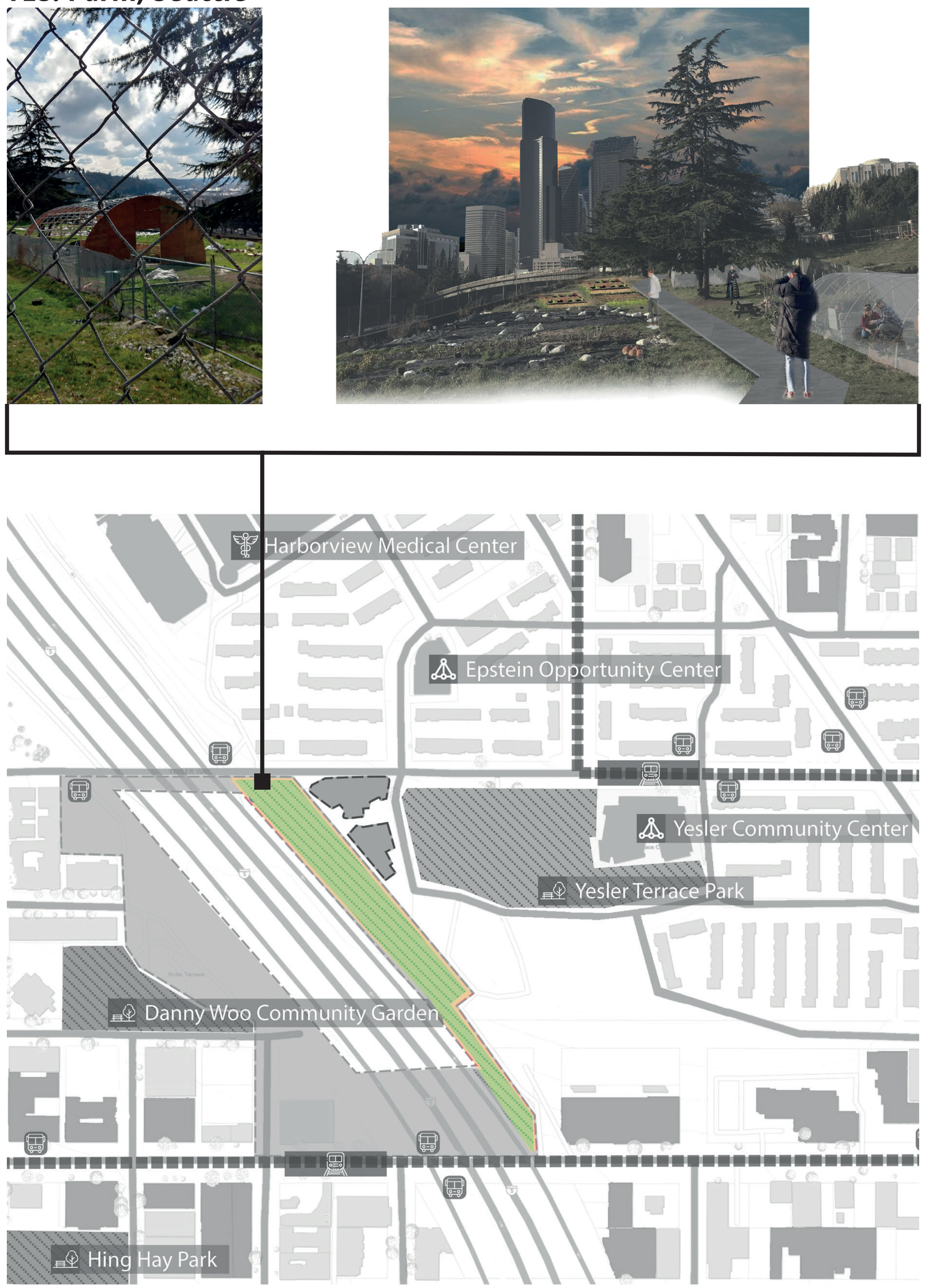


Image 6. Yes! Farm. Sources: Elizabeth Housley and Yuqing Zhang, 2019 1:50000

Local Floriculture Network: Small-Scale Urban Floral Farm

YES! Farm is a new urban farm in development in the recently redesigned Yesler Terrace neighborhood of Seattle (Image 6). The farm is situated on a stretch of land located directly adjacent and above a retaining wall of Interstate 5. YES! Farm is organized and led by Ray Williams of the Black Farmer Collective. Because the site is located immediately adjacent and above the interstate, ongoing contamination from air pollutants are expected. The farm is interested in remediating existing soil, mitigating future pollution, and exploring phytotechnologies that could result in end-product floral products to be sold at nearby farmer markets.

At the request of the farm, the University of Washington at Bothell conducted a soil survey for the site, and found areas with undesirable levels of arsenic and lead contaminants on site, but below recommended cleanup levels. Tests for Diesel #2 and Heavy Motor Oil were below WA DOE 2001 cleanup levels. Ray reports, "We have a bit of lead, well Under EPA limits (highest is 100ppm)...".

Arsenic (As) is a naturally occurring substance, and occurs in inorganic and organic states. Organic arsenic, which is relatively less toxic, occurs naturally in plants, fish, and shellfish. Inorganic arsenic - arsenic combined with oxygen, chlorine or sulfur - is the most toxic. In Washington, arsenic occurs naturally in the soil. The Washington State Department of Ecology and the United States Geological Survey have determined that the natural background level of arsenic in Puget Sound soil is 7 mg/kg (also known as 7 parts per million). In one area of the farm where a 7.2 mg/kg level of arsenic was detected, the farm is using raised beds.

The Washington State Department of Ecology and the United States Geological Survey have determined that the natural background level of lead (Pb) in Puget Sound soil is 24 mg/kg. The state average is 17 mg/kg. Washington law requires that soils contaminated with lead above the state clean up level be remediated. These levels vary depending on the use of the property. For residential sites, regulations require that soil be remediated if above 250 mg/kg. Lead is toxic to human beings and children are particularly sensitive to its effects. Ingesting lead is a serious health risk and can result in both short and long-term health problems. The Yes! Farm soil test indicates five of the twelve test areas contain lead above Puget Sound background levels (ranging from 69 to 110 mg/kg) but all well below the 250 mg/kg WA DOE cleanup level.

Yes! Farm served as a precedent for me to explore the general situation that urban farms may face when growing in soil that is part of a long history of industry and contamination. In addition to remediating soil contamination, this urban farm's goals included connecting to other small urban farms, creating a secure but inviting entrance, designing for truck right-of-way access, and installing a buffer of trees to guard against air and noise traffic pollution. Ray Williams shares his future plans: "We are planning to grow flowers on some of the farm to sell locally and possibly through a flower market in Georgetown ...Cash crop as well as phytoremediation. Non edible flowers as we start to understand the environmental concerns of the site". These concerns and desires helped guide me in my design.

The process of removing contamination from soil using plants is phytoremediation. Species of plants differ in their ability to remove contaminants. Some plants draw contamination into their bodies, but at the detriment to growth. Some plants are able to tolerate the contamination and grow within normal limits. Some plants remove heavy metals, but many do not. Phytoremediation will be introduced in more detail in the following chapters.

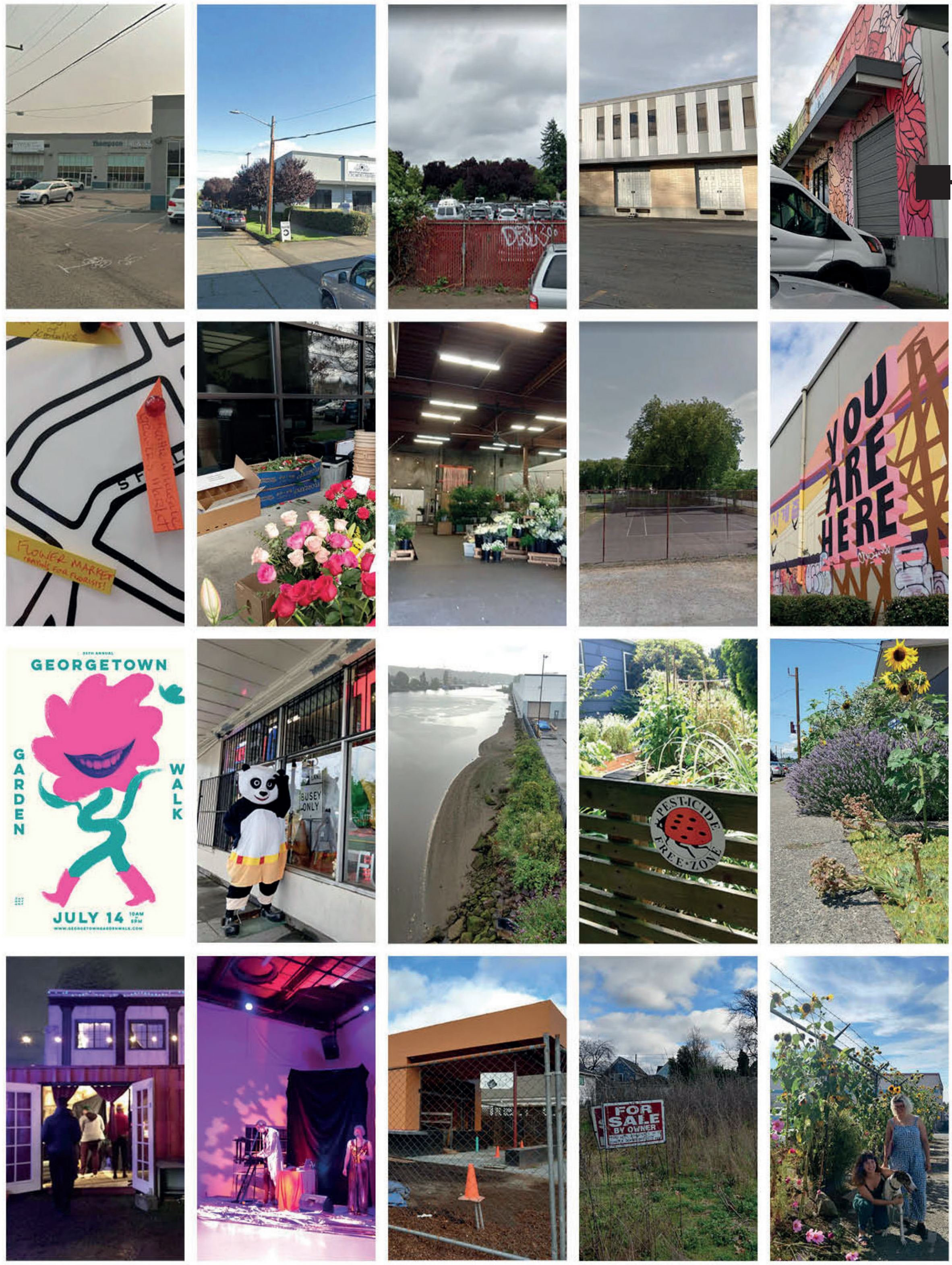


Image 7. Georgetown, Seattle is a mix of creative industries and plant communities.
Source: Housley

Image 8. Warehouse locations.

When examining Seattle, we see that the majority of Seattle wholesale florists are in the Georgetown industrial district. Wholesale florist warehouses are the main distributor point for floral products coming in from regional and international farms. Wholesale customers are typically retail florists, floral designers, and others who hold business licenses.

Image 9. Georgetown sits on the north edge of Boeing airfield.

Local Floriculture Network: Wholesale Market in an Urban Industrial Zone

Seattle Wholesale Grower's Market Cooperative is a floral farmers cooperative in Georgetown and a major inspiration for my project. It is situated in a warehouse near two other floral warehouses and two retail florists. The location is explored later in my design. Floral farmers from the nearby areas transport their products into the market at 5 a.m. every morning to sell to those with business licenses. The farmers pay a yearly fee and a board of directors set goals and costs. A colorful mural was recently installed on the outside of the warehouse (See Image 7).

An Urban Industrial Zone: Georgetown, Seattle

Georgetown in Seattle, Washington exists in what was once the Duwamish River Valley, a river delta formed thousands of years ago at the meeting of four rivers. The Duwamish Tribe settled in the river delta (Tuqwelticl) likely because of its abundance in edible plants, seafood, land mammals, and marine transit. European settlers colonized the land in 1852 and stripped local tribes of their land via violent occupation two years later. By the late 1800s, a developer bought and sold two square miles of lots along the Duwamish River, naming the area after his son George. An electric streetcar and the railway connected the area to the growing urban region, and natural resources were already becoming central to Georgetown's economy. Clay brick production, hop farming along the river delta, saloons, and the railroad industry fueled the establishment of Georgetown as a Seattle neighborhood.

In the first two decades of the 20th century, Georgetown was annexed into Seattle, the river was dredged and straightened, prohibition collapsed the breweries and saloons, and the neighborhood began to diversify into other industrial enterprises. Boeing, an industry mainstay in Seattle, established headquarters in Georgetown in 1917 and was the regional airport until Sea-Tac airport opened in 1944. The neighborhood has always been solidly industrial. This is due to explicit industrial zoning laws, a 1956 Seattle Comprehensive Plan that planned a residential phase-out in favor of more industry, and construction of an interstate that demolished businesses and connections to the east. Industry continued to grow, but at the expense of the environment. In 2001, the lower Duwamish waterway was designated a Superfund site and several lawsuits have led to remediation projects along the river.

Georgetown's industrial landscape is littered with potential and ongoing contamination sources. But it is also a thriving craft and trade neighborhood. An enclave of artists and craftspeople make an eclectic impression in the yards and alleys of Georgetown. And despite its industrial history, the tiny residential community boasts impressive private gardens and celebrates their investment with a yearly garden walk. I suspected that the cluster of floriculture warehouses, residences, and parks around the Seattle Wholesale Grower's Market Cooperative could provide multiple, novel benefits to the area.

The concerns and needs of the global and local floral industry led me to a central question of my research and design exploration:

Guiding Questions

Does phytoremediation research data from field-applications of ornamental species support the possibility of offsetting remediation costs with cut-flower profits?

How would a proposed "Flower District" in Seattle's Georgetown neighborhood provide an economic and social structure for a "phyto-to-market" system while improving surrounding ecosystem health?

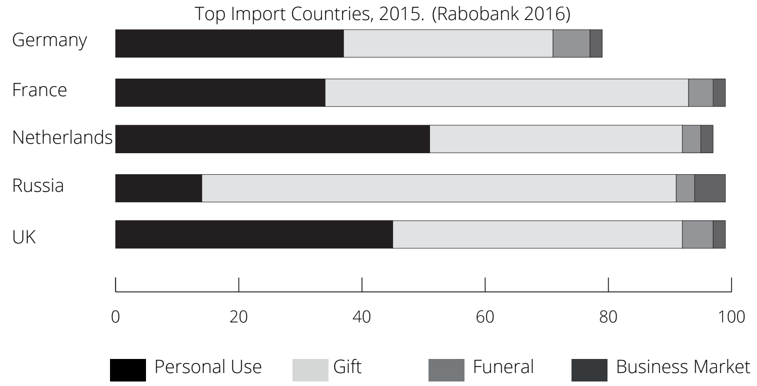
"Through all of the changes over the past two centuries, Georgetown has continued to be a lively and eclectic community. It remains a confluence of residents, industry, and commercial destinations. **The neighborhood is dotted with relics of its industrial origins: old brick and sandstone brewery buildings now house a chocolate shop, art galleries, design businesses, a wholesale flower market, and small breweries.** Other historic buildings within the neighborhood hold bars, shops, art studios, restaurants, and coffee shops. Equinox Studios, an enclave of artists and artisans, is housed in a World War II–era factory building. The architectural regalia of the former Hat 'n' Boots gas station, which was located along E. Marginal Way S., is now a sculptural icon at Oxbow Park. Ruby Chow Park offers views of the original Boeing Field complex as well as planes landing and taking off from the airfield...The Duwamish Manufacturing/ Industrial Center (MIC) plays an important role in the economic health and growth of Seattle as well as the state. It accounted for more than 57,000 jobs in 2013, and it supports the largest concentration of family-wage industrial jobs in the Puget Sound region."

- Seattle Parks Foundation. 2017. Georgetown Open Vision Framework.

Image 10. Garden culture is strong among Georgetown residents.

Research

Image 11. Floriculture purchaes by occasion



Flowers

Compared to most commodities, cut-flowers can be grown, are perishable, are nearly free, and are a bit impractical. In diverse cultures across recorded time and space, flowers provided emotional experiences for people. Flowers are expected to convey sympathy, guilt, romance, pride, and joyful celebration. Flowers are also used to express religious feelings and in some religions are considered the direct route for spiritual communication. Some flowers are used for personal adornment, both the blossoms themselves and their essences in the form of perfumes. Pollen was found in the graves of Neanderthals, suggesting that the flowers had a place in the burial ceremony. A tomb painting in Thebes from around 1400 BCE depicts an Egyptian florist's arrangement. Flower production has been documented in Roman Egypt in the first century CE. Ikebana, a thriving Japanese plant art in contemporary times dates back to scrolls from the fifteenth century. And in the 1600s, French women even wore tulips as jewelry. Ornamental plants are still grown in the contemporary flower industry for a variety of personal uses as well as for the business market, edible and medicinal uses, funerals, and gift exchange.

Flower gifts are known to have immediate and long-term effects on human emotional reactions, mood, social behaviors, and memory but there is little existing theory that explains these findings. In the most comprehensive study to date by Haviland-Jones et al. (2005), the authors demonstrate that flowers are a powerful positive emotion inducer. In three different scenarios, participants responded to flower gifts with a Duchenne smile (described as an "involuntary true smile"), reported more positive moods several days later, or had improved episodic memory. With consideration of possible theories, the authors proposed that cultivated flowers fit into an emotional niche - their sensory properties elicit human positive emotions. We will undertake a lot to get a positive high! And, evolutionary theory suggests plants have evolved to induce varying behavioral responses in a wide variety of species leading to the dispersal or propagation of the plants. Flowering plants are rewarding to humans and in return, the cultivated flowers receive propagation that only humans can provide (Image 12).

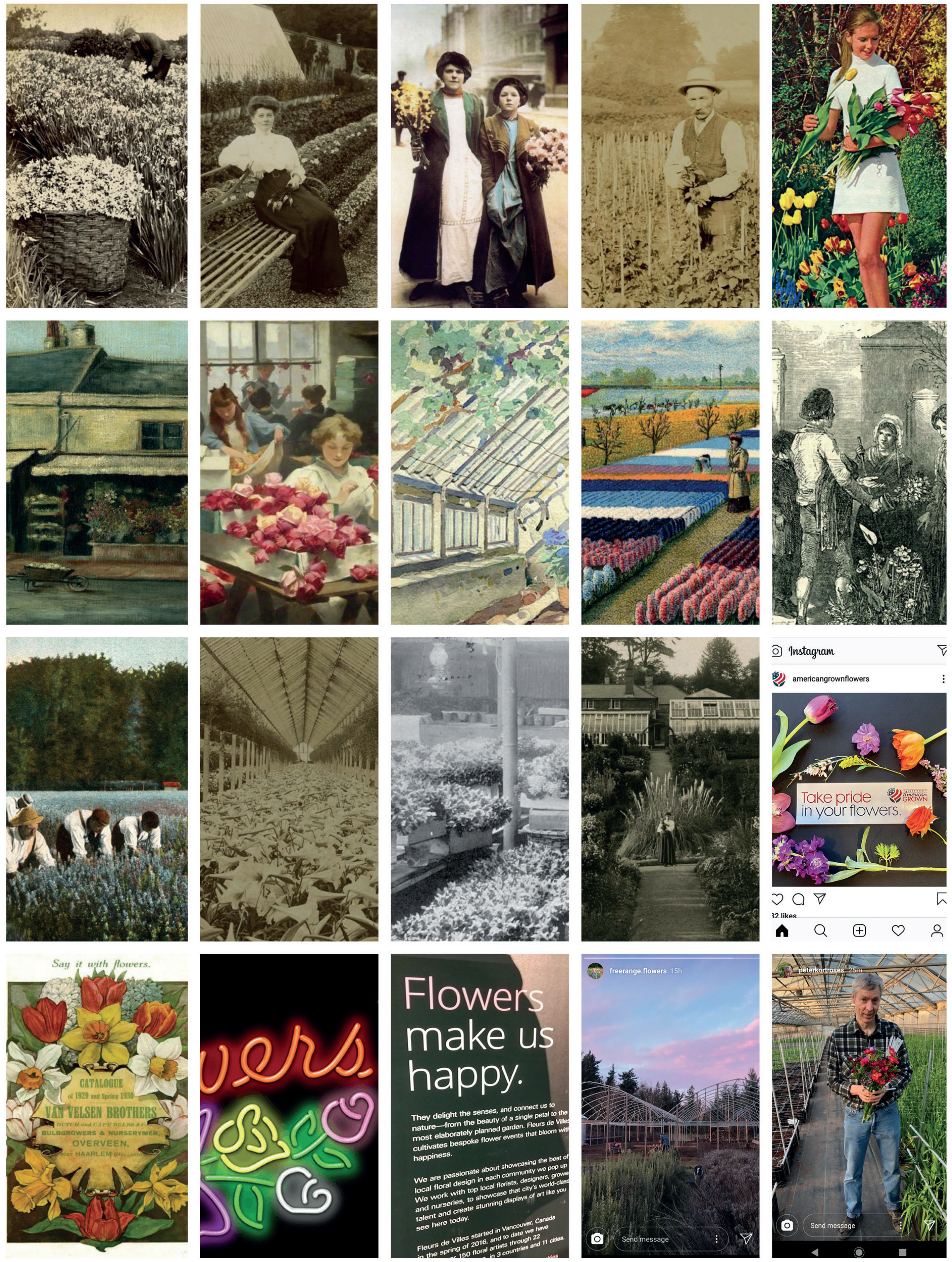


Image 12. Examples of floriculture technology and industry over time.

Positive emotion in humans facilitates both immediate and long-term social and cognitive functions, and may even lead to long-term survival benefits. Is positive emotional response enough of a reason to spend global resources on growing flowers? Perhaps so, and what if flowers contributed to landscape health and wellbeing too?

Floriculture History

During an early review of floriculture and phytotechnology literature, significant dates and summaries from the literature were added to an ongoing timeline (Image 13). Constructing a timeline allowed me to see shifts in floriculture transport, technology, and the socioeconomic landscape.

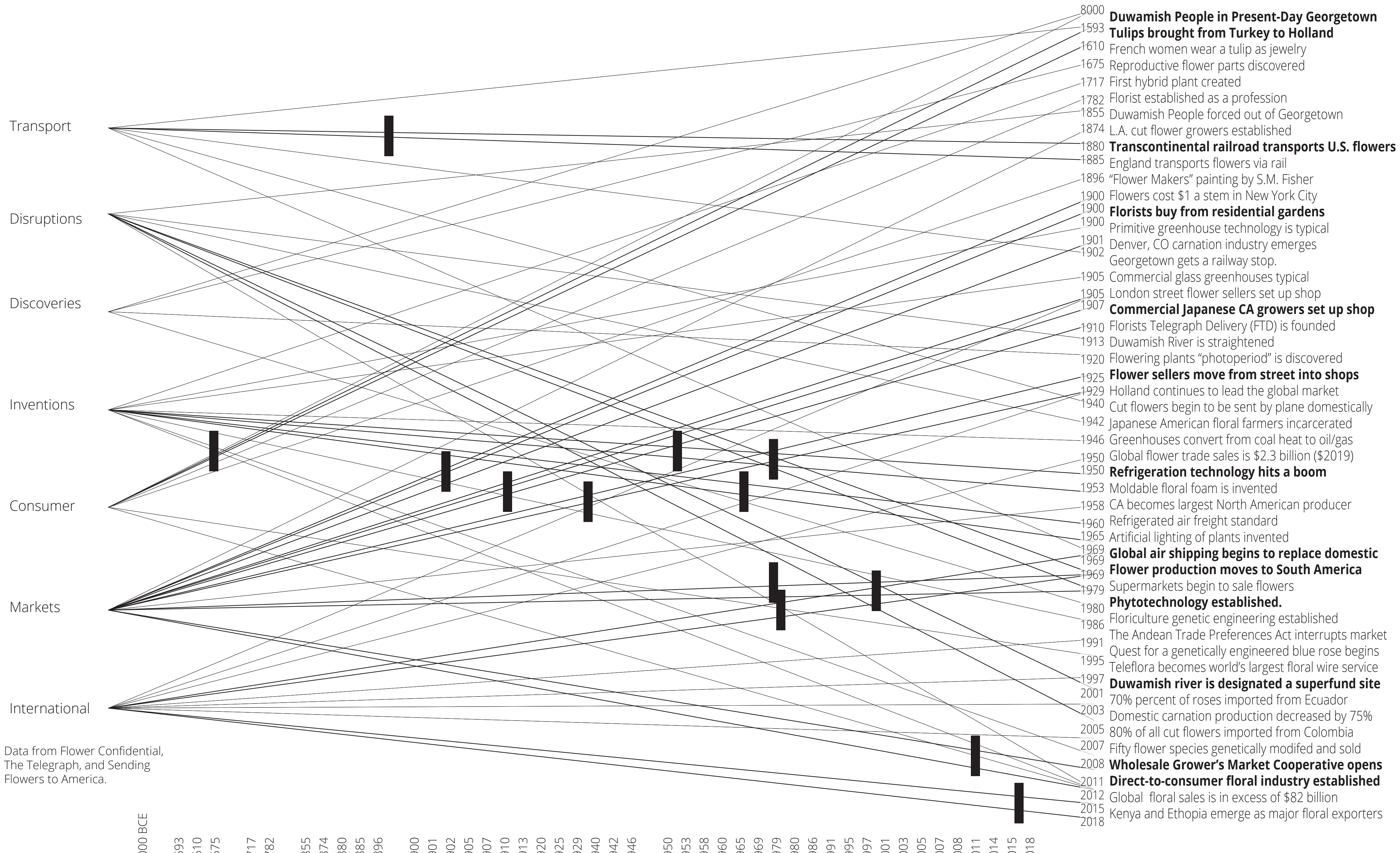
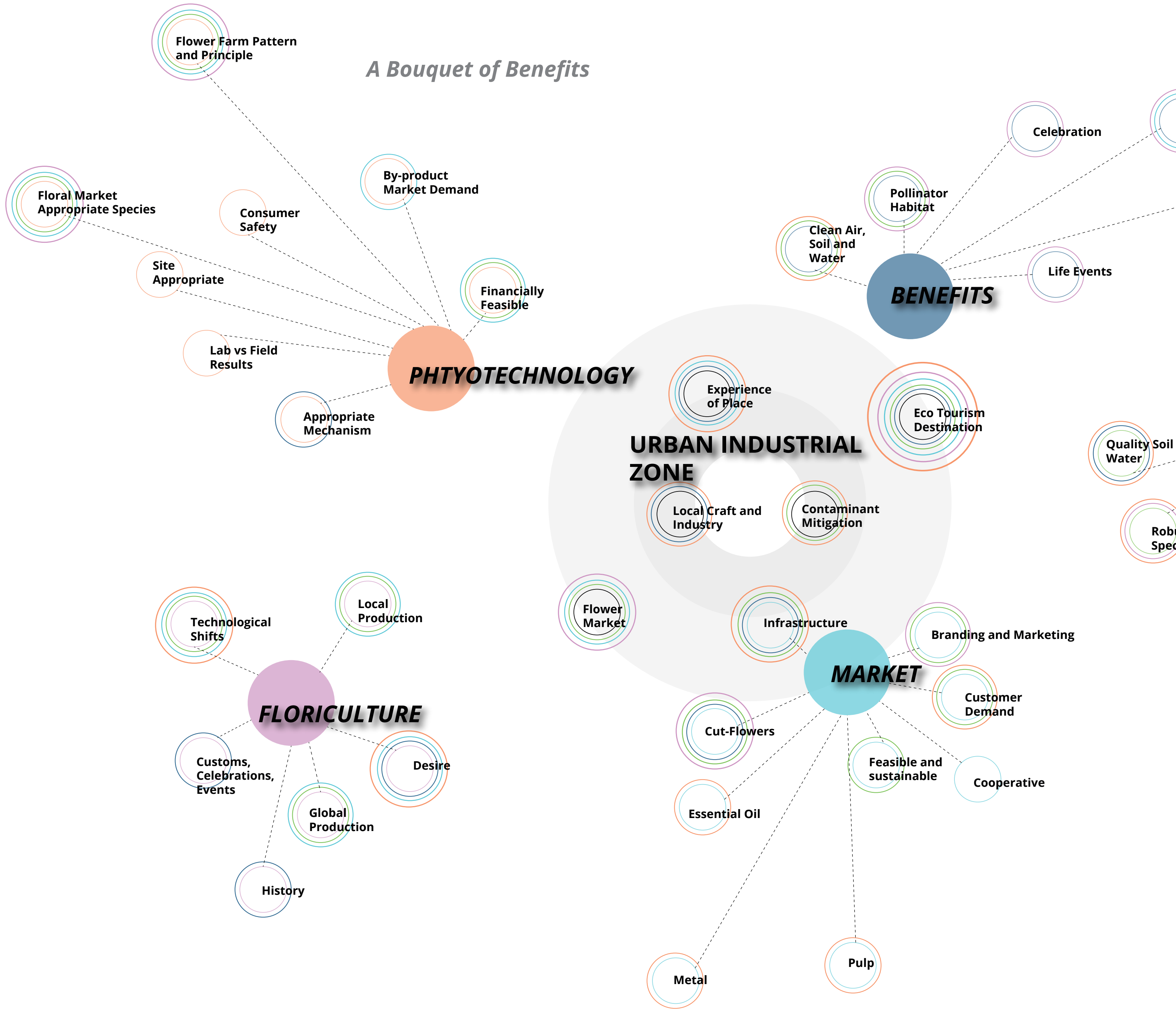


Image 13. Floriculture Timeline

In the course of floriculture history, florists as a profession began in the late 1700s and took 200 years to move from small-scale farms to commercial glass greenhouses. The first half of the 20th century sees rapid advancements in transport methods, with flowers moved from carriages to trains to global refrigerated air and marine transit. Holland continued to lead the global market until the mid 1960s, when greenhouse technology, artificial lighting, and air freighted flowers disrupted the U.S. production landscape. In the 1970s, many local U.S. farmers became wholesalers and importers instead. Late 20th century genetic engineering and scientific research allows growers to modify flower color, fragrance, stress resistance, and longevity. By the early 21st century, major floral export countries are Kenya, Ethiopia, Colombia and Ecuador.

Kroger Company, which owns Washington state's QFC and Fred Meyer chains, is the largest floral retailer in the United States (Halkias 2019). Kroger participates in third-party environmental and labor certifications through Rainforest Alliance and Florverde Sustainable Flowers. Florverde serves as the independent regulator for eight U.S. major retailers, including Kroger, Whole Foods, Wal-Mart, 1-800-Flowers, Costco, and ProFlowers. Four major U.S. distributors also participate. Although this is an ethical development, only 39% of Colombian floral exports are Florverde certified, and these certifications do not account for air transit carbon emissions (Florverde 2019).

The latest development has emerged out of the Instagram era, where customers are visually convinced to buy directly from a local floral farm, cutting out wholesalers all together. This is shifting the industry slightly back to the local. Although the percentage of imported cut flowers in the United States is staggering, the local cut flower industry in North America is growing. The number of members in a primarily U.S. group, the Association of Specialty Cut Flower Growers, more than tripled between 2014 and 2018. Several cases can be made for prioritizing locally grown flowers over internationally grown.



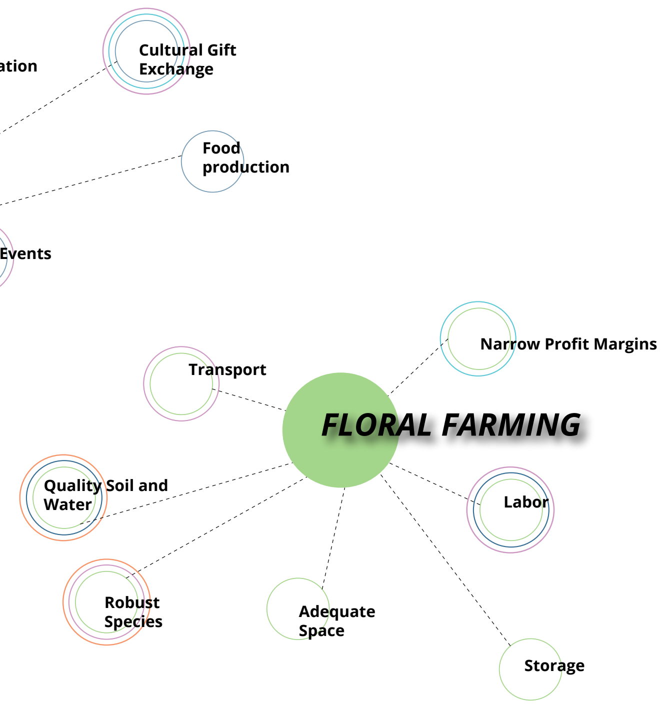


Image 14. Themes uncovered in the literature. Color of outlined circles indicates connection to other themes. Proximity to center indicates whether that theme is present in Georgetown.

Local vs. Global Market: Harm, Benefits, and Technology

From a consumer-focused perspective, the diversity of shape, color, and behavior in locally grown flowers vastly outnumbers internationally grown species. Depending on the season, hundreds of species are available at any one time commercially as cut flowers in the United States. Although imported flowers dominate, growers are limited to ~30 durable and transportable species due to the vast refrigerated distances the floral products must travel.

Global cut flower operations may be less desirable in terms of adverse carbon emissions, pesticide applicaiton, and water consumption. Air pollution and carbon emissions from South American shipped flowers are significantly higher than their local counterparts due to the sheer comparison of air versus land shipping emissions Although internationally shipped flowers have significantly higher carbon emissions than their local counterparts grown outdoors in-season, locally grown species grown in greenhouses out of season can have as much or more carbon impact as their shipped counterparts. At the ground scale, international growers may apply more pesticides because the USDA regulations on imported cut flowers are less stringent compared to imported edible crops. Sadly, in a recent study conducted through a Californian institution, researchers found altered short-term neurological behaviors in Ecuadorian children including impaired attention, self-control, and eye-hand coordination during the peak pesticide spraying season linked to the U.S. Mother's Day flower harvest (Suarez-Lopez et al. 2017). Perhaps similar to water bottling plants and general agriculture, growing flowers can be water intensive, especially in areas that are already water scarce. Cut flowers account for 45 percent of the water Kenya uses for exported goods (Mekonnen and Hoekstra, 2014).

In the Complete and Universal English Dictionary of 1782, a florist is defined as "a person curious and skilled in the names, nature, culture of flowers". By the 19th century, a florist referred to someone who grew and sold flowers, not just a seller. It was common then for the public to buy flowers directly from the grower. A fictional book from the late 19th century offers a peek into the floral industry. In *My Ten-Rod Farm; or, How I Became a Florist*, the fictional character turns to floral farming after her husband dies. The details in the book suggest floral shops at the time bought flowers from private residences with robust gardens. These "private houses" existed alongside "commercial houses" operating as traditional businesses. Then, as is mostly true now, a floral farmer receives one-tenth of what the customer pays for a flower. The price of roses relative to other goods has stayed quite consistent for 200 years; perhaps telling of culturally held ideas of the economic cost of flowers.

Technology over the past two hundred years has shaped the industry and the products themselves. Greenhouses in the 19th century were manually controlled glass structures. Opening a window or lighting a stove was the common temperature control mechanism. Irrigation was a watering can or a hose and cistern. There was no refrigeration or long distance product transit. Because of this, florists grew their flowers within or near cities. A florist in the 1830s, a man named Michael Floy Jr., farmed on a tract of land at 125th and 5th avenue on the upper east side of Manhattan.

In the late 1800s as the transcontinental railroad became a viable option, growers began to experiment with long distance shipping. Floral farming, mostly an East Coast endeavor, began to spread westward. The carnation industry took hold in Denver in the early 1900s. The fern industry consisted of pickers visiting farms in Michigan and Wisconsin offering payment in exchange for land access. The west coast of Washington, Oregon and California became central for bulb-growing and a wealth of other varieties. Eventually, California became the largest producer of flowers in North America. Immigrants from Japan, Italy and China established the major flower markets in Los Angeles and San Francisco and still hold a presence today.

Guessing where the next floral farm in the world will be is fairly simple, and it's not in the U.S. Find a globe, trace your finger along the dotted equator line, and pick a spot. Along this line you will find the emerging markets in Kenya, Singapore, Ecuador, and Colombia (Image 3). In addition to ideal growing conditions, you will need decent amounts of rainwater, cheap labor, an international airport, and roads suited for heavy freight.

Phytotechnologies

Floral farmers consider environmental factors such as temperature, rainfall, day length, and light intensity variables when calculating profit margins and species growth. For urban farmers, contaminated soil and water quality become additional concerns. Phytotechnology is a broad term that encompasses the application of plant species to control or remediate contaminated soil, water or air. In this proposal, we will begin to consider the crossover between the floral industry and phytotechnology.

Overview

This section largely draws from the 2015 publication by Kennen and Kirkwood titled *PHYTO: Principles and Resources for Site Remediation and Landscape Design.* Although only five years old at the time of this writing, it is already a classic reference manual for the process of phytoremediation.

The practice of using plants to control or remediate contaminated resources, phytotechnology, was generally established in the 1980s. In the 1990s, greenhouse and lab experiments resulted in publications and discovery of species that hyperaccumulate heavy-metal contaminants. However, field applications of the controlled experiments failed to produce desired remediation in most cases.The star of phytoremediation, the sunflower, was proven to uptake and remediate lead contaminants in lab experiments but did not meet expectations at the field scale. In the last twenty years, a steady flow of scientific research and field testing has contributed to a better understanding of the biology and mechanisms involved in phytotechnologies.

Phytotechnology is a broad term that encompasses the application of plant species to control or remediate contamination through several processes. Phytostabilization, for example, stores contaminants in a species' root system or surrounding soil but prevents the spread of contamination. Phytoremediation is the process of rendering the contaminant null through several different processes. In addition to phytoremediation potential, appropriate plant species for a field application should be hardy, perennials (preferably), drought tolerant, have high biomass production (growth), exhibit adequate root depth, and (ideally) evapotranspirate (Riz Reyes, personal communication) .

Mechanisms

Phytodegradation/Phytotransformation and Rhizodegradation are the mechanisms to remove organic contaminants only. In phytodegradation, the plant body destroys the contaminant. In Rhizodegradation, the soil biology destroys the contaminant. Phytodegradation, also called phytotransformation, occurs through the process of organic contaminants metabolized (or mineralized) inside plant cells by specific enzymes. The contaminant is taken in by the plant, and broken down into (usually) non-toxic smaller parts. Some plants degrade contaminants through exuding of its own biodegrading enzymes. Degradation can also occur through photosynthesis. Populus species are the most well known species to process contaminants through this mechanism.

The rhizodegradation mechanism is a process where the plant roots promote the proliferation of microorganisms in the soil surrounding the roots, the "rhizosphere". These microorganisms "feed" on the exudates and metabolites of the plant and in turn degrade the contaminant. The application of rhizodegradation is limited to organic contaminants.

Mechanisms to remediate organic and inorganic contaminants include phytovolatilization, phytometabolism, phytoextraction/phytoaccumulation, phytohydraulics, and phytostabilization. The mechanisms most applicable to floriculture include phytovolatilization, phytometabolism, and phytostabilization. Phytovolatization is the process of a plant taking up a contaminant and transpiring into slowly into the atmosphere as a gas. Depending on the uptake potential of a species, a contaminant is completely removed from the site. This process can be used for organic pollutants but some heavy-metals (Hg, Se and As) can be absorbed by a plant's

DEFINITIONS

Accumulation Factor (AF):
The ratio between element concentration in plant(parts) to that in soil.

Note: Literature also uses the term Biological Absorption Coefficent (BAC) or the Bioconcentration Factor (BF)

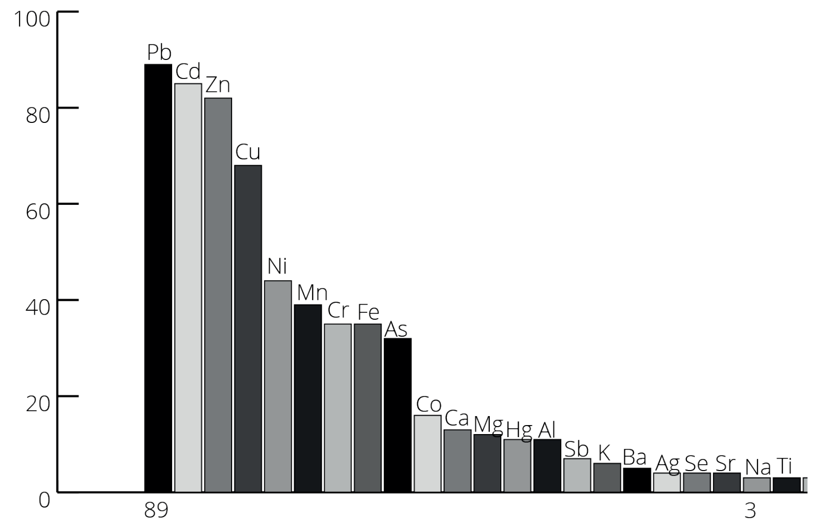
Translocation Factor (TF):
The total element concentration in shoot tissue divided by total element concentration in root tissue.

Note: Some experiments use this term to define the total element concentration in a site sample of Above-ground presence of contamination divided by a site sample of Below-ground presence of contamination.

Yoon et al. (2006) state that species with both BFs and TFs greater than the value of one have the potential to be used for phytoextraction, while heavy metal-tolerant species with high BCF and low TF can be used for phytostabilization of contaminated sites. In addition, the same authors reported that plants exhibiting TF and particularly BCF values less than one are unsuitable for phytoextraction, as stated also by Fitz and Wenzel (2002).

Image 15.

Number of Articles in which each element was taken into account



roots, converted into non-toxic forms, and then released into the atmosphere.

Phytometabolism describes the process by which many plant species generally grow new plant parts. Nutrients needed by most plants to grow include the inorganic elements Nitrogen (N), Phosphorus (P), and Potassium (K). If, for example, excessive nitrogen from over application of fertilizer runs off into water systems, leading to eutrophication and algae blooms, ornamental species such as Eucalyptus are known model species in the phytometabolism application of nitrogen.

Phytostabilization processes organic or inorganic contaminants in the lignin of the cell wall of roots cells or in the surrounding soil of the root system. Roots exudate and subsequently "trap" contaminants in the surrounding soil matrix. The contaminants are limited in their mobilization and diffusion in the soil or groundwater. Gladiolus are one floriculture species that processes contaminants through phytostabilization.

Image 16 provides a diagram of all mechanisms.

Phytotechnologies and the Industrial Floral Landscape

In survey-based research conducted by Weir and Doty (2016), the authors suspected visitor pushback when adding willow phytoremediators to the iconic, shrub-less rolling hills at Seattle's Gasworks Park. Gasworks is a former gas production site that was converted to a public park. The site was partially remediated several decades ago, but much of the soil is still contaminated with polycyclic aromatic hydrocarbons (PAHs). The primary form of remediation at the site has been capping. In anticipation of using endophyte-assisted phytoremediation as a site remediation strategy, the goal of the Gasworks study was to explore the social acceptability of phytoremediation strategies. Although phytoremediation has been employed for several decades, research on public opinion and knowledge of the process is lacking.

Using in-person and online follow-up surveys, researchers asked participants about environmental values, visitor behavior, phytoremediation acceptability, perceived risk, and knowledge. Results indicated a high level of social acceptability of phytoremediation at the park and suggest that messages intended to encourage the use and acceptability of phytoremediation should focus on the environmental benefits of phytoremediation. Perception of risk (such as the likelihood that the presence of PAHs could harm oneself or a child) was not a unique predictor of acceptability, but the authors note this could be due to confounding factors. Potential park visitors who are already aware of Gaswork's contamination may be less likely to visit, and therefore not be available as study participants. However, Gasworks is an extremely popular Seattle park. The study authors suggest delving deeper into research on the basis of risk perception at contaminated sites. The design proposal described in later chapters considers perception and actual risk by proposing a raised walkway through a phytoremediation demonstration garden, egress barriers, and interpretive signage.

Potential of Ornamental Plants for Phytoremediation and Income Generation

Does phytoremediation research data from field-applications of ornamental species support the possibility of offsetting remediation costs with cut-flower profits?

The research presented in this section is narrowed to field trials within the past 5 years, and is occurring mainly outside of the United States. From my examination of the literature, Liu et al (2008) is the earliest explicit reference to the aesthetic and mechanistic properties of an ornamental plant remediation landscape. Early research suggests not underestimating the design potential of growing ornamental plants for phytoremediation and the visitor experience within a large scale textured and colored landscape.

In an international meta-analysis of phytoextraction of heavy metals using ornamental plants, Asgari Lajayer et al. (2019) review the current known mechanisms and potential by-products. A slightly earlier review out of

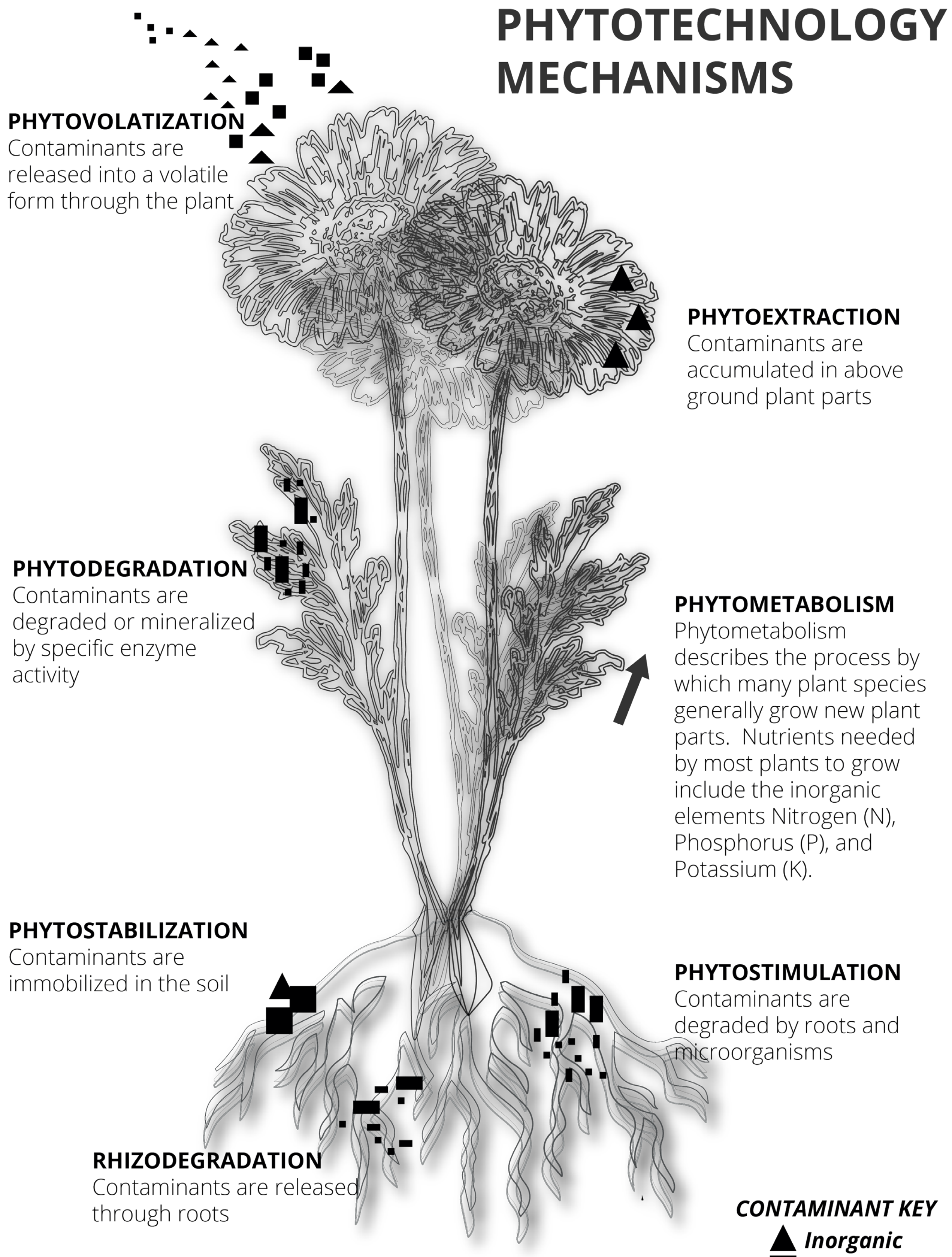


Image 16. Phytotechnology mechanisms

Thailand (Nakbanpote, Meesungnoen and Prasad, 2016) suggests that in addition to species and contaminant removal relationships, a suitable phytoremediation-to-market strategy must consider economic benefits, harvesting management, and by-product uses. These authors situate the surge of interest and experimentation with phytoremediation within the need for a more cost-effective and eco-friendly approach to remediation than conventional techniques. The authors argue that ornamental plants are more viable remediators than edible or medicinal plants because they provide colorful aesthetic design possibilities, are not generally in the food chain, and offer potential by-product generation and related economic benefits. Income from cut-flower sales or ecotourism can subsidize management and disposal costs of discarded plants, and provide incentive for land owners. It is strongy suggested that cut flowers that contain a limited amount of contaminants be sold to consumers.

Factors to consider in a potential phyto-to-market scenario include popular ornamental species according to a regional market, their associated contaminants, where the contaminate is stored in the plant body, and the adverse growth effects on the species. Reviewing this set of literature led to several guidelines in my design:

- Species which accumulate contaminants in their root system, instead of the stem, leaf or flower parts, are especially suited. Potential species for cut-flowers are those that store contaminants in the root system and whose growth is not significantly reduced.

- Contaminant uptake efficiency is improved with soil amending and microbial additions and must be included in any real-world scenario. The authors recommend amending the soil with fungi, manure, and plant growth-promoting bacteria to help heavy-metal uptake. To maximize phytoextraction efficiency of plants, repeat harvests, harvest soon after the flower begins to appear, and apply N-P-K compounds or manure depending on soil condtions. These suggestions seem to be general phytoremediation best practices.

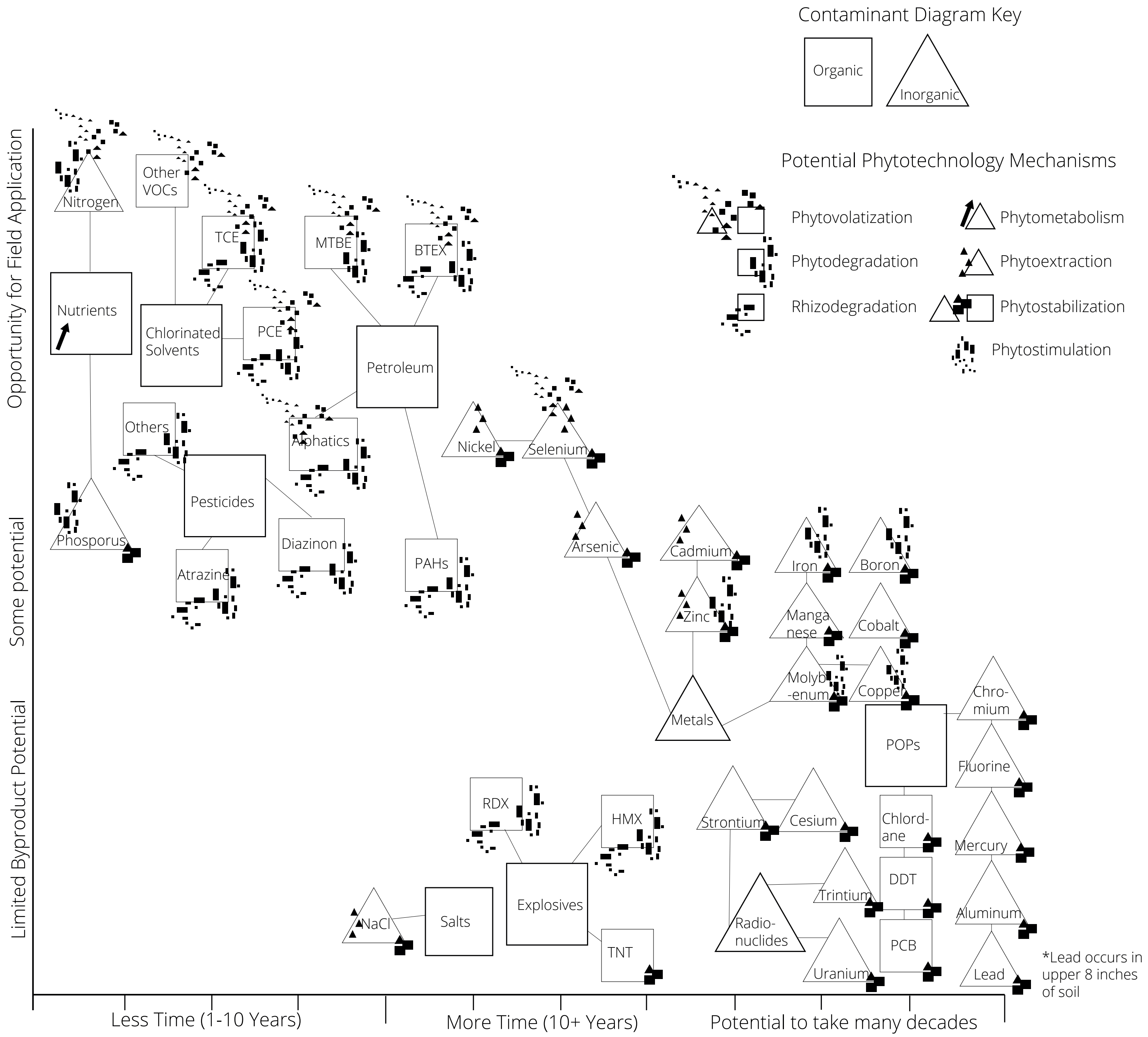
- For heavy-metal contaminated soil, there is a strong post-remediation potential of ornamental plants for perfume production. Perfume obtained from phytoextractors through distillation was found to be safe for human use and met criteria for essential oil certification (Nakbanpote et al. 2016; Asgari Lajayer et al. 2019).

- Ornamental plants could be grown on heavy- metal or highly-contaminated sites and exist as a landscape covering and ecotourism destination. In this case, visitors would not be at risk for toxins accumulated in the plants. However, plants grown in heavy metal-contaminated soil cannot be composted or discarded after death because the heavy-metal contamination would be diffused from the discarded plants. Management and disposal of the plants with high heavy -metals content needs to be addressed. A system of disposal varies across the world, and is typically a difficult issue to solve. Several techniques to process the contaminated plants after death include incineration, composting, compacting, biogas production, and pyrolysis (Ghosh and Singh 2005). Ghosh and Singh suggest a potential topic for future research is heavy-metal induced risks to human health associated with dermal contact of heavy-metal contaminated cut flowers.

- In this design proposal, I suggest a phyto-to-market system where heavy-metal contaminated soil is used to produce floral products for phytomining, essential oils, or biomass. These would prevent any possible human or environmental harm.

- Organic contaminant remediation poses potentially less threat to human contact than heavy-metals. Floral products for the cut-flower industry would be produced in organic and/or soils without heavy-metal contamination.

Species supported by field trials include *Tagetes sp., Helianthus sp., Daphne jasminea, Mirabilis jalapa, Iris lactea Pall, Iris pseudacorus L., and Nymphea spontanea Landon.* Some of these species are not well suited for Puget Sound climate zones 8 or 9, or are aquatic and may be best suited for an indoor hydroponic system.



Phytotechnology Options x Relative Remediation Time

Information adapted from PHYTO (Kennen and Kirkwood 2015)

Image 17.

Note:

Other detailed findings about possible plant species include the following:

*Tagetes patula (*French marigold*), T. arecta* (American marigold*), hybrid Nugget marigold, T. erecta, T. minuta, T. lucida, T. tenuifolia* are recommended because they deter pests, are vibrant, control nematodes, are allelopathic, can act as a cover crop and is culturally significant (in East Asia). *T. arecta* can be applied to soil contaminated with Cd, Cr, Ni, Pb, As and Cu. *T. patula* has potential for Cd, Fe, Cu,Pb and organic pollutants such as Reactive Blue 160 and benzoaphyrene. Nugget marigold has potential for As. but it is not clear if the contaminant is stored in roots.

The adult plant of the *Helianthus annuus* has a lower sensitivity to heavy-metal toxicity than young seedlings. For Cd content it is roots >leaves>stems> for young plants; stems>leaves>roots>flowers in adult plants.

Ornamental ferns known for As potential include *Pityrogramma calomelanos and Pteris vittata*.

Ornamental grasses appropriate for Cd contaminated soils include *Amaranthus hypochondriacus, Amaranthus caudatus, Panicum maximum* (Guinea grass), and *Cyperus rotundus* (nut grass). *Pelargonium sp.* "Frensham" (Lemon scented geranium) accumulated large amounts of Cd, Pb, Ni, and Cu.

Other species to consider include *Nerium oleander, Quamoclit pinnata, Antirrhinum majus, Erica andeavalensis, and Calendula officinalis.*

(Right) Image 18. Table from a manual on the market opportunities in phytoremediation (Pandey and Bauddh 2018). The book is an edited collection of chapters, each describing different by-products from the phytoremediation process. The table summarizes phytoremediation strategies and techniques and their known landscape benefits and weaknesses.

TABLE 1.1 Phytoremediation Strategies/Techniques With Their Description, Benefits, and Weaknesses

Strategies/ Techniques	Description	Benefit	Weakness	References
Phytoextraction	Plants absorb pollutants and store them in harvestable plant parts, that is, leaves, stems, and roots. Examples: Indian mustard, sunflower, rapeseed, etc.	**1.** Its cost is fairly reasonable **2.** Pollutants are permanently removed from sites	**1.** Mostly, hyperaccumulators have slow growth rates with lesser biomass and superficial root systems **2.** Harvested biomass needs proper disposal	Kumar et al. (1995), Bañuelos et al. (1999), Henry (2000), and Prasad (2004)
Phytostabilization	Plants limit the mobility and bioavailability of pollutants in the root zone through immobilization or precipitation. Examples: Grasses for soil stabilization; poplar and willow trees for hydraulic control; plants having dense root systems help reduce contaminants' mobility	**1.** There is no need for the disposal of hazardous biomass **2.** Plant lessens soil erosion and the amount of water available in the system	**1.** Pollutants remain in sites **2.** Regular monitoring is compulsory	Smith and Bradshaw (1979), Henry (2000), Vangronsveld et al. (2009), and Pandey et al. (2012a)
Phytodegradation	Plants degrade organic pollutants using hydrolytic enzymes and metabolites, both internally and through secreted enzymes. Poplar trees (*Populus*) have been successfully used in the metabolization or degradation of toxins and recalcitrant organic compounds. Examples: Poplar, cottonwood, willow, fescue, sorghum, clover, cowpeas, and alfalfa	**1.** It is not dependent on microorganisms associated with the rhizosphere **2.** Plant enzymes are involved in degradation	**1.** It is limited only to degradation of organic pollutants **2.** It does not work well on deep contamination but works best in shallow contagion	Burken and Schnoor (1998), EPA (2000), and Schröeder et al. (2007)
Rhizofiltration	Plant roots absorb, accumulate, or precipitate pollutants from wastewater through root systems. Examples: *Pistia stratiotes*, *Eichhornia crassipes*, *Lemna minor*, and *Hydrocotyle umbellata*	**1.** Mostly aquatic plants are used, but sometimes terrestrial plants are used **2.** Heavy metals need not be translocated to the shoots	**1.** It needs to maintain at an optimum pH **2.** Growing plants in a nursery first and then transferring in remediation site	Dushenkov et al. (1995), Henry (2000), and Prasad and de Oliveira Freitas (2003)
Phytovolatilization	Conversion of pollutants to volatile form and their subsequent release to the atmosphere. Examples: Poplar, cottonwood, willow, grasses (sorghum, bermuda, rye), legumes (alfalfa, clover, cowpeas)	**1.** Pollutants could be transformed into less-toxic form **2.** Pollutants released in the atmosphere is much diluted and in less toxic forms	**1.** Pollutants can accumulate in vegetation **2.** Low levels of pollutants have been reported in plant tissue	Bañuelos et al. (1999), Burken and Schnoor (1998), and Prasad (2004)

Image 19. Plantworks remediation park. Source: Offshoots

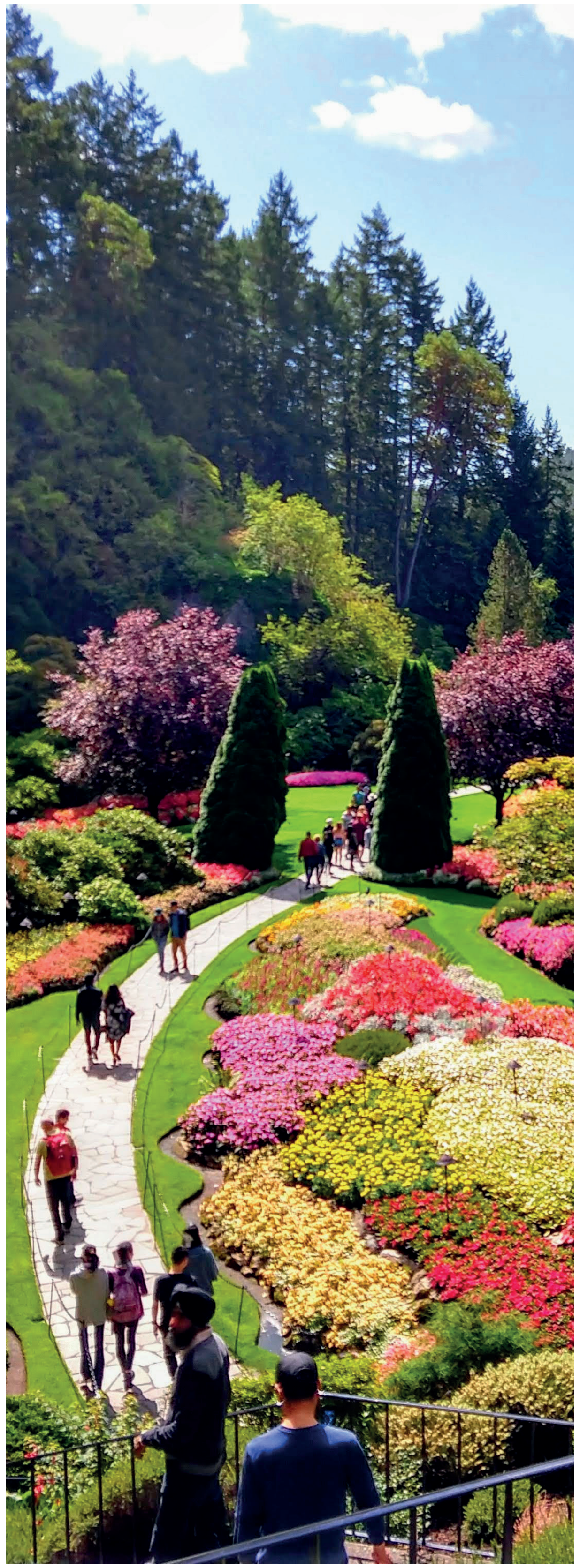


Image 20. Butchart Gardens. Source: Housley

Precedents

Image 19. PlantWorks
Location: Hyannis, MA
Installation Date: 2009
Designer: Offshoots, Inc.

Formerly a gas station, PlantWorks is a one acre community park serving two functions: it employs phytoremediation plantings to improve the quality of the existing soil and doubles as a public nursery, creating a free source of plant material for a Massachusetts town. I learned about this site in the popular reference manual PHYTO. In the site description, the landscape firm Offshoots emphasized a planting design that would appeal to the town and include culturally relevant species. It also serves as a public nursery on site where the plants grown could be split and used for plantings in the town's other public areas. Seeds are also collected on-site and planted elsewhere in city-managed public spaces. A section of the site's soil was contaminated and plant species were chosen for their remediation potential on that portion. **This project provides an example of a U.S. system of phytoremediation and ornamental flower production operating safely and sustainably.**

Image 20. Butchart Gardens
Location: Victoria, British Columbia, Canada
Installation Date: 1921
Designer: Jennie Butchart

This is one of the most visited ornamental gardens in the world. It is an extravagant example of a designer's vision to remediate her husband's mining operation into a horticultural wonderland. She rappelled down rock faces to plant ferns in crevices, and re-imagined a jutting pile of unwanted mineral into a vegetated point of prospect. **The immersive experience and long-term remediation goal was a major inspiration for my project.**

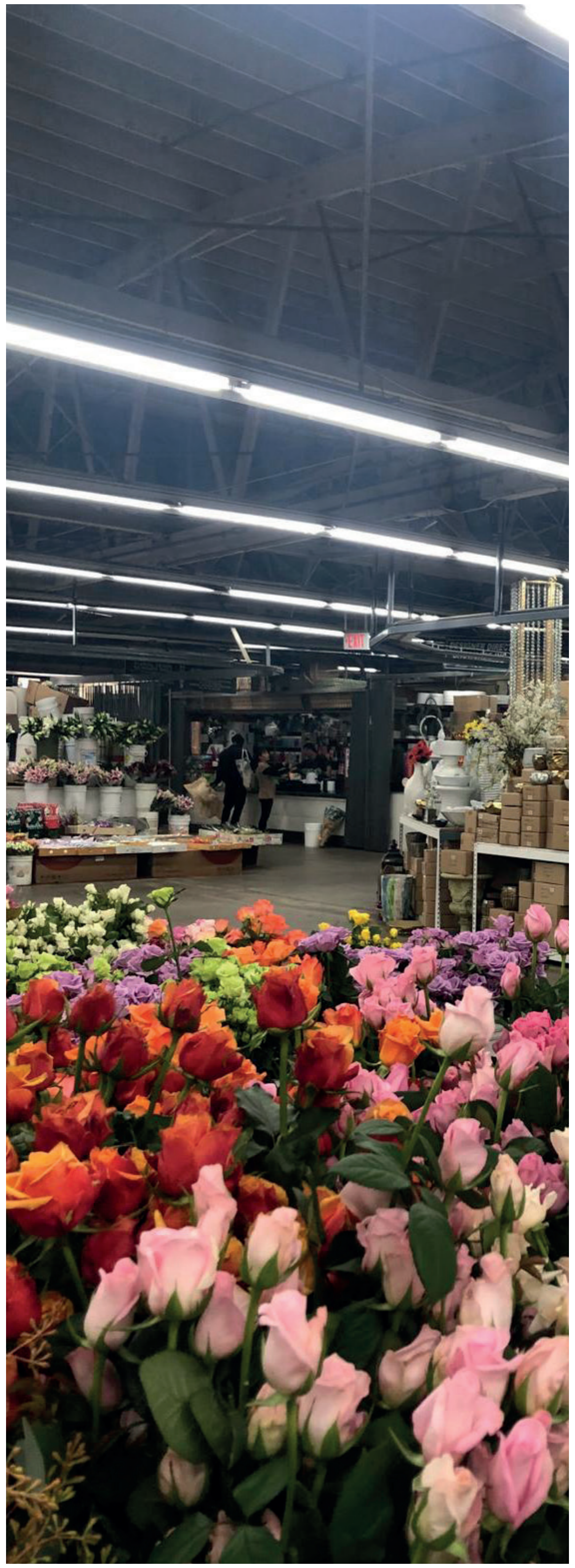


Image 21. Los Angeles Flower Market. Source: Housley

Image 22. Evergreen Brick Works. Source: Claude Cormier

Image 21. Los Angeles Flower District
Location: Los Angeles, California
Installation Date: 1912
Designer: n/a

Two large wholesale flower markets and several retail tenants comprise the Los Angeles Flower District, on Wall St. between E. 7th and E. 8th streets. This is the largest wholesale flower district in the United States. Southern California flower farmers supplied the entire nation with fresh cut flowers from the late 1800s until imports arrived in the 1960s. The Southern California Flower Market, founded by Japanese immigrants in 1912, was the first centralized center for flower sales in the region. Flower growers traveled by train and trucks before dawn to sell their floral crops in downtown Los Angeles. The socio eocnomic relationships developed out of early morning commerce is considered a major contibutor to the resilience of Japanese farmers who lost their livelihood in WWII discrimination. The Flower Market was able to withstand this disruption, and it still continues to operate in full occupancy today. The Los Angeles Flower Market, across the street from the Southern California Flower Market, was organized in 1921 by European immigrants. **This flower district provides a model of flower-district-as-destination within a working industrial area.** Retail and pedestrian focused design, with a ticket system for tourists, is one model of a flower district. Seattle has a series of famous flower stalls in Pike Place Market, and is a major draw for tourists, but it is not in an industrial warehouse setting such as Los Angeles.

Image 22. Evergreen Brick Works
Location: Toronto, Canada
Installation Date: 2010
Designer(s): architectsAlliance; ERA; Claude Cormier, Evergreen

Evergreen Brick Works is an adaptive re-use community space and “nature center” among the grounds of 16 heritage brick factory buildings. Several design awards recognize the use of green technologies to showcase a working, productive landscape within the center of Toronto, on public land. The landscape is designed primarily for education and food production, with urban farming, open air markets, and on-site kitchens displaying the cultural and biological diversity of people, food, and native plants within Toronto. The site is often described as a model for ecological urbanism. The site’s history and present use represents a working example of a similar design to my thesis project. **I am inspired by the layering of community engagement and active agriculture within an urban industrial zone.**

Image 23. Marigolds used in arsenic remediation are cut, packed, and trucked to Thai markets. Source: Mitsui

Image 24. Typical floriculture production landscape in Carlsbad, CA. Source: Shutterstock

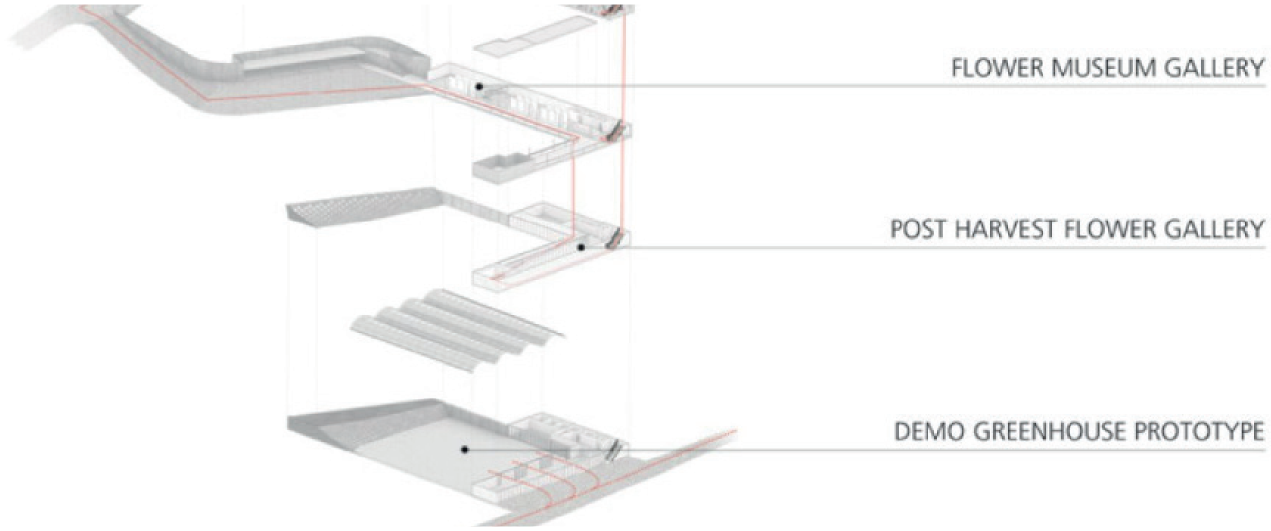


Image 25. Chimerical Line. Source: Somatic Collaborative

Image 23. Marigold Farm
Location: Pobqra District, Tak Province of Thailand
Installation Date: 2000
Designer: Mitsui Mineral Development Engineering CO., LTD

An influential body of research for this design proposal comes from a review of the cut-flower market potential of culturally significant plants such as marigolds and lotus in India and Thailand (Nakbanpote, Meesungnoen and Prasad, 2016). An ecotourism margiold farm in the Pobqra District, Tak Province of Thailand is rich in Zn and Cd contaminants. The plants are safely processed and sold in markets, and provide income and jobs to many along the supply chain. In addition to cut-flowers, the authors describe and show images of pulp byproducts such as mats, baskets, and religious offerings. **The strongest example of a feasible phyto-to-market system comes from this project and others in Thailand and India.**

Image 24. Tulip Bulb Production Fields
Location: Skagit Valley,WA; Carlsbad, CA; the Netherlands
Installation Date: Mid 16th century
Designer: n/a

Tulips were first imported into the Netherlands from Turkey in the mid-16th century and quickly became the epicenter of the floral trade. Flower growers in the North Holland region are mostly bulb producers, rather than growers who supply the cut-flower industry. But, growers in the U.S. and elsewhere will buy Dutch bulbs for local cut-flower production. Visitors from all over the world flock to Netherland flower fields (and Washington and California) in early April to experience and photograph the colorful bands of tulip varieties. **These colorful bands embedded within a production landscape inspired my demonstration garden and floral farm design.**

Image 25. Chimerical Line
Location: Latacunga, Ecuador
Installation Date: 2014 (design commission only)
Designer: Somatic Collaborative

A design proposal from Somatic Collaborative (led by Felipe Correa, the chair of Architecture at UVA) offers a floriculture museum embedded in an Ecuadorian industrial landscape. Their applied research and design project begins similarly to my own project, with exploratory mapping of the global trade of cut-flowers and contemplations of the ephemeral nature of cut-flowers. Their design component includes a post harvest research facility and flower museum, embedded in the farmlands of the Ecuadorian Andes. Although this project was discovered well after initial developments in this thesis, it proposes a demonstration greenhouse and a recreational circuit similar to my own design conclusions. **The design also proposes a large scale structure with a hotel, flower museum, and "post harvest flower gallery" but does not directly address the surrounding landscape or community health as I do in this thesis.**

Framework

This project is an exploration of floriculture, challenges and interventions to achieve economic and landscape sustainability, and the variations of existing or potential floral gifts produced from a productive landscape. I propose a series of prototypical systems and design integrations that highlight potentials for shifting floriculture from solely an experience enhancing industry to one with value-added environmental benefit. Anthropological theory, urban farm "incubators" such as Viva Farms, cutting-edge phytomanagement literature, and industrial ecology theory frame the parameters of this design. An initial assumption in this project is that a bouquet and an immersive productive landscape (i.e. a "flower district") each provide joy and experience through materials. This assumption and literature leads me to propose that beliefs and values about the floral industry, flowering plants, and phytoremediation can be explored through the concept of "gifts".

Ecosystem Services as Landscape Gifts

In an initial exploration of floral bouquet exchange, I was interested in Mauss's short essay *The Gift* (1925). This is an influential academic text in anthropology on the logic of gift and counter-gift as opposed to contract or barter. Mauss argued that the flow of gifts is driven by a universal social rule "to give, receive and give back" that applies not only to ancient communities but to modern societies as well (Godbout and Caille, 1998: 7). Mauss claims that gifts are not just "an economic system" but a "social system concerned with personal relationships" (Godbout and Caille, 1998: 10). In trying to understand gift-giving, Mauss asked the now-famous question, "What force is there in the thing given which compels the recipient to make a return?" (Mauss, 1954 [1924]). The essence of Mauss's answer is that a gift carries with it a part of the identity of the gift-giver, and that "the mechanisms of obligation… are resident in the gifts themselves" (Graeber, 2001: 155). In the context of phytoremediation and the floral industry, I propose that a "phyto-to-market bouquet" would carry a message of environmental awareness between the giver and receiver. A potential new question (if this productive landscape were to come to exist) is whether the receiver would make a return gift to the landscape through changes in pro-environmental behavior.

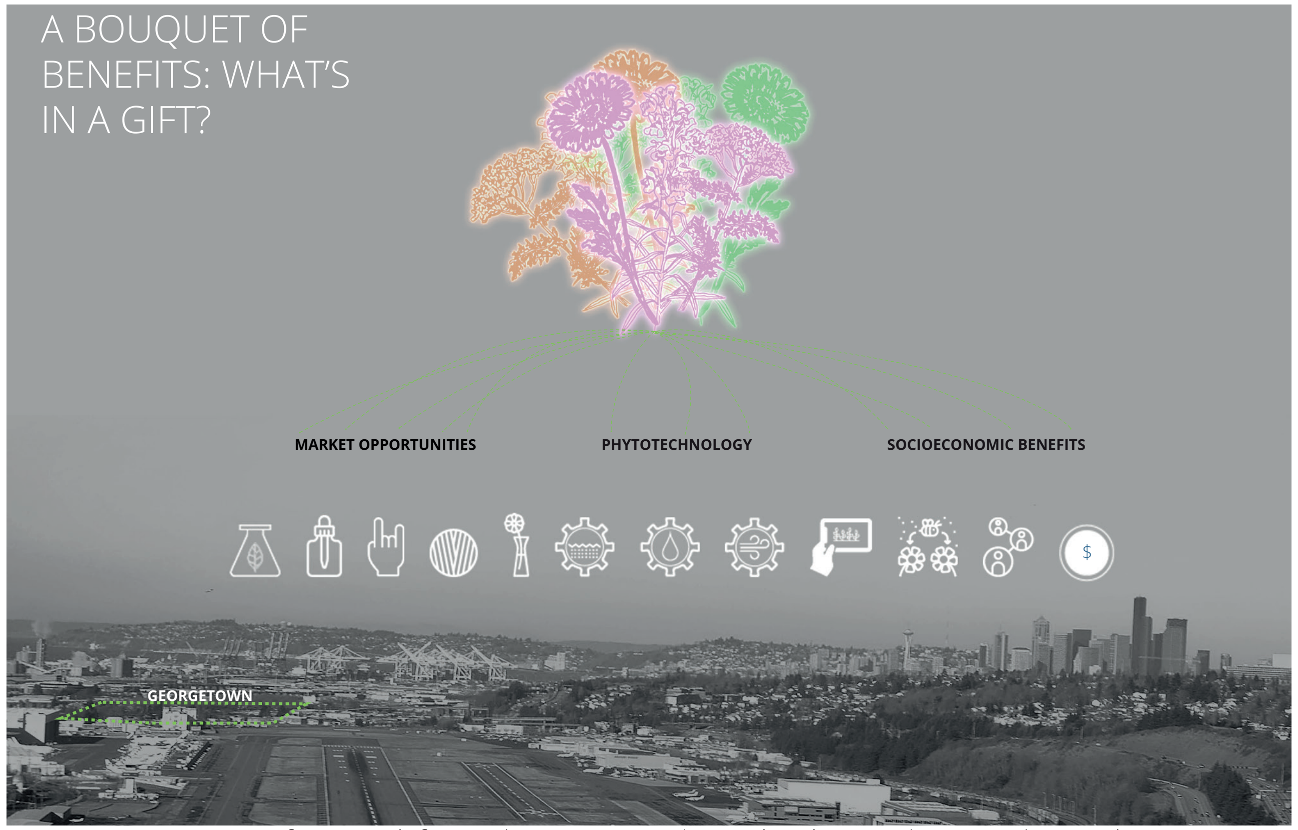


Image 26. Ecosystem gifts. Icons left to right: Biomass, Oil, Metal, Pulp, Cut-Flower, Soil Remediation, Water Remediation, Air Remediation, Ecotourism, Habitat, Connections, Income

In an examination of ecosystem services and conservation, Singh (2015) examines the philosophical and anthropological literature on gift giving to illuminate how the paradigm of the gift helps animate a different politics of environmental care and stewardship. The author critiques the assumptions made by entities who use financial payments to incentivize conservation. The article builds on previous work that cautions against market-based approaches which modify human ways of relating to nature and are counterproductive to long-term conservation goals. Singh then shows how instead of framing conservation as a burdensome activity that entails sacrifice and costs alone, attention should be paid to the joyful and life-affirming aspects of conservation care labor and its transformative potential.

Building on Singh, I further their description of the gift paradigm in the context of environmental conservation. I argue that ecosystems, and by extension ecosystem services, function as gifts to humans and non-humans who are embedded in relations of reciprocity and communication with their biophysical environments. In outsider anthropology literature, indigenous cultures are described as viewing nature and human existence as a gift. In the cultures examined, nature is viewed as a self-organizing system that brings living entities into being. In an attempt not to essentialize "indigenous cultures" and their relations to nature, anthropologists suggest we recognize that such ways of conceptualizing nature emerge from intersubjective communication in the process of making a home in the environment. Latour (2004) reminds us that it is possible to shift our relationship to nature because we as human beings have the capacity to learn to be affected. In contrast, Ingold (1993) claims that the notion of global environment signals the culmination of a process of separation rather than marking humanity's reintegration into the world. The floral industry, which is at once local and global and embedded in an industrial landscape, provides a material examination of human-environment reciprocity.

In "Landscape Machines: Productive Nature and the Future Sublime", Roncken et al. (2011) coin the term landscape machines to describe what they see as an emerging type of landscape architecture design experiment which contains combined elements of a machine and a natural ecosystem. For example, a mechanical character of a landscape design may be predictability, production, or input/output efficiencies which may produce ecosystem gifts such as food, energy, healthy soil, or fresh water. The concept of landscape machines can be dated back to early landscape architecture. Meyer (2008) describes Olmsted's conceptualization of landscape performance as environmental cleaning machines with "open spaces of healthy sunlight, well-drained soils, and shady groves of trees reducing temperatures, absorbing carbon dioxide and releasing oxygen". The authors recognize there may be a negative connotation in using machine as metaphor due to contemporary imaginations of machines as parasites, waste producers, and disruptors of landscape process. They choose to refer to these emerging landscape designs as machines because of an explicit design emphasis on productivity. These designs are "made of landscape features and are driven by landscape processes, and in the meantime they produce a multitude of food products, natural biotopes, clean air, and clean soils..." In this design thesis, I explore the co-occurence of color saturated floral farms and biotechnological processes.

The authors define two main aspects of a landscape machine. In the first instance, the machine metaphor is quite literally a design where material input and output is driven by energy input. In the second instance, the landscape changes, the machine changes, but the input does not change. The input is typically an artificially introduced element into an otherwise evolving physical, chemical and ecological process. Georgetown's industrial history and likely future is this second instance. The area will likely continue to receive contamination from industrial sources but zoning and technology will continue to shift.

In one case study of a landscape machine, the authors describe a proposed park in the Netherlands that is not necessarily attractive in the classical sense of a park with trees and pathways. Instead it is essentially a display of a contaminated dredge cleaning process. The authors describe how the Dredge Landscape Park could function and provide an economic solution when funding for large scale parks is lacking. The park provides environmental gifts of remediation at a large scale and over a long period of time (Image 27).

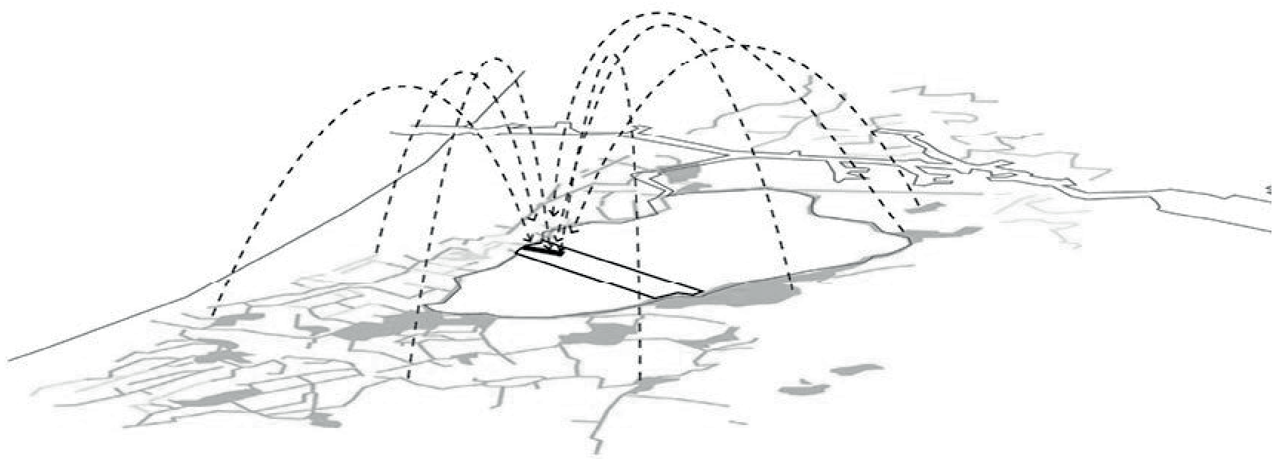


Image 27. Dredge Landscape Park
Location: Haarlemmermeer polder, Netherlands
Installation Date: 2007
Designer: Alexander Herrebout & Gerwin de Vries

Start-up Farm Model

In a 2019 report in HortTechnology, Loyola, Dole, and Dunning surveyed over 200 cut flower producers and handlers in the United States and Canada about the challenges they faced producing and distributing 31 popular cut flowers. Results indicate the five most commonly grown or handled crops were zinnia, peony, snapdragon, sunflower, and dahlia. The study showed that the main issue for local cut flower producers was insect management, especially if a farm is certified organic and does not use pesticides. Properly timing crops was the second most prevalent problem among growers who relied on open farmland (as opposed to indoor greenhouses). Flux in growth disrupts delivery for products tied to specific holidays or events. Cut flower production can be even more challenging after the harvest. The co-authors found that the main postharvest problems were temperature management (keeping flowers cool after they are harvested), as well as properly hydrating and feeding cut flowers. During storage and transport, damage and hydration were the most common issues. The farms in this study did not indicate soil quality as an issue, likely because the majority of these farms are in rural farmland valleys located away from industrial sources of contamination. For urban floral farms, such as the YES! Farm, contaminated soil is more likely an issue, and temperature management less likely an issue because of a shorter period between cut and delivery to local customers.

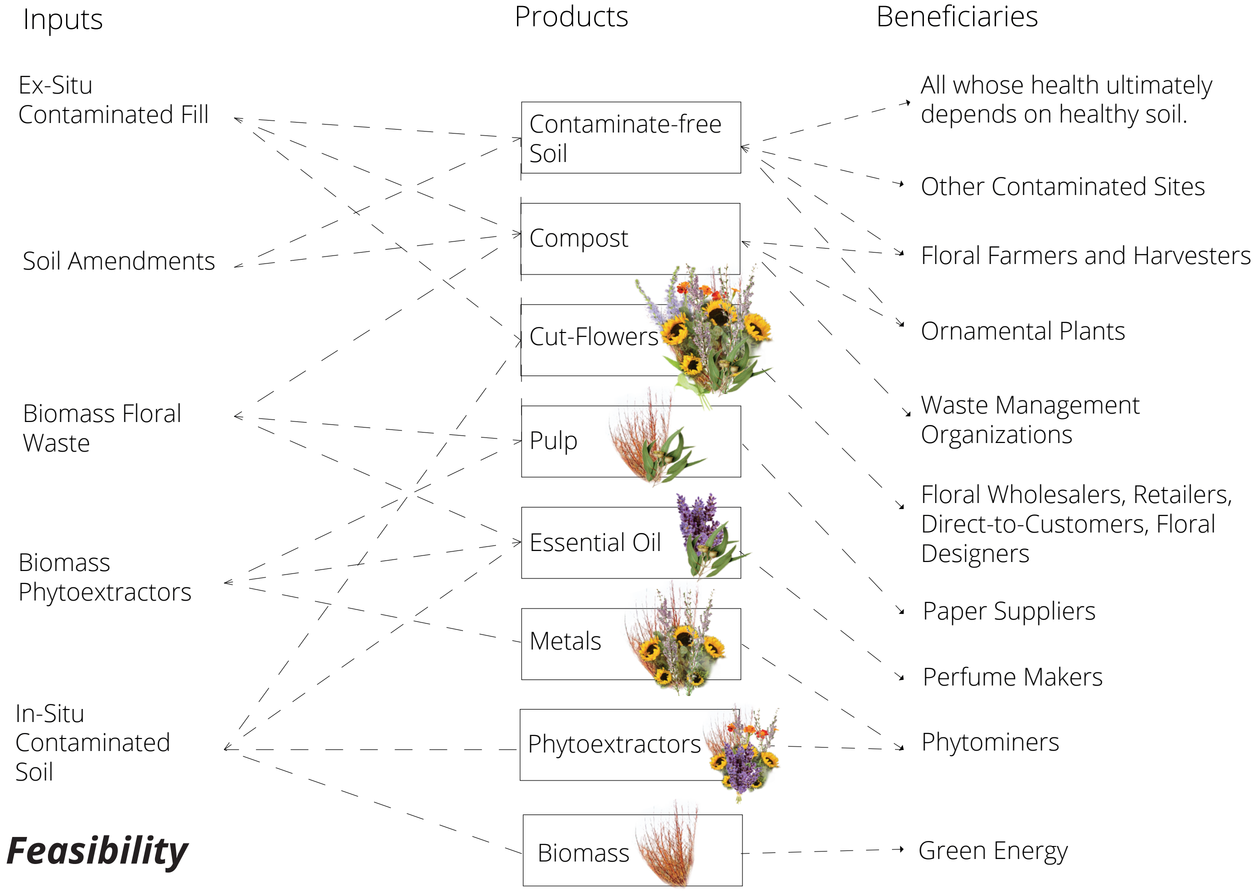
Viva Farms is a non-profit farm business incubator and training program established in 2009. They operate in two Washington State counties: Skagit and King County. Viva has educated over 900 small scale farmers in sustainable organic farming and in 2019 they supported 24 independent farm businesses. They promote their commitment to the Latinx community, with seven of their incubator farm businesses proudly Latinx owned, and almost a quarter of their participating farmers Spanish speaking. Viva Farms provides a host of resources to emerging farmers, including financial and business planning. The Whole Farm Template from Viva Farms provides an outline for start-up farms to follow in their business plan development. The template provides structure to develop and declare overarching goals, evaluation of current resources, property mapping, marketing outlets, a general description of the planned farm, a crop plan with details on target seeding and harvest dates, field layout, crop production plan by plant family, livestock details, and a financial overview.

For the purposes of this project, I used the template as a guide in determining the feasibility of a phyto-to-market floral farm. When evaluating the current resources in Georgetown, I examined available labor, the quality and availability of soil, water and land, and the existing market and community. I conducted site mapping, with attention to the location of wholesale markets. The template prompts also include thinking through challenges and possible solutions when considering local climate, soils, water, buildings, fencing, machinery, labor, regulatory/liability factors, cover crop plan, crop rotation plan, soil conservation practices, pollinator habitat plan, field layout, and methods for monitoring the effectiveness of the plan. The design proposal ultimately did not consider fine detail in all these areas, but all areas were considered at the conceptual design level. At a finer level detail, a crop plan by plant family, seeding date, harvest date, # of succession plantings, and projected yield was used as a guide in a time analysis diagram (Image 45). If this project were to continue into a next phase of design, the template suggests addressing crop production by plant family by outlining fertility, weed, irrigation, pest and disease, and harvest and seeding management. A financial plan with attention to risk management, costs and fund sources,and short and long term sustainability was suggested but beyond the scope of this project.

Phyto-to-Market Agents

As I began to consider the market and soil quality needs of floral farmers, I created a diagram to map the inputs, products, and beneficiaries involved in floral farming. I began with initial assumptions of in-situ contaminated soil on urban sites and the associated flower products and consumers. As my project design evolved, other products and beneficiaries began to emerge (Image 28). This framing of products and beneficiaries dovetails into the framing of ecosystem services as gifts. These are explored later in my design.

Image 28. Phyto to Market Agents



Feasibility

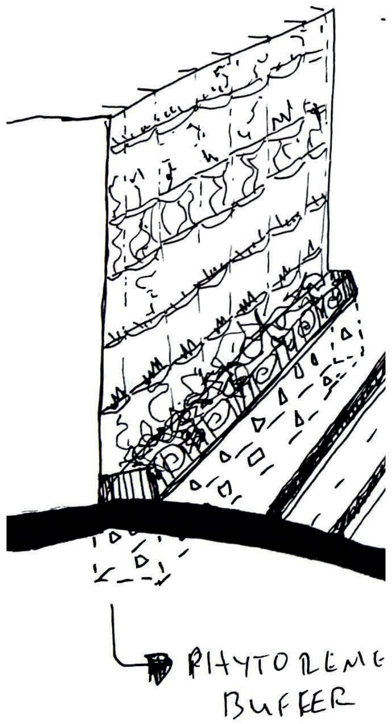
This design proposal assumes that regulation and liability for a phyto-to-market design could be possible. The species chosen in this design grew from the assumptions and reviewed species in a body of work titled *Phytomanagement of Polluted Sites: Market Opportunities in Sustainable Phytoremediation* (Pandey and Bauddh eds. 2019). This book supports design and horticulture explorations of a phyto-to-market system and should be referenced if one is considering by-product and cut-flower possibilities within a phytoremediation scenario. In Image 29 below, the authors outline floriculture species they suggest for a market system. presented in this manual.

Jasminum auriculatum	Oleaceae	Most tolerant	Floriculture	Cr contaminated soil	Ramasamy (1997)
Jasminum grandiflorum	Oleaceae	Most tolerant	Floriculture	Cr contaminated soil	Anandhkumar (1998) and Mahimairaja et al. (2011)
Jasminum sambac	Oleaceae	Tolerant	Floriculture	Cr contaminated soil, tannery effluent irrigation	Ramasamy (1997), Anandhkumar (1998) and Mahimairaja et al. (2011)
Nerium oleander	Apocynaceae	Tolerant	Floriculture	Tannery effluent irrigation	Anandhkumar (1998)
Tagetes erecta	Asteraceae	Tolerant	Floriculture	Cd contaminated soil	Lal et al. (2008)
Chrysanthemum indicum	Asteraceae	Tolerant	Floriculture	Cd contaminated soil	Lal et al. (2008)
Gladiolus grandiflorus	Iridaceae	Most tolerant	Floriculture	Cd contaminated soil	Lal et al. (2008)
Calendula officinalis	Asteraceae	Tolerant	Floriculture	Cr contaminated soil	Ramana et al. (2013)
Nelumbo nucifera	*Nelumbonaceae*	Hyper-tolerant	Floriculture	domestic wastewater treatment, ex-mining area, mined out shallow pond	Kanabkaew and Puetpaiboon (2004) and Ashraf et al. (2011)

Image 29. Species proposed by Pandey and Bauddhs eds. 2019

Design Outcome

This thesis proposes several design and system ideas that highlight new potentials in the floral industry. A design outcome of this proposal includes new associations and meanings available when one gives or receives a floral bouquet, and a phytoremediation-to-market system that is relevant to urban industrial zones. I show how the floral industry could operate as a phytoremediation service and provide an experience of place. This design, if implemented, could contribute to strengthening the local supply chain of floriculture within the craft, trade and agriculture Industry, reduce carbon emissions due to shipping of the floral industry, and aid reduction in soil contamination from human activity.



Methods and Analysis

Several methods were used to generate informative data for the proposed design outcomes. Interviews, content analysis, mapping, site analysis, and relational diagramming led to an imagining of an industrial ecology model. Online mapping and narrative tools hosted by ArcGIS Online helped construct a path of inquiry. These initial maps and narrative can be accessed by clicking here. Material analysis and 3D modeling extended these methods into design. The data generation led me to see areas of potential design interventions in Georgetown, Seattle. The design interventions are elaborated in the next chapter.

Walking Interviews

Using a walking interview methodology, I engaged local floral farmers, wholesale florists, phytotechnology researchers, and Georgetown stakeholders about their needs and goals from an economic and environmental perspective. In the Fall of 2019 I conducted walking interviews with two leaders and farmers at UW Farm, a leader and farmer at YES! Farm (Image 6), a floral farmer from Jello Mold Farms, and two floral growers who are also landscape architects. In early 2020 I had planned to curate connections with farmers markets and local floral farmers and conduct field interviews with consumers and stakeholders of various Seattle farmers markets. Unfortunately, this opportunity did not present itself in the Covid-19 environment.

Documentation and Diagramming

Site visits, literature diagramming, and plant studies helped me organize and understand the floral industry and phytoremediation (Images 30-40).

Image 30. Green wall and marigold studies.

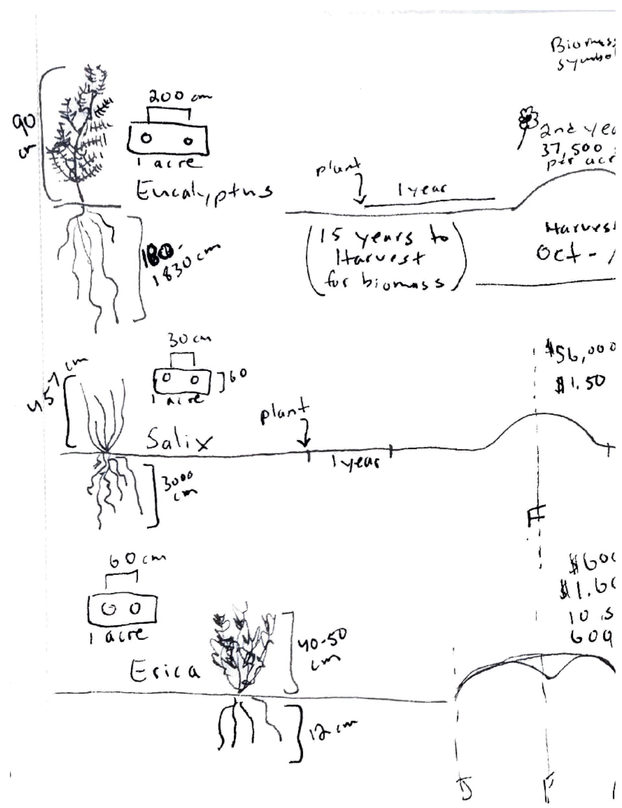


Image 31. Spatializing literature data.

Image 32. Multiple site visits occurred in 2019.

What do floral farmers think about a phyto-to-market system?

- Public perception of the pollinator benefits from floral industry is needed
- Increased public knowledge of the mental health benefits of floral products is needed
- Phyto Flowers must be marketable and desired
- Customer surveys must be done to know desire
- Would customers pay more for phyto flowers? Info needed.
- Urban phyto floral farmers should receive a tax subsidy
- Flowers must be pollinator friendly
- Hardy urban plants means little or no Irrigation

Image 33. Interviews w/ Jello Mold Farm: Diane Szukov; Hazel Landscapes and Design: Annika McIntosh

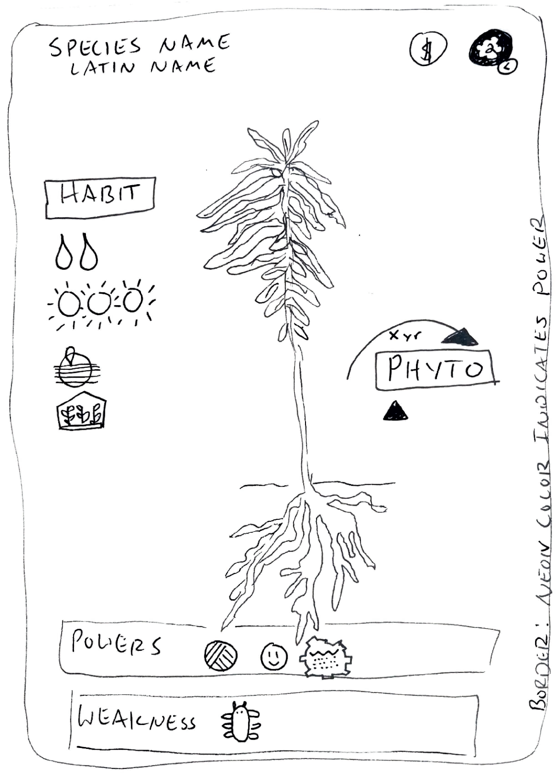


Image 34. Plant Card Sketch

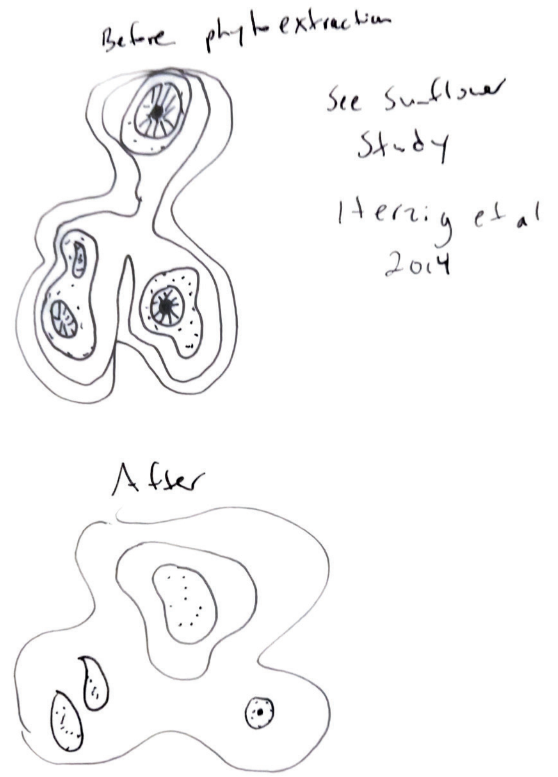
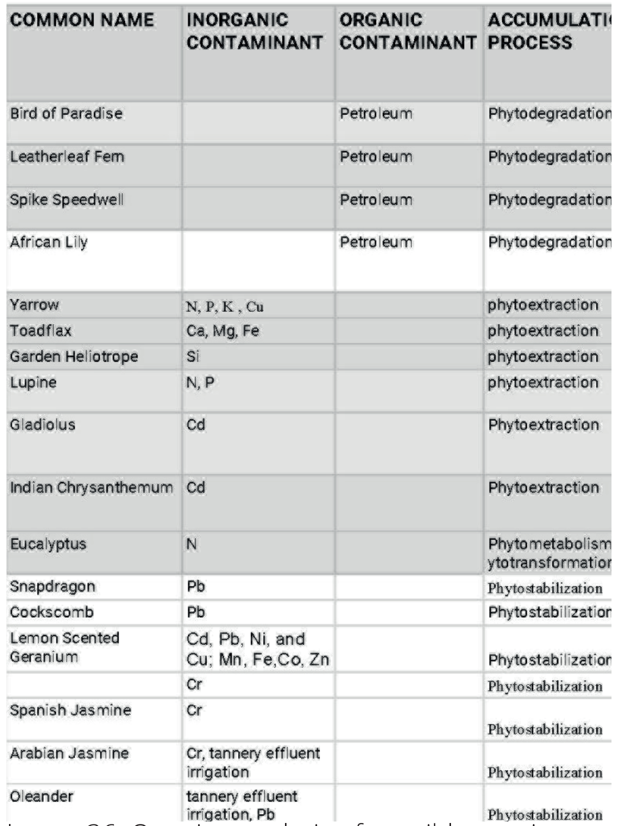


Image 35. Remediation article diagram (Herzig et al 2014).



COMMON NAME	INORGANIC CONTAMINANT	ORGANIC CONTAMINANT	ACCUMULATI PROCESS
Bird of Paradise		Petroleum	Phytodegradation
Leatherleaf Fem		Petroleum	Phytodegradation
Spike Speedwell		Petroleum	Phytodegradation
African Lily		Petroleum	Phytodegradation
Yarrow	N, P, K , Cu		phytoextraction
Toadflax	Ca, Mg, Fe		phytoextraction
Garden Heliotrope	Si		phytoextraction
Lupine	N, P		phytoextraction
Gladiolus	Cd		Phytoextraction
Indian Chrysanthemum	Cd		Phytoextraction
Eucalyptus	N		Phytometabolism ytotransformatior
Snapdragon	Pb		Phytostabilization
Cockscomb	Pb		Phytostabilizatior
Lemon Scented Geranium	Cd, Pb, Ni, and Cu; Mn, Fe,Co, Zn		Phytostabilizatior
	Cr		Phytostabilization
Spanish Jasmine	Cr		Phytostabilization
Arabian Jasmine	Cr, tannery effluent irrigation		Phytostabilization
Oleander	tannery effluent irrigation, Pb		Phytostabilization

Image 36. Ongoing analysis of possible species

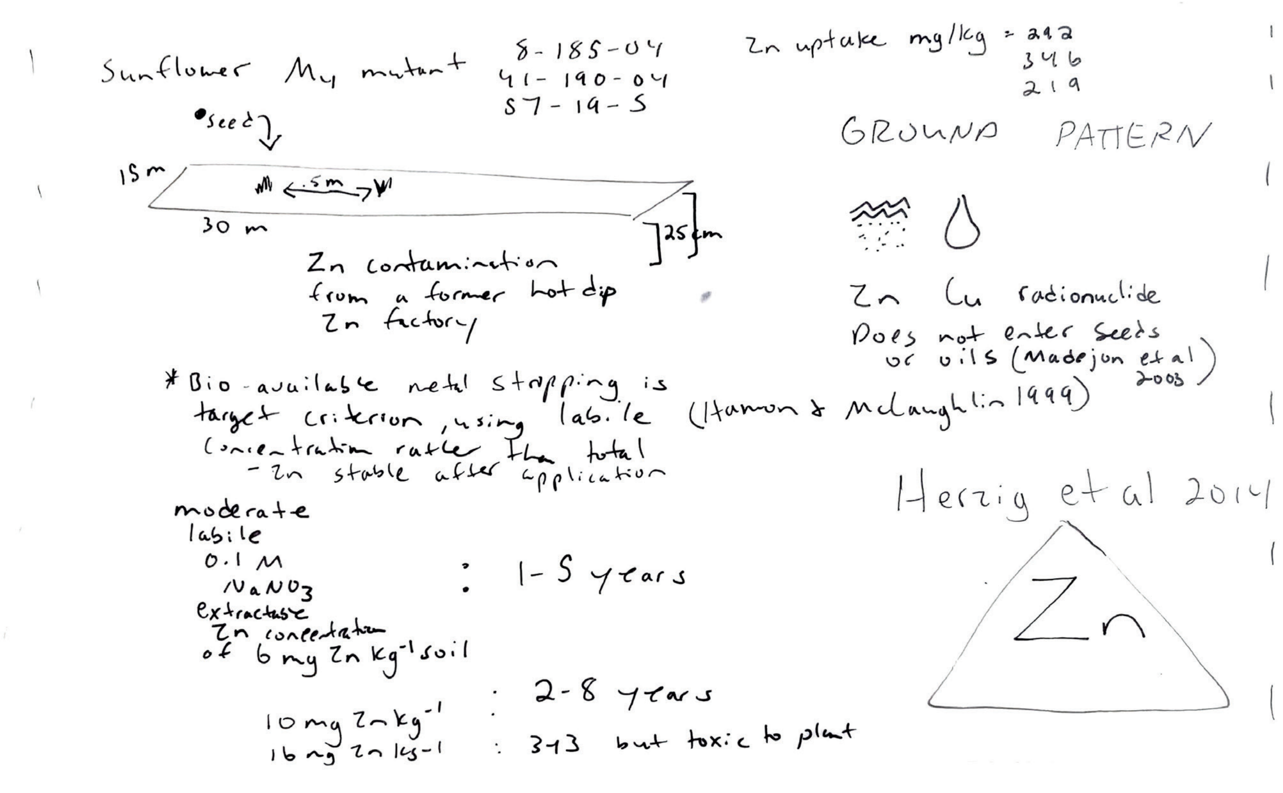


Image 37. Phytoremediation research data is complex and detailed (Herzig et al. 2014) .

SEATTLE WHOLESALE GROWERS MARKET

Wholesale Price List

Fresh Sheet Feb 9 - 14

Click HERE to Preorder

Valentine's Day

FLOWERS

Product	Grower	Location	New this week	Delivery Days	Each price	Stems	Availability	Notes
Alstromeria	Mellano & Co	Carlsbad, CA		M	$8.50	10	good	assorted colors
Anemone	CamFlor	Watsonville, CA		M, W	$13.50	10	good	assorted colors
Anthurium, designer	Green Point Nursery	Hilo, HI		M	$3.50	1	limited	dark red, coral, chocolate, white, pink
Anthurium, medium	Green Point Nursery	Hilo, HI		M	$5.00	1	limited	white, lime green, limelight, blush, yellow, pink, red, brown
Anthurium, tulip	Green Point Nursery	Hilo, HI		M	$3.50	1	limited	burgundy, lavender, pink, blush, green
Edible Flowers	Field to Heart	Curtis, Wa			$15.00	30	limited	Viola (burgundy, rose tones)
Feverfew	Sun Valley	Arcata, CA		M	$8.50	gb	good	
Gerrondo gerberas	Green Valley	Salinas, CA		M, W	$13.00	gb	limited	
Grevillea flowers	Resendiz	Fallbrook, CA		M	$9.00	3-8 st	limited	
Hyacinth	Oregon Flowers	Aurora, OR		M	$10.00	5	limited	assorted colors
Lilies Asiatic	Peterkort Roses	Hillsboro, OR		M, W	$15.00	10	good	
Lilies Hybrid	Peterkort Roses	Hillsboro, OR		M, W	$15.00	10	good	
Lilies Oriental	Peterkort Roses	Hillsboro, OR		M, W	$30.00	10	good	
Narcissus	Camflor	Watsonville, CA		M	$14.00	10	limited	
Poppy, Icelandic	CamFlor	Watsonville, CA		M, W	$9.00	10	good	mixed color bunches

Image 38. Site visits to the floral farmer's market helped me get a sense of popular regional species

Image 39. The Erica plant has odd umbels.

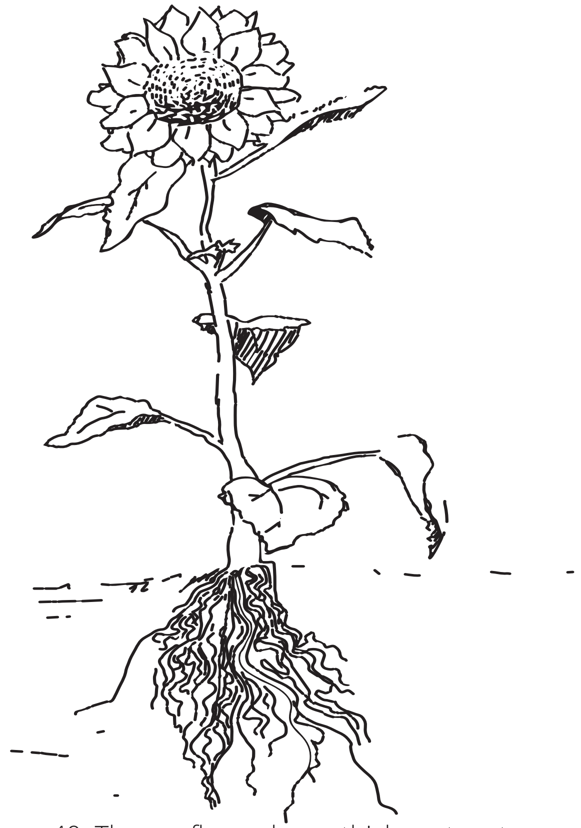


Image 40. The sunflower has a thick root system.

GEORGETOWN
SEATTLE, WASHINGTON

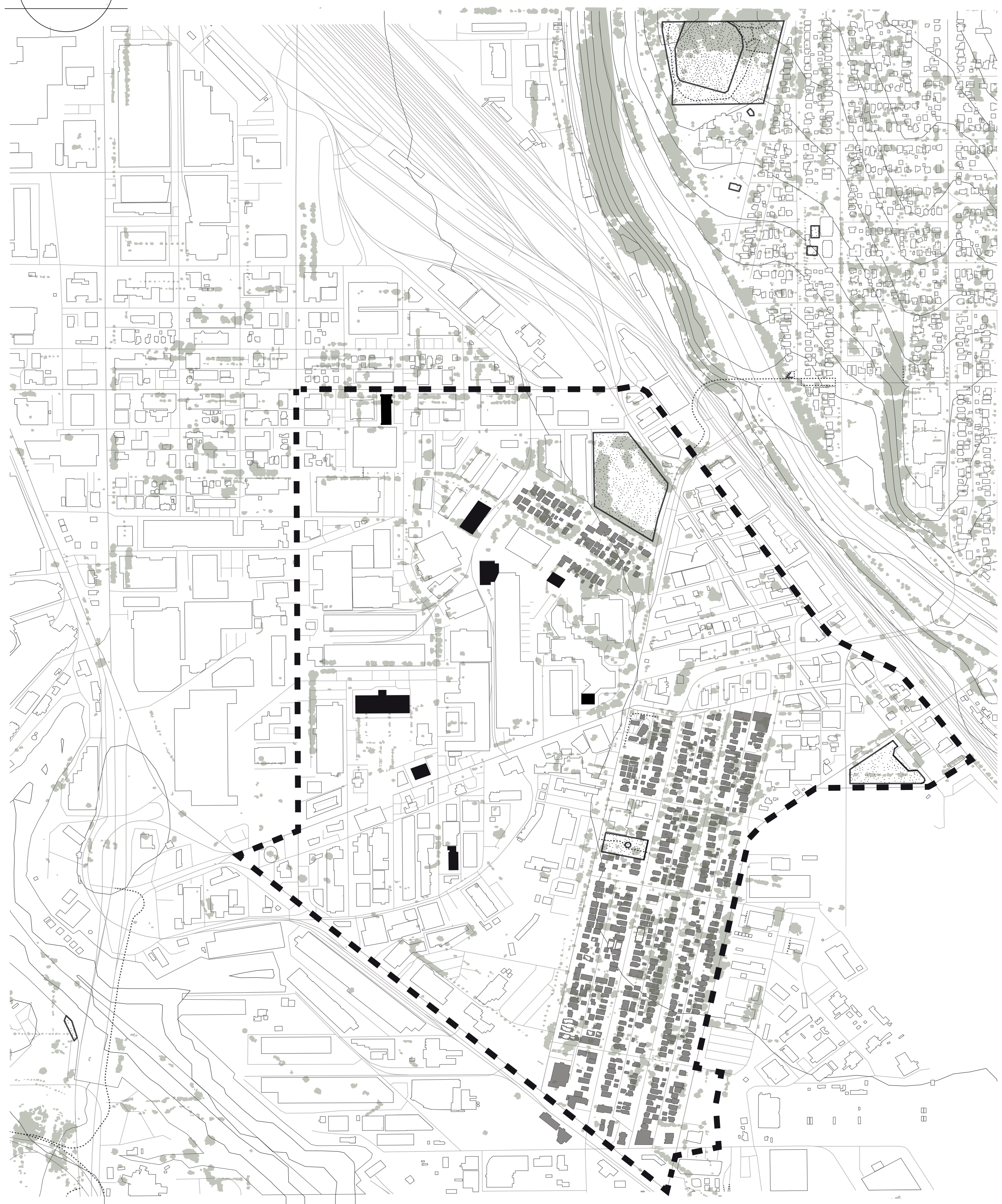


Image 41.Georgetown area of interest.

COMPOST FACILITY, 1 mile away

Mapping

Initial context mapping of the global, regional, and county floriculture network is presented in the first chapter. Here we examine in more detail the pre-existing urban industrial zone in Seattle's Georgetown neighborhood with established networks of local and global production and the location of several wholesale floral warehouses.

Georgetown Site Analysis

Compared to all of Seattle, Georgetown has less canopy cover and a concentration of active or historic sources of soil and water contamination. The neighborhood has always been solidly industrial. This is due to explicit industrial zoning laws, a 1956 Seattle Comprehensive Plan that planned a residential phase-out in favor of more industry, and construction of an interstate that demolished businesses and connections to the east. In 2001, the lower Duwamish waterway was designated a Superfund site and several lawsuits have led to remediation projects along the river.

Georgetown's industrial landscape is littered with potential and ongoing contamination sources. But it is also a thriving craft and trade neighborhood with a small but strong residential community. As this thesis project developed, I suspected that the cluster of floriculture warehouses, residences, and parks around the Seattle Wholesale Grower's Market Cooperative could provide multiple, novel benefits to the area.

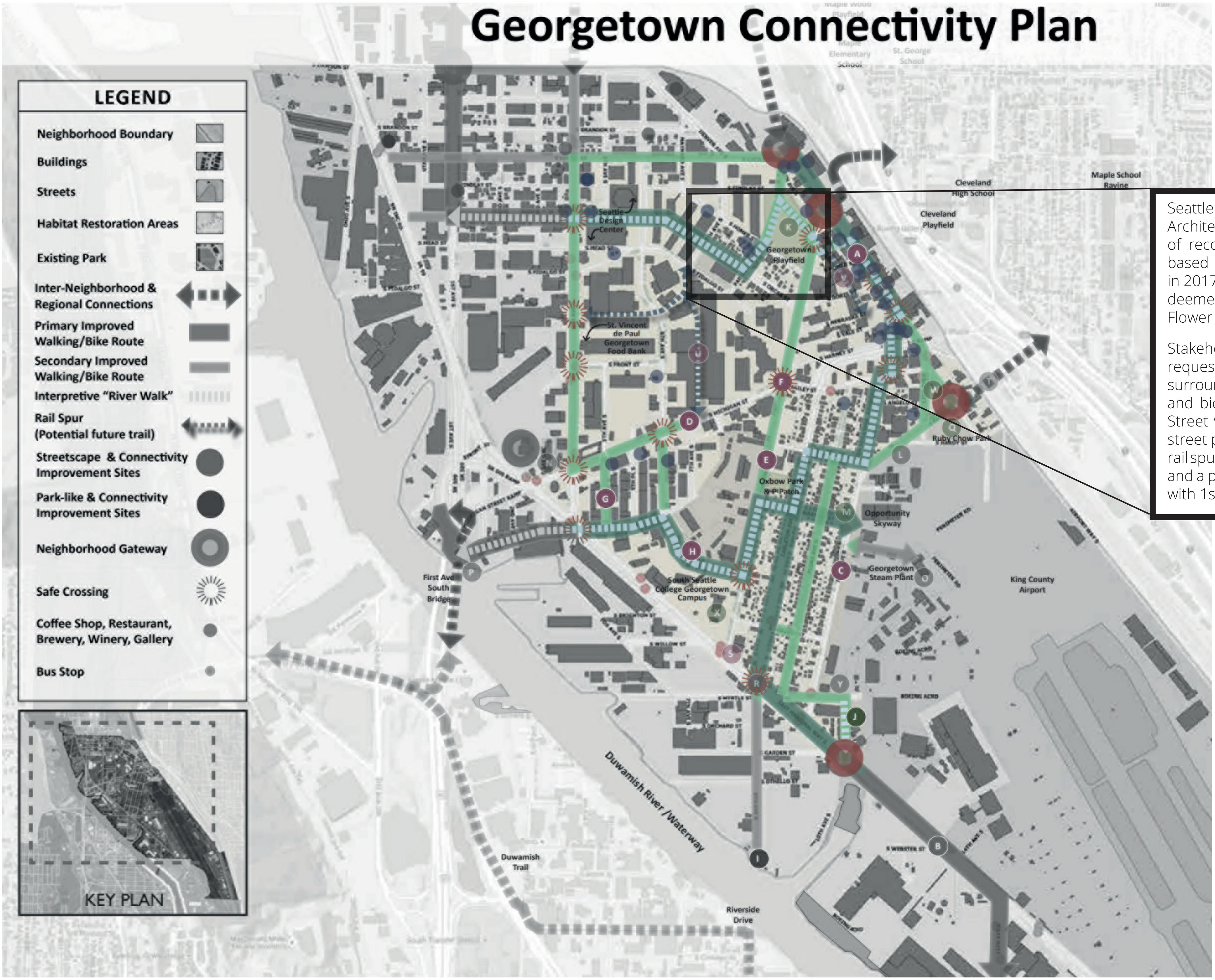
WHOLESALE FLORAL WAREHOUSES

ACTIVE, KNOWN CONTAMINANT SITES

PUBLIC PARK

RESIDENTIAL

TREE CANOPY, 2016



Seattle Parks Foundation, in partnership with Barker Landscape Architects and several community organizations, developed a set of recommendations for Georgetown's future. The results are based on several outreach and community engagement efforts in 2017. The report proposes a 10% schematic design for 10 sites deemed immediately feasible. Two areas adjacent to the proposed Flower District were included in the top 10 sites.

Stakeholders who participated in the community charrette requested several improvements in the immediate blocks surrounding the floral warehouses. These include safe pedestrian and bicycle crossings, an interpretive 'river walk' along S. Orcas Street where the lost curve of the Duwamish River once flowed, street plantings and habitat, pedestrian conversion of the defunct rail spur running through the block adjacent to the floral warehouse, and a primary walking/bike route connecting Georgetown Playfield with 1st avenue (Seattle Parks Foundation, 2017).

Image 42. Georgetown Connectivity Plan. Seattle Parks Foundation, 2017

Contaminated Soil

A municipal report, "Historical Georgetown Neighborhood Inventory: Sites with Potential Recognized Environmental Conditions" released by King County Department of Natural Resources and Parks, Solid Waste Division gives evidence to my assumption that Georgetown is an appropriate site for a phyto/floriculture collaboration (ECOSS 2016). A long list of known contaminants and their suspected source point is included in the report. The majority of sources are gas stations and dry cleaners (existing or pre). For my design proposal, I am interested in the immediate public and right of way areas around the wholesale flower market. This includes Georgetown Playfield. Following these constraints, there are two Model Toxics Control Act Sites (MTCA) but gas station or dry cleaner sources are slightly out of the immediate area. The MTCA is legislation passed by the State of Washington in 1988 to identify, investigate, and clean up facilities where hazardous substances have been released (ECOSS 2016, p.51).

1 PNB Building/ King County Orcas Street Facility, 707 South Orcas Street (near the market). The site has a history of repeated contamination and cleanup. In 2015 "excavation sampling, consisting of 34 samples, found lead above MTCA Method A cleanup levels at two locations. Groundwater has not been characterized at the site to determine if the localized metals contamination has had any impacts". This is the location of the proposed phytoremediation demonstration garden, and a main circulation route between the playfield, residential areas, and transit. This is an MTCA site.

2 American Dry Ice Orcas, 672 South Orcas Street. This site is classified as a TIER2 Emergency/Hazardous Chemical Point. It is an active site directly across the street from the cooperative floral farmer's market.

3 Pioneer Enamel Manufacturing, 5531 Airport Way South (near the Playfield). In 1990, Ecology investigated and collected soil samples that contained excessive levels of cadmium, chromium, lead, and zinc. Evidence suggests it was never remediated. This is an MTCA site.

4 Sonn Property. 950 S. Nebraska Street. This site is a notorious "wrecking yard" with many sources of petroleum and BETX. It is unknown if there is inorganic contamination.

5 Mail Dispatch. 917 S. Nebraska Street. This site has an underground storage tank, and is a possible point source of petroleum or other PAHs.

Image 43. Location of contaminated areas nearest site of interest.

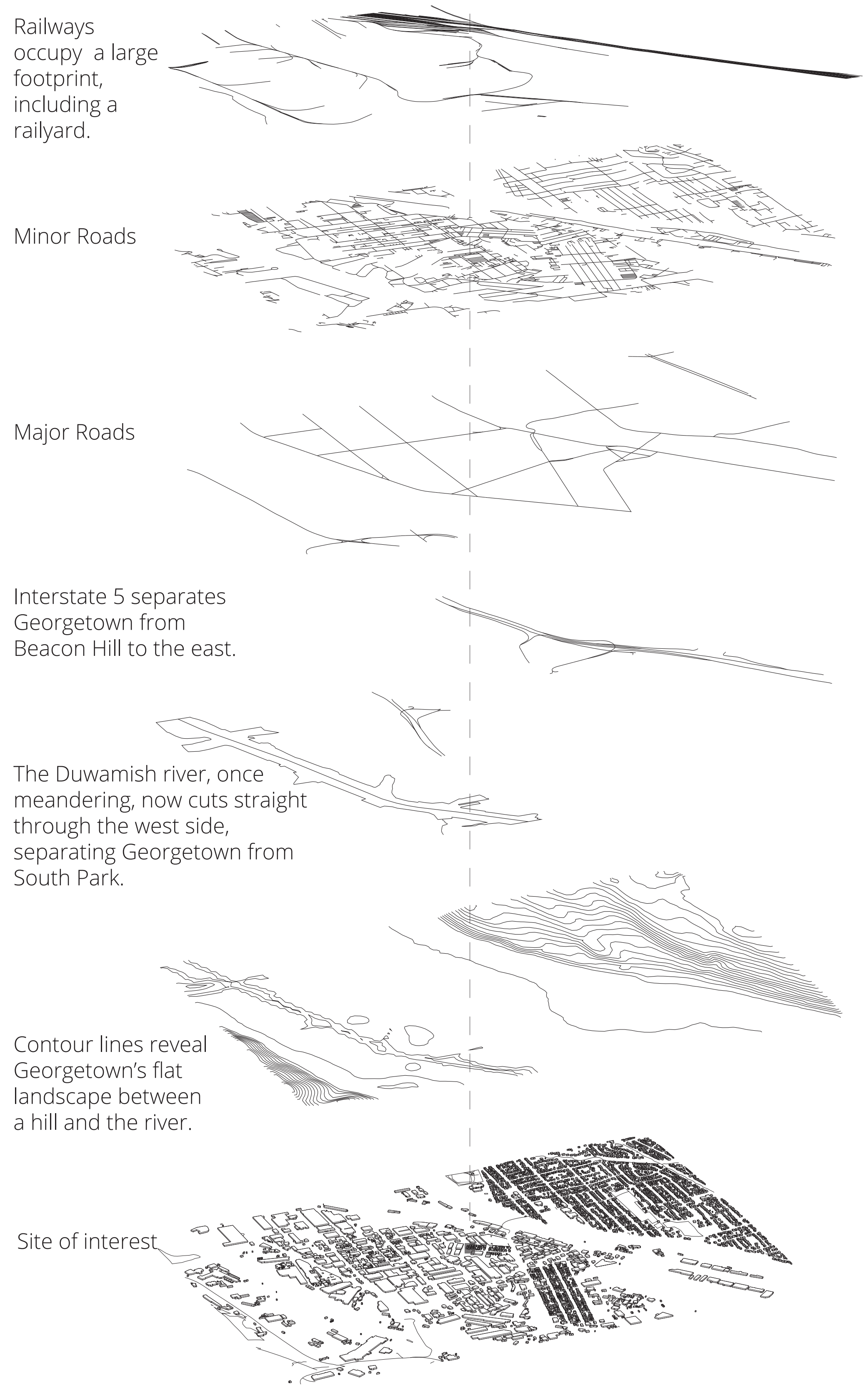
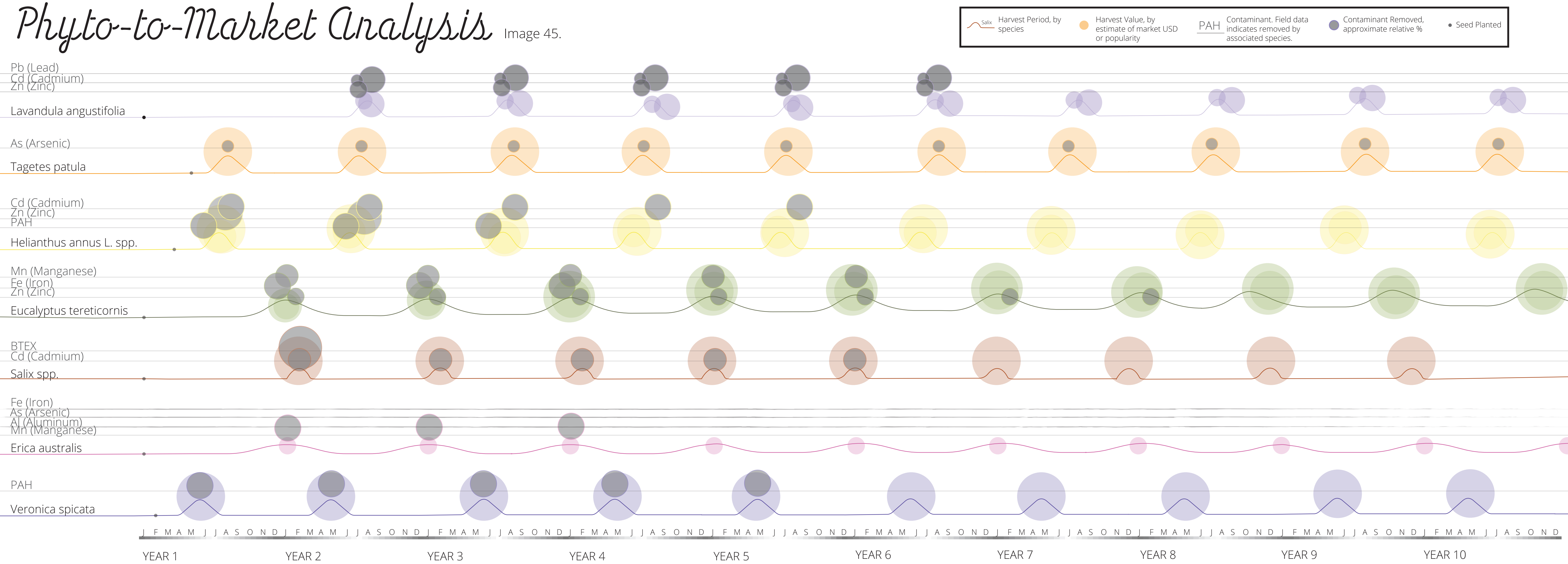


Image44. Existing Infrastructure

Phyto-to-Market Analysis

Image 45.



Phyto-to-Market Analysis

In the early stages of my research, I compiled a data matrix of popular cut-flower species that process contaminates with attention to phytoremediation mechanisms and other significant factors. Image 45 displays the potential of a narrowed sample of ornamental plants (from the compiled data matrix), popular as cut flowers, to act as phytoremediators on contaminated sites with consideration for their market value. The size of colored circles indicates expected profit and harvest times over a 10 year period. Grey circle sizes indicate the amount of contamination removed and expected time to remediate.

Many flowering species possess the ability to filter pollutants (phytoremediation) in contaminated soil. Species which store negligible and below toxic levels of contaminants in their bodies could theoretically continue their lives as cut-flowers for the retail industry. Some plants (such as Lavender) that remove and store heavy-metal contamination (typically through phytoextraction) can be safely used for essential oil and/or biomass products, but are not recommended as cut-flowers (Pandey and Bauddh eds. 2019).

All species examined are identified for plant hardiness zones 8-9, and have been tested for phytoremediation capacities in at least one peer-reviewed field trial. In addition to phytoremediation potential, ideal plant species for a field application should be hardy perennials, drought tolerant, have high biomass production, and exhibit adequate root depth-to-contamination. Phytotechnology mechanisms that degrade or metabolize contamination are ideal for cut-flower marketability. Species known to stabilize or extract contamination are best suited for the byproduct industry.

Lavandula angustifolia. In a field test of Lavandula angustifolia (Angelova et al. 2015), or English Lavender, the results obtained show that the majority of the heavy-metals contained in the flowering stalks of the lavender do not pass into the oil during the distillation, therefore their content in the oil are much lower and the oil extraction met European standards. The distribution of heavy-metals in the organs of the lavender has a selective nature, which reduces in the following order: leaves > roots >stems >flowering stalks. Cadmium (Cd) phytoextraction remediation takes 1-3 years (BF: 5.22 TF: .7), Lead (Pb), hyperaccumulation takes 1- 3 years, (BF: 1.92 TF: 3.69), and Zn phytoextraction takes 1-3 years (BF: 5.16, TF: 1.64). Essential oil testing for all three inorganic heavy-metals indicated mg/kg was below maximum accepted values and met requirements for an environmentally friendly product (Cd: none detected; Pb: .14 mg/kg; Zn: .24 mg/kg). In addition, "one acre of lavender will yield well for 8 to 10 years. A floral farm acre supports 34 rows of 80 plants and it takes three years from when 4-in. cuttings are planted until the first full harvest" (farmshow 2005). After the first full harvest, many lavender varieties produce 3 harvests a year. Multiple sources indicate lavender is a profitable farm venture (Rittenhouse 2018).

Tagetes patula. The striking French marigold is most commonly used in cultural and religious ceremonies in South-East Asia. It is more commonly grown as a garden ornamental in the United States. Research data suggests Tagetes species removes inorganic contaminants from Iron ore tailings, Cd, Fe, Cu, Pb and organic contamination benzopyrene and Reactive Blue 160. It is known to phytoextract Cd and P but otherwise is a phytostabilizer. Arsenic field trials have the most robust data and are presented in the plant card. Tagetes patula (French Marigold) removes arsenic trioxcide from soil at a root depth of 8 inches. It typically takes 45 days to remediate and 30-50 days to flower, with multiple harvest possible through a summer. In results specific to arsenic content in a Thailand site (Mitsui 2000), based on a simulation of growth using a 45-day crop cycle with 30 or 50 g l -1 of phosphate fertilizer, it would require at least 60 years to remove 417.76 mg As/kg-1 from soil. But, in a sociocultural market where marigolds are prized, Thailand datasets indicate growers could generate $300,000 acre/year from cut-flower marigolds. Substantial profit could make a long term remediation goal attractive. Field data also suggests Tagetes accumulates contaminants less in the blossom than in the lower plant parts. Data for other marigolds such as Tagetes arecta and Calendula officinalis suggest these species may also be appropriate (Nakbanpote et al. 2016; Chaturvedi et al. 2014.; Chintakovi et al. 2007).

Helianthus annus L. sp. The iconic phytoremediating Sunflower is in the top five domestic cut-flower products according to a survey of floral farmers (Loyola et al 2019) and USDA (2019) crop datasets. It is also a lucrative essential oil product, bringing in over $3 USD a gallon, with a long vase life of 7-10 days. It is known to phytostabilize inorganic Cd contamination, phytometabolize N, and phytoextract Ca, Cu, Mn, and Zn. It also phytoextracts organic PAH in soil (Nakbanpote et al. 2016; Asgari Lajayer et al. 2019). It takes about 3 years to remove PAH contamination, 5-8 years for Cd, and 2-8 years for Zn. Although the late 20th century proved too optimistic for sunflowers, research is fine tuning field trials in the past decade, with emphasis on soil amendments to increase field scale remediation. A phyto-to-market system would need to ensure the use of seeds from previous phytoremediating subspecies.

Eucalyptus tereticornis. Forest Red Gum is a species of Eucalyptus native to the South Pacifc but suitable in a controlled farm setting in the western coast of the United States. Although this species could reach several stories tall, itcan be grown in compact form on a floral farm, with branches pruned for cut-foliage material in floral arrangements. It also has multiple by-product uses such as furniture and essential oil. Findings indicate organic and inorganic remediation (Mn, Fe and Zn) is phytometabolized in less than 8 years for most soil and water contamination (Shukla et al. 2011; Kennen and Kirkwood 2017).

Salix spp. Coralbark Willow (Salix alba L. 'Britzensis') is a shrubby, woody plant with striking four-season color. It can be used similarly to dogwood and other willow types in floral arrangements as a flexible filler and structural material. It also removes soil and water contamination through all known accumulation processes. It has a short (3-5) year remediation period and extremely deep roots capable of reaching deep contamination. It's superior growth, biomass production and efficient hydraulic control of soil water levels (due to high rates of evapotranspiration) makes Salix spp. suitable as a potential "bioreactor" for cyanide removal. It's vast range of accumulation processes requires thorough field testing on specific site conditions to avoid repeat contamination. It can generate $56,000 acre/year as a cut-foliage product, and more as a fiber product (Kuzovkina and Quigley 2005; Wallin 2019).

Erica australis. This flowering shrub, also known simply as Heath, is used in flower bouquets to add fullness but is less commonly used than similar heaths and heathers. It can be formed into shapes or used as an accent but has a short vase life (3 days). It is a potentially consumer safe phytoextractor for inorganics such as Mn and a phytostabilizer for acids, Al, As, and Fe. It is a good choice for highly acidic soils and remediates within a few years. Although phytoremediation data exists for limited species, findings suggest many other Erica species may extract or stabilize soil contamination (Nakbanpote et al. 2016; Pérez-López et al. 2014).

Veronica spicata. The Veronica plant, sometimes known as Spike Speedwell, is a profitable cut-flower product and can remove petroleum contamination from the soil in 6-10 years via phytodegradation (Kennen and Kirkwood 2017). It is used as an accent in a floral arrangement; popping out and towards the sky.

Phyto Plant Cards

Image 46. Erica Plant Card

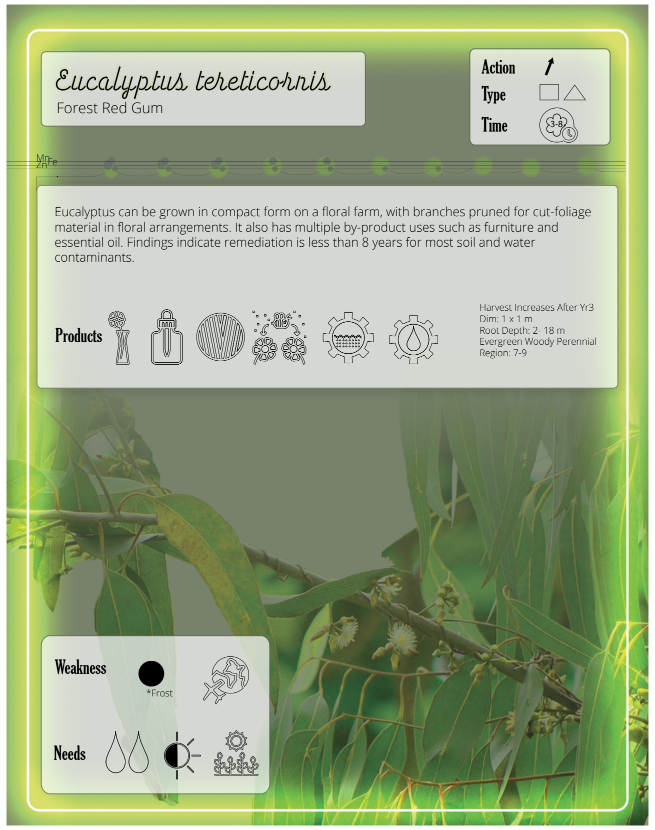


Image 47. Eucalyptus Plant Card

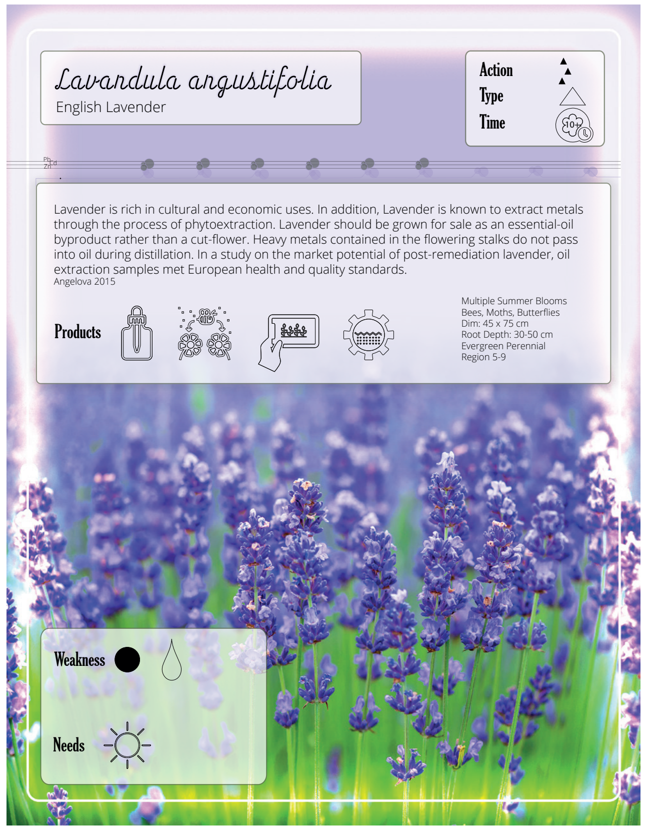


Image 48. Lavandula Plant Card

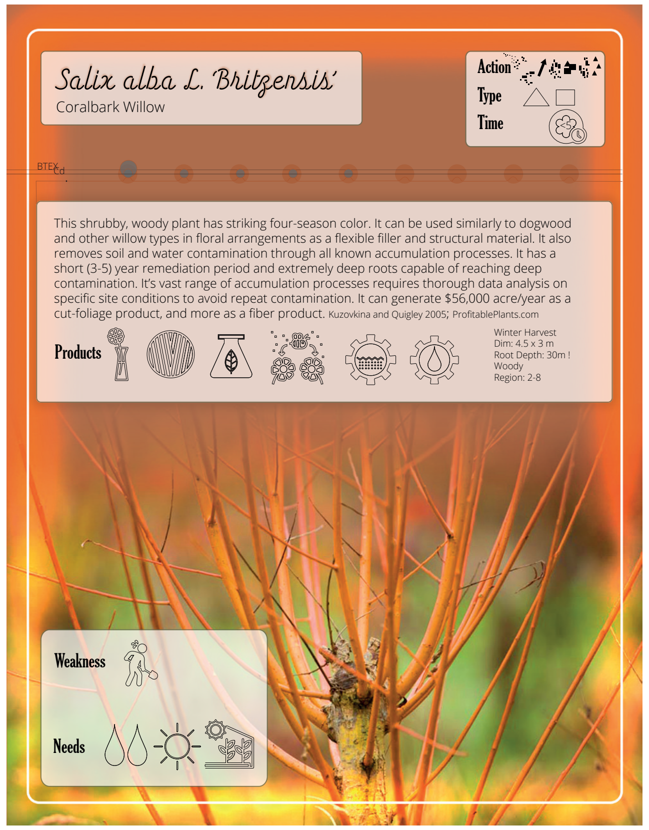


Image 49. Salix Plant Card

Image 50. Tagetes Plant Card

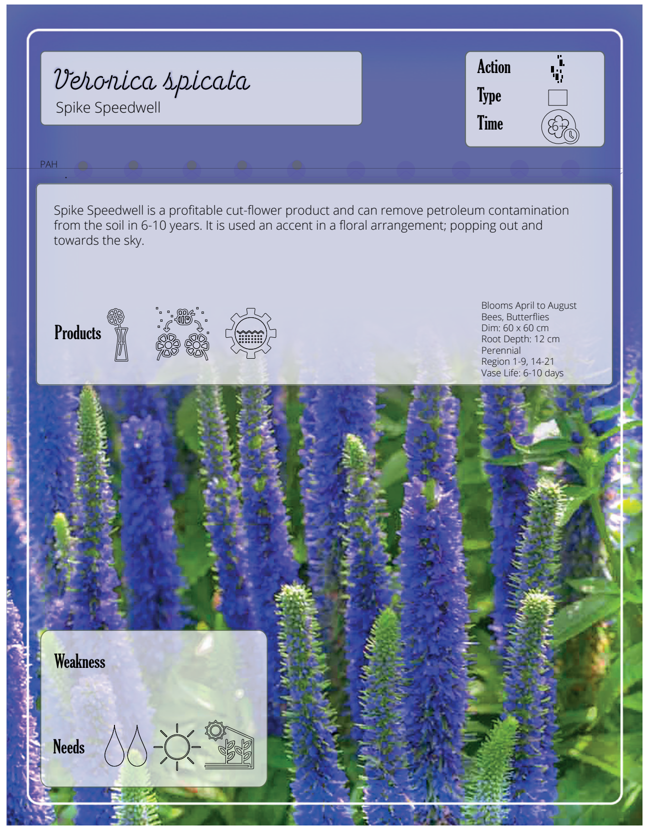


Image 51. Veronica Plant Card

Crafting Gifts

Investigation of the plant species eventually led to testing floral arrangements and developing Phyto Plant Cards. This tactile expression and "playing card" infographic are floral gifts that express my individual interests, aesthetic, and message, much like a bouquet of flowers. The Phyto Plant Cards (Images 46-52) are a final synthesis incorporating the market analysis (Image 45) and my design interventions.

These cards are included at a larger scale in the appendix, and could be used as reference cards for designers, floral farmers, and remediation engineers.

Icons developed for the plant cards and throughout the design are labeled in the Appendix.

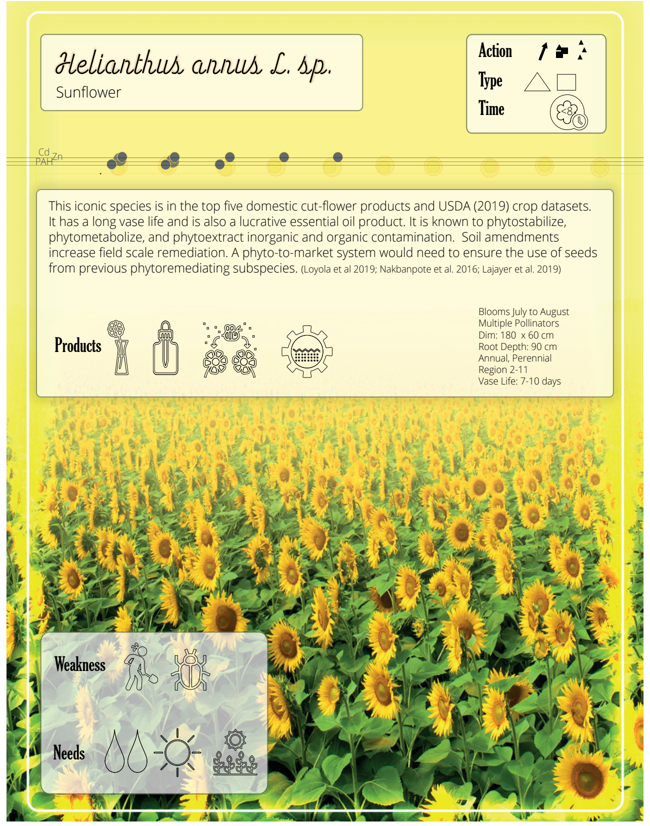


Image 52. Helianthus Plant Card

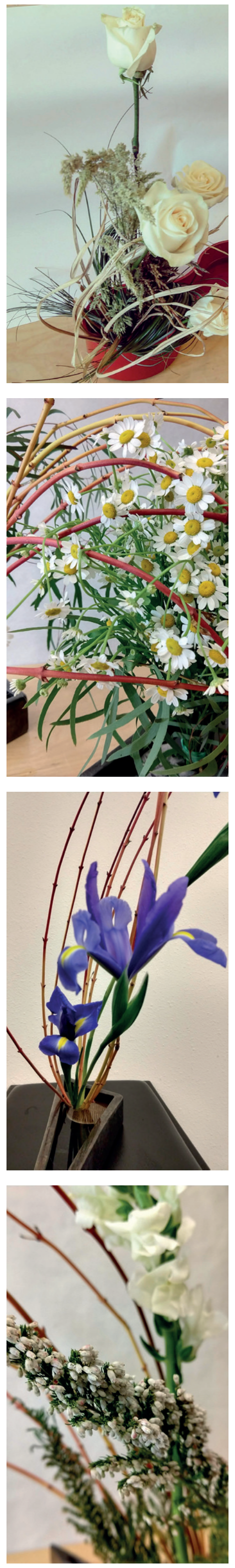


Image 53. Ikebana material analysis

Floral Arrangement

For the past eight years, I have studied Sogetsu Ikebana under a Seattle-based Sensei, Megumi Schacher. Ikebana is the Japanese art of flower arrangement. This form of art dates back to the 7th century when Chinese Buddhist missionaries introduced Japan to the concept of flower offerings to the Buddha. The first "school" of ikebana design theory, Ikenobo, developed during that century and has since evolved into several secular schools of design. Sogetsu is the modern school established in the 20th century, with an emphasis on novel uses of line, mass, color and material to create plant-based sculptures. This practice initially influenced me to learn more about cut-flowers and how they are produced. Ikebana theory includes the concept of plants as raw art materials, with a beauty and essence of their own, but the "art" is created through the act of bending and shaping the plants according to the artist's intent. Because of this concept, I was drawn to the idea of cut-flowers straddling the line between living material with its own agency and an art object capable of evoking emotion and curiosity in the viewer.

Material analysis proved to be a positive emotional experience. As an initial study in the possibility of phytoremediating plants being sold in a cut-flower market, I compiled a matrix of ornamental species I knew to be commonly available from the florist and that I suspected had potential to remove contamination from the soil. This final list is represented in the plant cards. Using identified species from the cross-referenced list, I bought cut-flowers and foliage from local and international florists and arranged these into bouquets and ikebana arrangements as an experiment in "aesthetic" testing of potential phyto-to-species (Image 53). These arrangements were made as expressions of my discovery of native grasses and rose production in Ecuador, the multiple benefits provided by Salix species, aquaponic and water filtration abilities of blue irises, and the potential of heath and snapdragons. Some of these species are included in my final design. As I made these bouquets, I asked myself whether these bouquet of flowers that could be doing work (pollinator habitat or remediation) before they are cut changes the ephemeral nature of a cut-flower bouquet. In spring 2020, I had planned to explore this question in field surveys with farmer market customers and stakeholders, and by inviting other floral designers to create a phyto bouquet. These plans did not become possible in the wake of Covid-19.

Design

Georgetown Flower District

The analysis process led to a proposed Georgetown Flower District located in a nexus of existing floral warehouses and contaminated soil sites. The Flower District, in addition to the warehouses themselves, includes a one-acre urban floral farm start-up, a phytoremediation demonstration garden, a compost facility, and indoor remediation cut-flower greenhouses and byproduct facilities. The phytoremediation demonstration garden serves as a test bed for the feasibility of a phyto-to-market system and an ecotourism destination, and a neighborhood remediation benefit for Georgetown residents. The garden is a gathering point for the community, with the other site components in this design rotating resources around this point. This final design showcases a phyto-to-market model relevant to urban industrial zones, not only Georgetown.

Design Proposal as a Gift

This design proposes a working landscape machine that remediates and contributes to the creation of an industrial ecological system. The remediated and colorful floral landscape is an ecosystem "gift" to humans, soil, and pollinators. Floral and heavy-metal waste is passed through this system as a resource, crafting gifts as it goes. Let's explore this in the design section.

Image 54. Georgetown Flower District

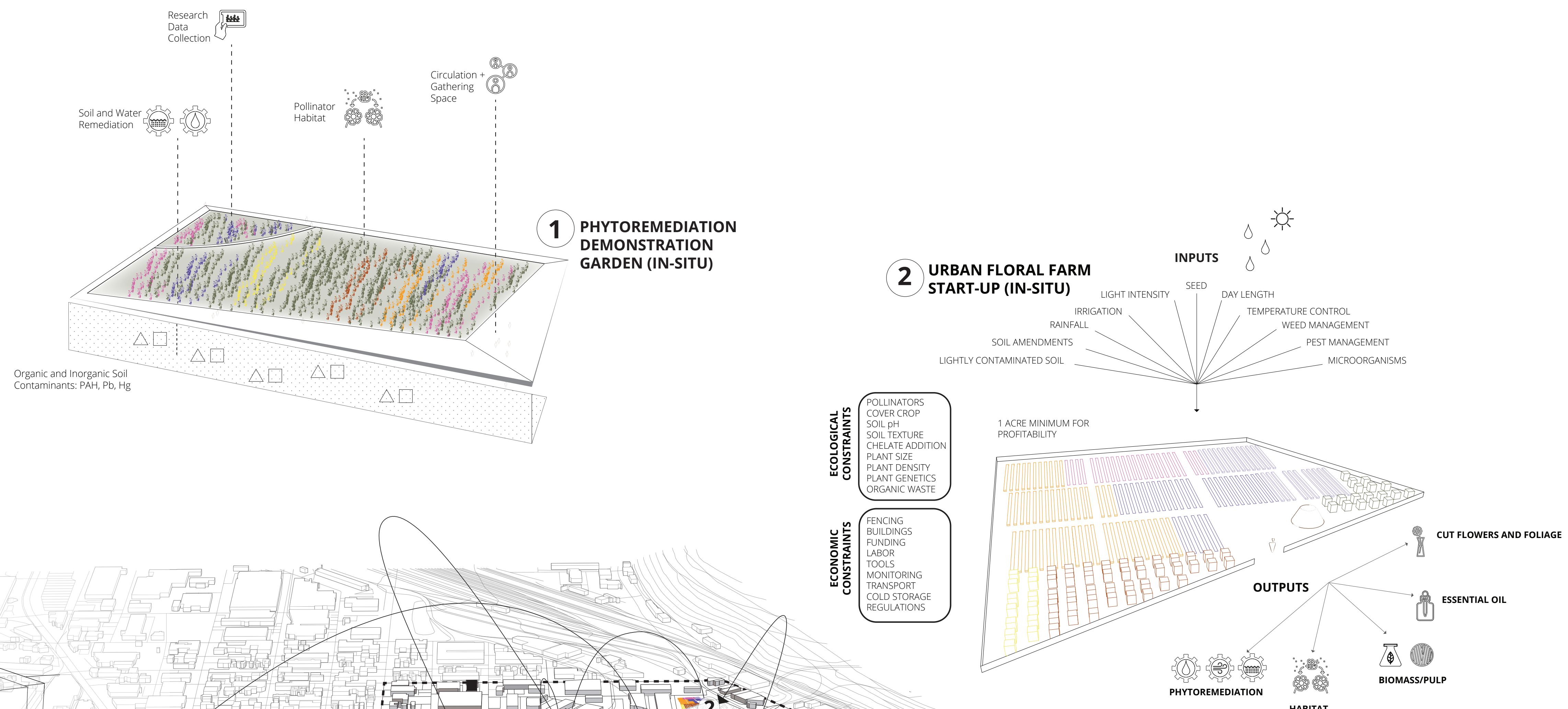
Proposed Phyto-to-Market System

The traditional floral industry and phytotechnology is a linear system leading to waste disposal. In the proposed system, waste is re-purposed and composted within a closed loop. Referencing back to the Roncken et. al (2011) description of the productive landscape, where it is "made of landscape features and are driven by landscape processes, and in the meantime they produce a multitude of food products, natural biotopes, clean air, and clean soils..." this design remediates and contributes to the creation of an industrial ecological system. The remediated and colorful floral landscape is an ecosystem "gift" to humans, soil, and pollinators. Floral and heavy-metal waste is passed through this system as a resource, crafting gifts as it goes.

Image 55. Proposed Phyto-to-Market at the Urban Floral Farm

Resource Exchange

Inspired by the Dredge Landscape Park (Image 27), this design proposes a resource exchange between the proposed sites and existing sites within Georgetown and beyond. The urban farm (2) produces cut-flowers using slightly contaminated soil and compost produced on-site and from nearby (5). The nearby warehouses buy and sell the cut-flowers, and their floral waste is in-turn moved to the compost facility (5) and byproduct facility (4) as biomass. The indoor greenhouses (4) produce cut-flowers from ex-situ contaminated soil and water, acting as a holding site for contaminated fill. Byproduct facilities (4) can produce essential oils, pulp, metal aggregate, and biofuel from heavy-metal-contaminated floral waste removed from remediated sites within Georgetown or beyond. The garden (1) and pathway (3) exists in the middle of this exchange.



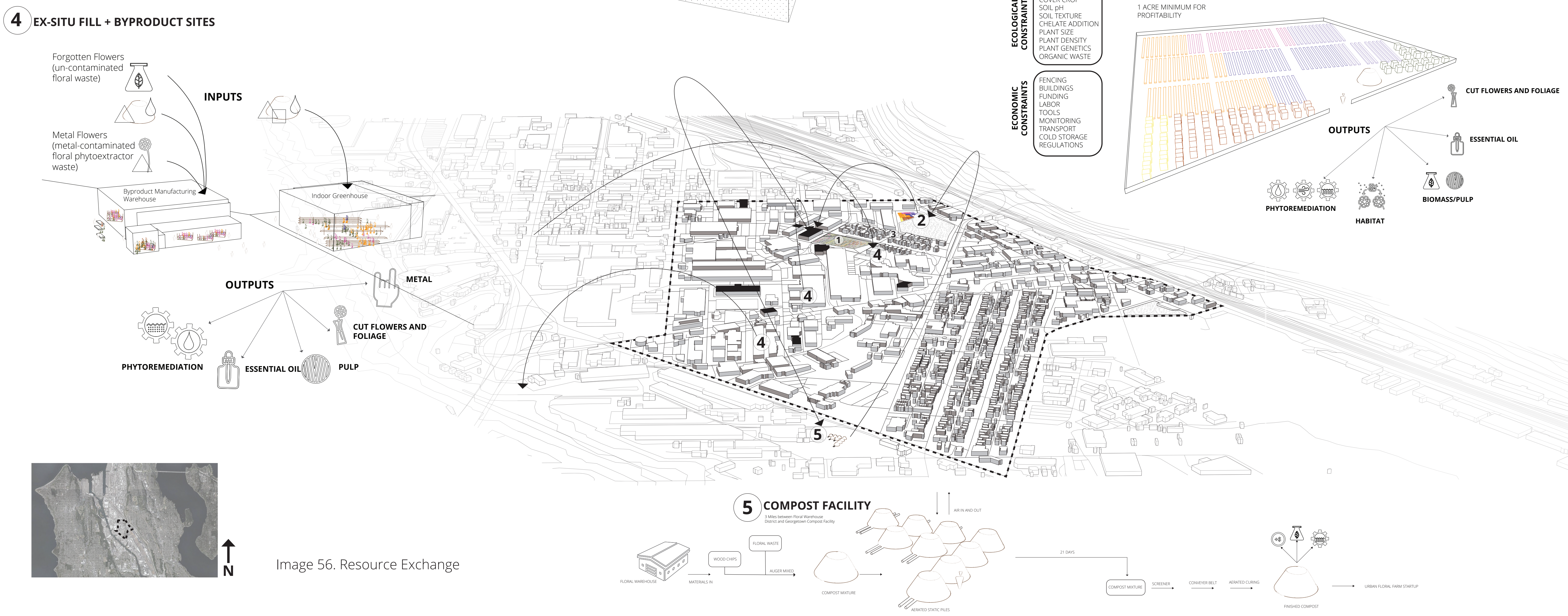


Image 56. Resource Exchange

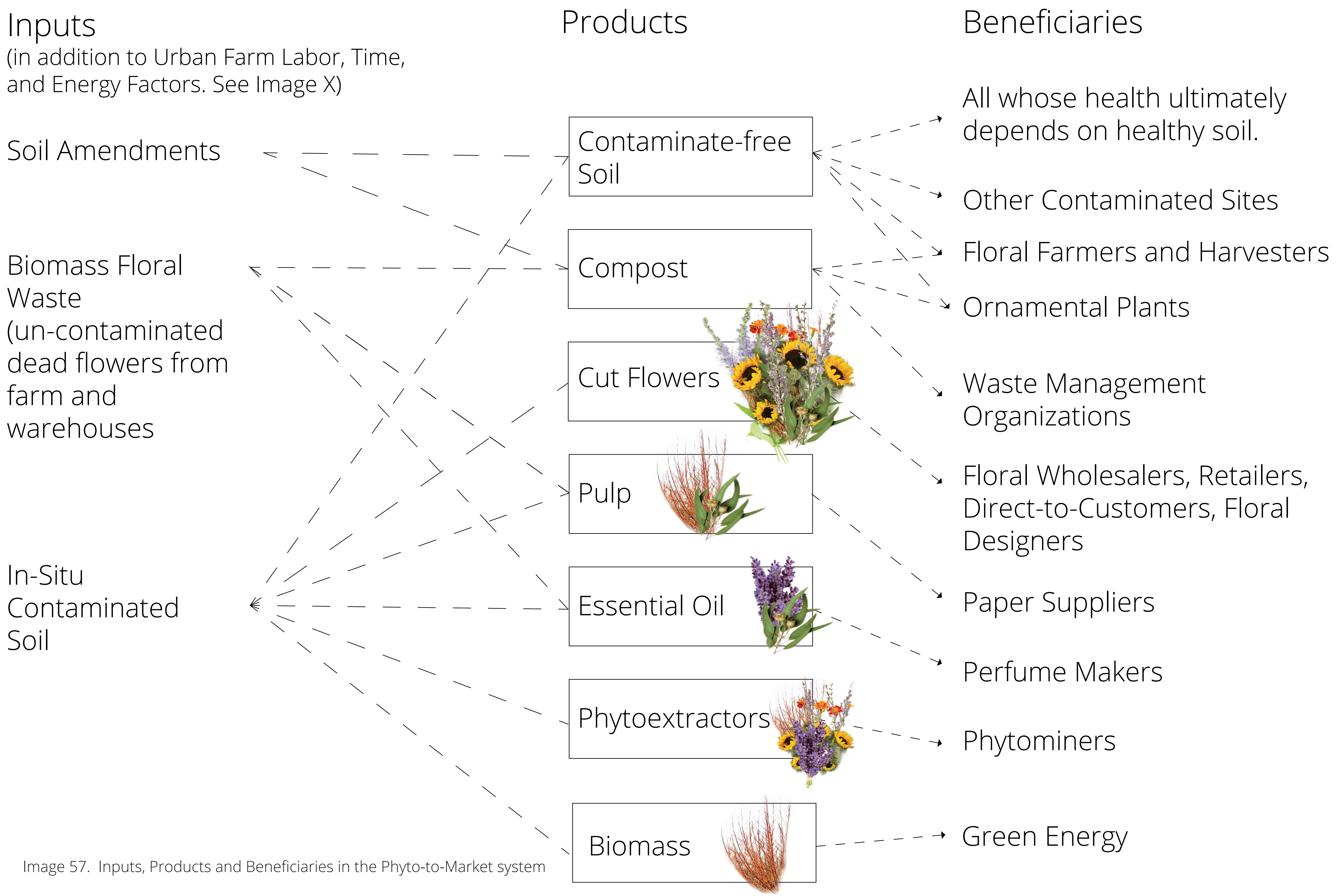


Image 57. Inputs, Products and Beneficiaries in the Phyto-to-Market system

In-Situ Contaminated Sites

In-Situ (on site) contamination may be an issue for urban farms and industrial neighborhoods. Georgetown has many source points of industrial contamination in soil and water, and there are two Model Toxics Control Act Sites (MTCA) in the immediate area around the proposed Flower District. The MTCA is legislation passed by the State of Washington in 1988 to identify, investigate, and clean up facilities where hazardous substances have been released (ECOSS 2016, p.51). The urban floral farm and phytoremediation demonstration garden are in areas with slight contamination. In addition to inputs needed to operate a small, one-acre floral farm (e.g. farm labor, irrigation, and seeds) inputs specific to this design proposal include contaminated soil, biomass waste from the farm and nearby warehouses, and soil amendments (compost, mycelium, lechates). These inputs produce many products available to sale or test as a proof of concept. These ecosystem gifts benefit many industries and connect people socially and economically across this urban ecological system (Image 57).

① *Phytoremediation Demonstration Garden Site Condition*

SITE

PNB Building/ King County Orcas Street Facility
701 South Orcas Street
3.1 Acres

This site is nestled between several wholesale and retail floral warehouses, two blocks of residential buildings, and a nearby park. The site has a history of repeated PAH contamination and cleanup and currently serves as a maintenance facility for county vehicles. Most recently, excavation sampling found lead and mercury above MTCA Method A cleanup levels. Groundwater has not been sampled to determine if the localized contamination has spread. In a recent community design meeting, Georgetown residents requested this block serve as a pedestrian corridor between the park, housing, and a major commercial district. In addition to in-situ phytoremediation, this proposal includes interpretive signage about phytoremediation, human and non-human habitat, and environmental data collection.

image X. Seating options with a view of habitat.

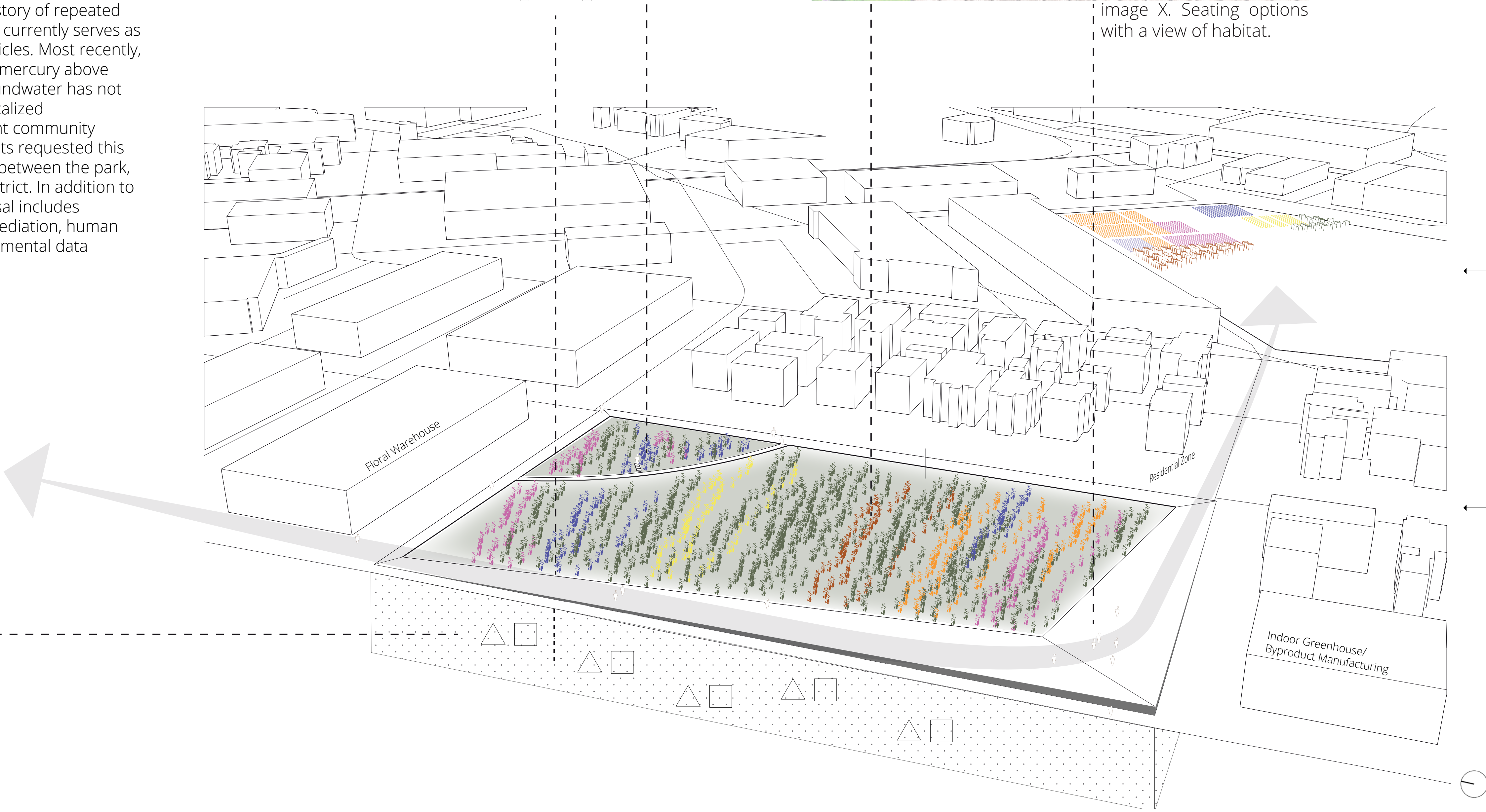


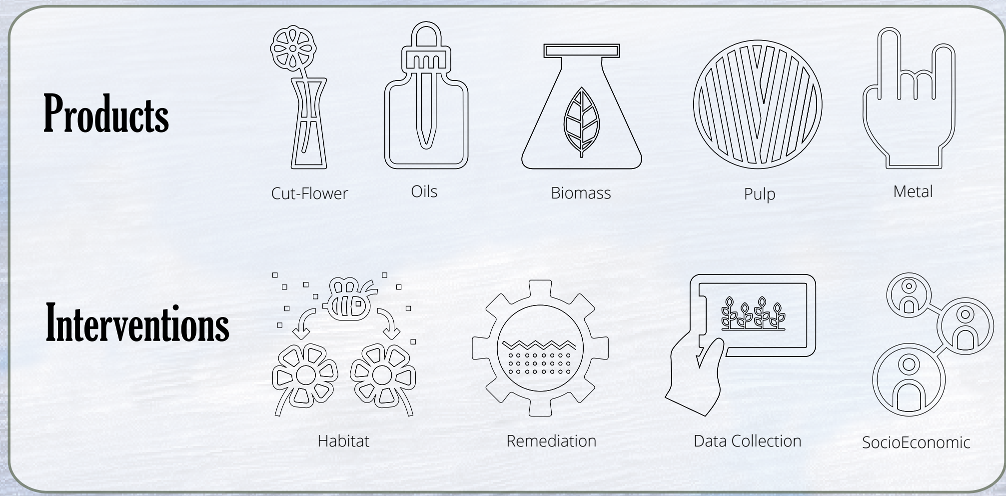
Image 58. Phytoremediation Demonstration Garden Site Condition

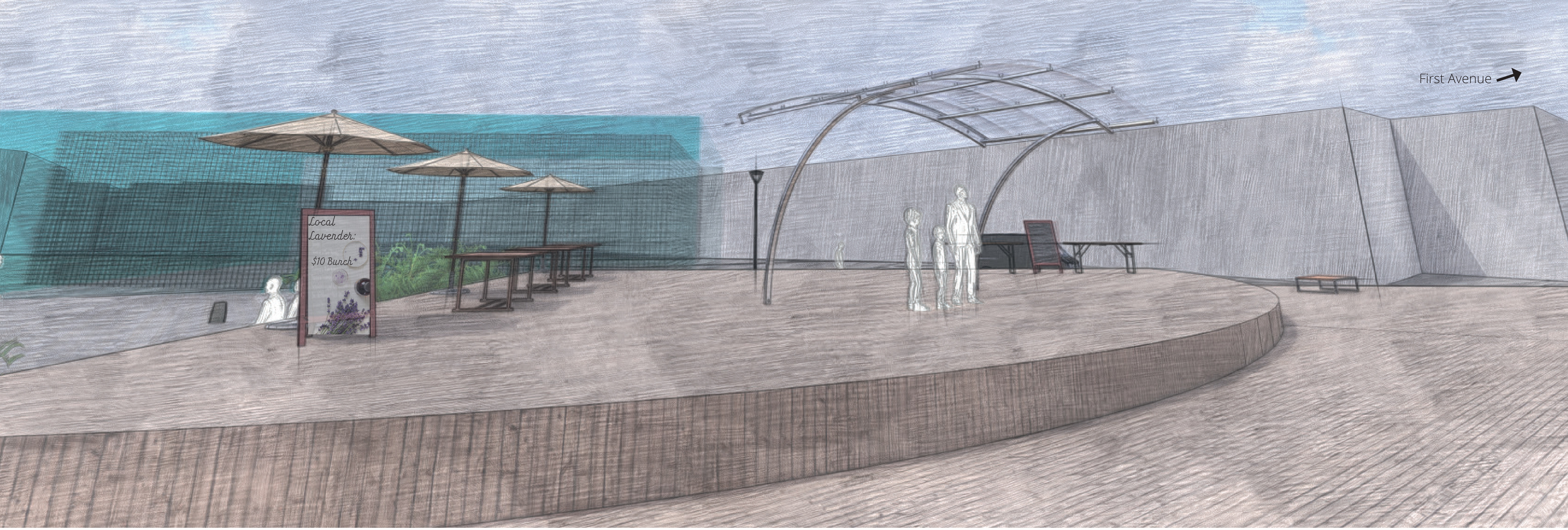
Ecosystem Gifts

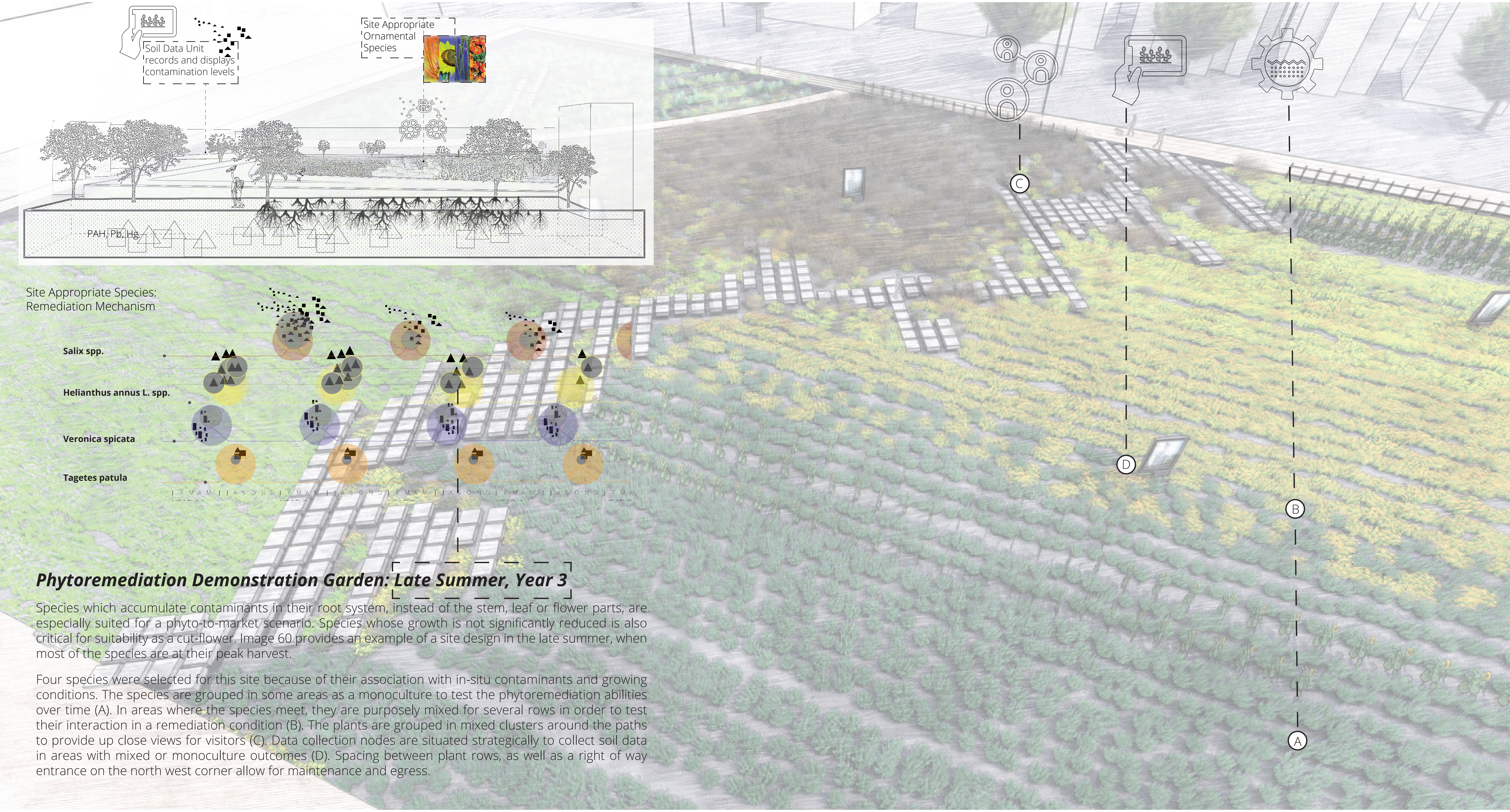
Images 59-63 provide examples of programming in areas of the Phytoremediation Demonstration Garden that provide landscape gifts to a variety of beneficiaries.

Stakeholders who participated in a Georgetown community charrette requested several improvements in the immediate blocks surrounding the floral warehouses. These include safe pedestrian and bicycle crossings, street plantings and habitat, pedestrian conversion of the defunct rail spur running through the block adjacent to the floral warehouse, and a primary walking/bike route connecting Georgetown Playfield with 1st avenue (Seattle Parks Foundation, 2017).

Image 59. Seating, gathering space, and circulation is provided on the south west corner of the site. A flexible space provides opportunities for an outdoor market, community events, and environmental education activities.





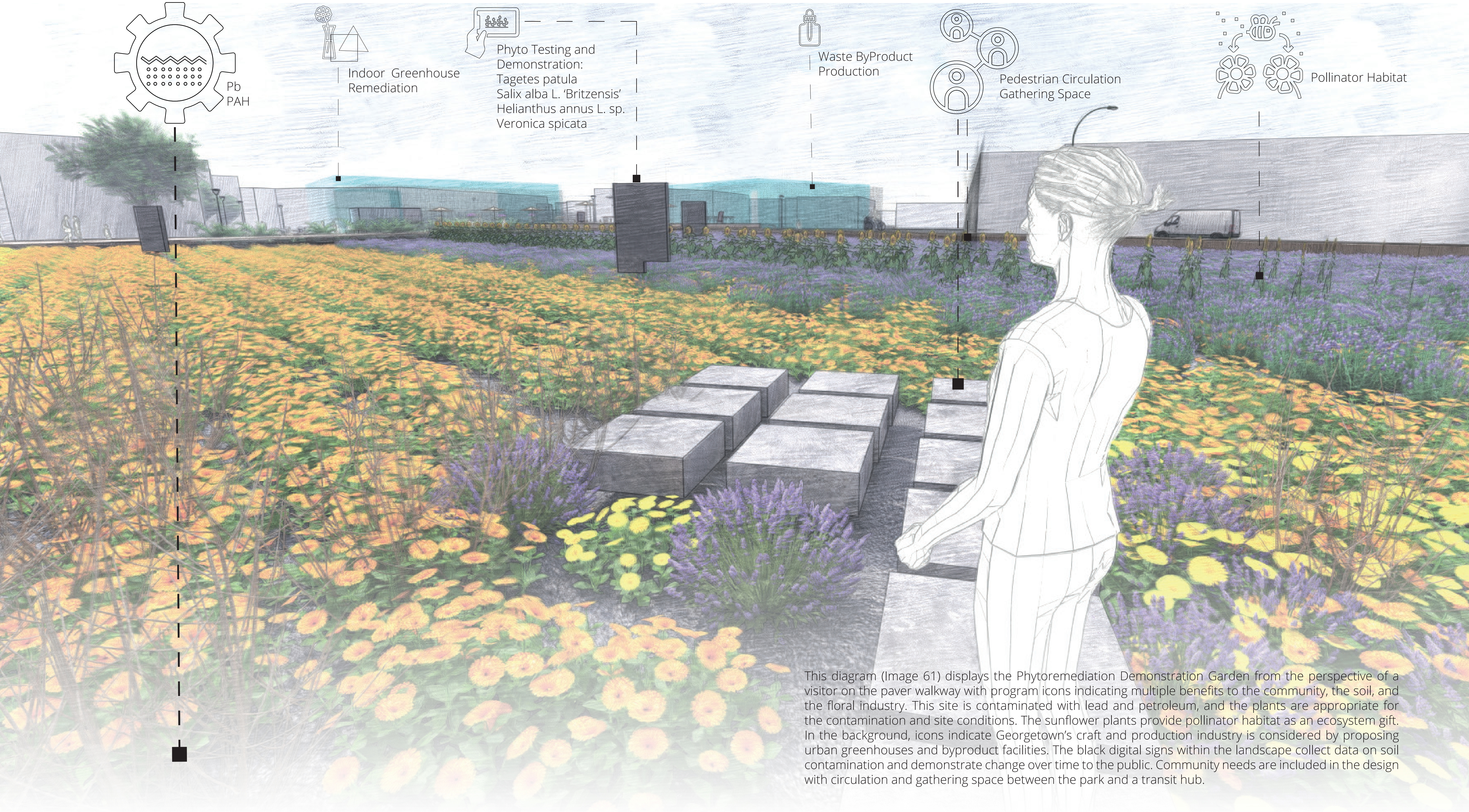


Phytoremediation Demonstration Garden: Late Summer, Year 3

Species which accumulate contaminants in their root system, instead of the stem, leaf or flower parts, are especially suited for a phyto-to-market scenario. Species whose growth is not significantly reduced is also critical for suitability as a cut-flower. Image 60 provides an example of a site design in the late summer, when most of the species are at their peak harvest.

Four species were selected for this site because of their association with in-situ contaminants and growing conditions. The species are grouped in some areas as a monoculture to test the phytoremediation abilities over time (A). In areas where the species meet, they are purposely mixed for several rows in order to test their interaction in a remediation condition (B). The plants are grouped in mixed clusters around the paths to provide up close views for visitors (C). Data collection nodes are situated strategically to collect soil data in areas with mixed or monoculture outcomes (D). Spacing between plant rows, as well as a right of way entrance on the north west corner allow for maintenance and egress.

Image 60. Elevated pavers and test species extend across the demonstration garden.



This diagram (Image 61) displays the Phytoremediation Demonstration Garden from the perspective of a visitor on the paver walkway with program icons indicating multiple benefits to the community, the soil, and the floral industry. This site is contaminated with lead and petroleum, and the plants are appropriate for the contamination and site conditions. The sunflower plants provide pollinator habitat as an ecosystem gift. In the background, icons indicate Georgetown's craft and production industry is considered by proposing urban greenhouses and byproduct facilities. The black digital signs within the landscape collect data on soil contamination and demonstrate change over time to the public. Community needs are included in the design with circulation and gathering space between the park and a transit hub.

D Phytoremediation Demonstration Garden: Phyto-to-Market Testing

Data collection nodes are situated strategically to collect soil data in areas with mixed or monoculture outcomes (Image 62). Ongoing data collection documents the remediation process for the general public and floral industry stakeholders. Progress and benefits are displayed on digital signage and is periodically updated.

Image 62. Phyto-to-Market Testing

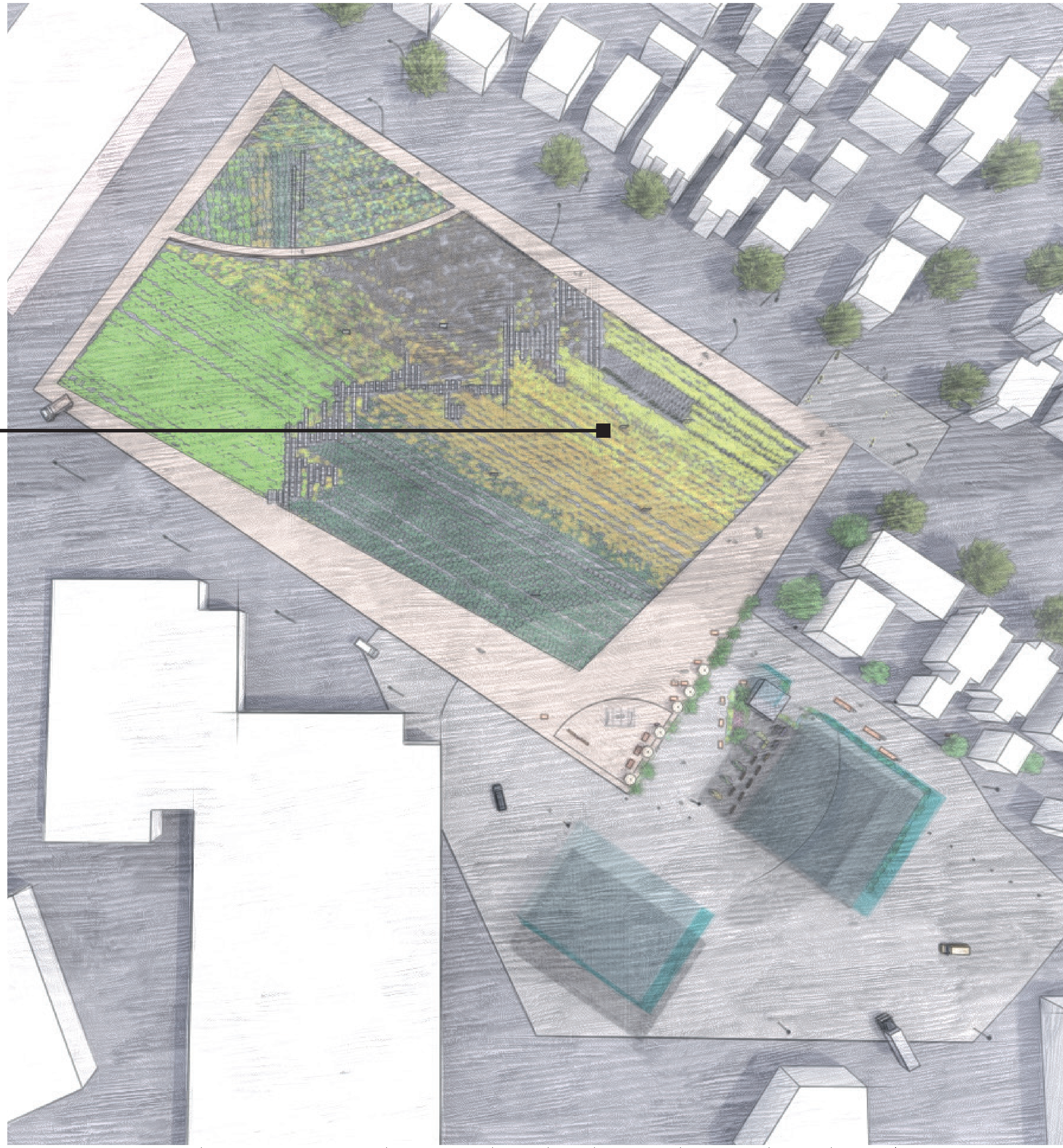


Image 63. The Demonstration Garden is situated near the Indoor Greenhouses and Byproduct Facilities.

Phytoremediation Demonstration Garden: Raised Pathways

This Phytoremediation Demonstration Garden provides a pedestrian connection between the nearby park (Georgetown Playfield) and a transit corridor on 1st Avenue. Circulation occurs around the perimeter of the site and through the site on two types of pathways. An elevated wooden boardwalk and stone pavers provide circulation through the site, with ADA accessibility provided on the wooden boardwalk only.

In a study on social acceptability of phytoremediation in a former industrial-site-turned-park, the findings suggest that messages intended to encourage the use and acceptability of phytoremediation should focus on the environmental benefits (Weir and Doty 2016). Perception of risk (such as the likelihood that the presence of PAHs could harm oneself or a child) was not a unique predictor of acceptability in that study, and visitors reacted positively to learning about phytoremediation. This design proposal considers perception and actual risk by proposing a raised walkway rising from the edges towards the center, egress barriers to discourage trampling, and interpretive signage. The elevated design discourages walking through the plantings and lightly contaminated soil and could be adjusted depending on site conditions.

Click to view a short video tour of the garden.

Image 64. Elevated pathways through the garden.

Image 65. Pedestrian pathway

Image 66. Pollinator species.

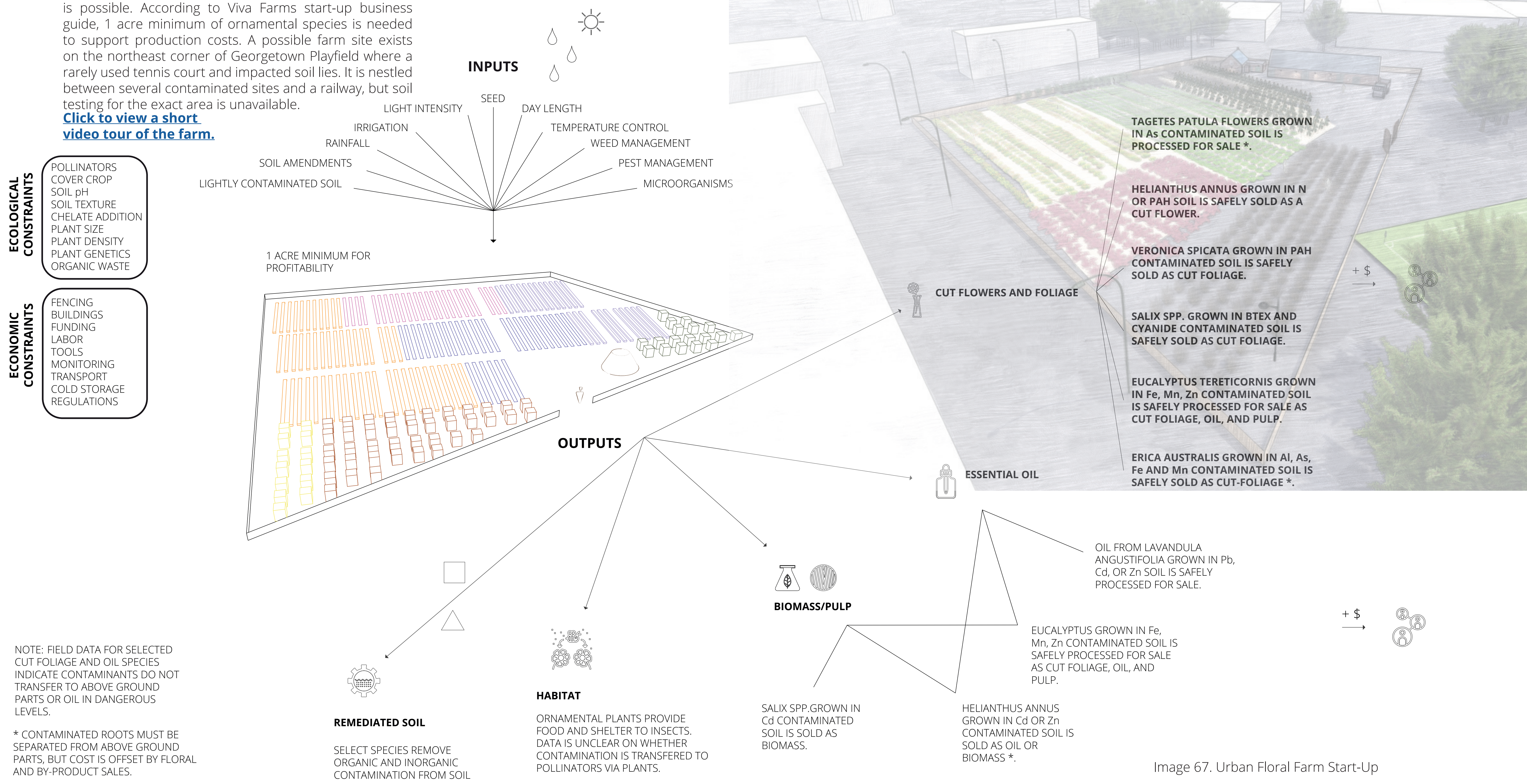
3 ***Pedestrian and Pollinator Pathways***

In 2017, Seattle Parks Foundation led stakeholders in a community charette to document their needs and desires for the future of Georgetown. Residents requested several improvements in the immediate blocks surrounding the floral warehouses in this thesis. Their requests include safe pedestrian and bicycle crossings, street plantings and habitat, pedestrian conversion of the defunct rail spur and a primary walking/bike route connecting Georgetown Playfield with 1st avenue (Seattle Parks Foundation, 2017). This design (Image 65) takes their requests into account by connecting the proposed urban farm (on the corner of the playfield) with the garden via a pedestrian corridor between residential buildings. The design includes raised beds with pollinator habitat plant species such as Lavandula (Image 66). The garden continues the pedestrian corridor westward to 1st avenue.

2 *Urban Floral Farm Start-Up*

Floral farmers consider multiple inputs and constraints when calculating profit margins and species growth. In addition, urban farms must consider contaminated soil, water or air. Producing cut-flowers and clean soil is possible. According to Viva Farms start-up business guide, 1 acre minimum of ornamental species is needed to support production costs. A possible farm site exists on the northeast corner of Georgetown Playfield where a rarely used tennis court and impacted soil lies. It is nestled between several contaminated sites and a railway, but soil testing for the exact area is unavailable.

Click to view a short video tour of the farm.



NOTE: FIELD DATA FOR SELECTED CUT FOLIAGE AND OIL SPECIES INDICATE CONTAMINANTS DO NOT TRANSFER TO ABOVE GROUND PARTS OR OIL IN DANGEROUS LEVELS.

* CONTAMINATED ROOTS MUST BE SEPARATED FROM ABOVE GROUND PARTS, BUT COST IS OFFSET BY FLORAL AND BY-PRODUCT SALES.

Image 67. Urban Floral Farm Start-Up

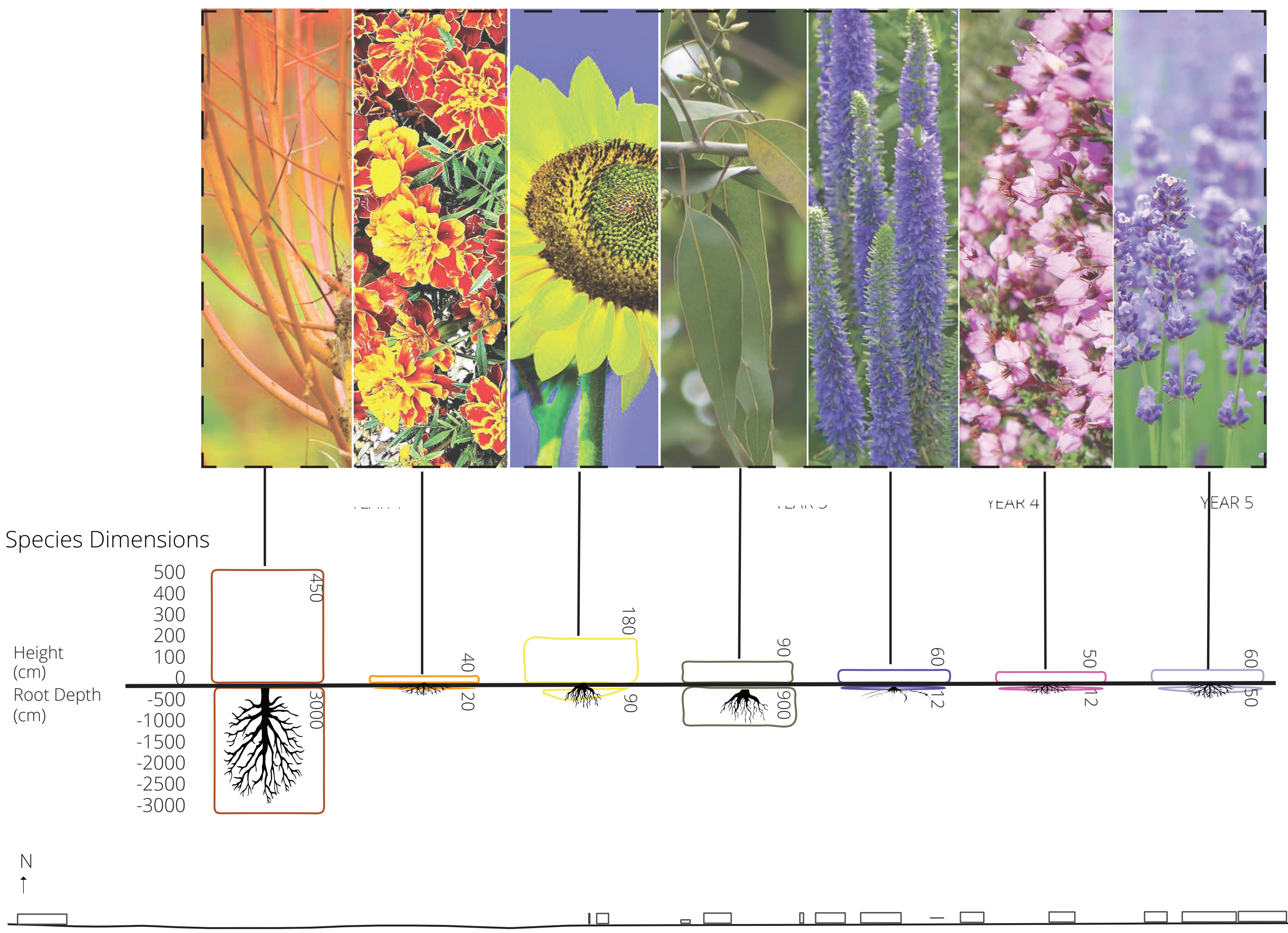
Urban Floral Farm: Example Species

Factors to consider in a potential phyto-to-market scenario include popular ornamental species according to a regional market, their associated contaminants, where the contaminate is stored in the plant body, and the adverse growth effects on the species. Contaminant uptake efficiency is improved with soil amending and microbial additions and must be included in any real-world scenario. Phytotechnology literature and farm manuals recommend amending the soil with fungi, manure, and plant growth-promoting bacteria to increase heavy-metal uptake. To maximize phytoextraction efficiency of plants, repeat harvests, harvest soon after the flower begins to appear, and apply N-P-K compounds or manure depending on site conditions.

Species which accumulate contaminants in their root system, instead of the stem, leaf or flower parts, are especially suited. Potential species for cut-flowers are those that store contaminants in the root system and whose growth is not significantly reduced. The root system must be deep enough to reach the contamination in the soil profile.

Organic contaminant remediation poses potentially less threat to human contact than heavy- metals. Floral products for the cut-flower industry would be produced in organic and/or soils without heavy-metal contamination.

The seven species provided here are an example of phytoremediating ornamentals with documented evidence of economic benefits and adequate root depth. Note that other species are possible, and this is an example.



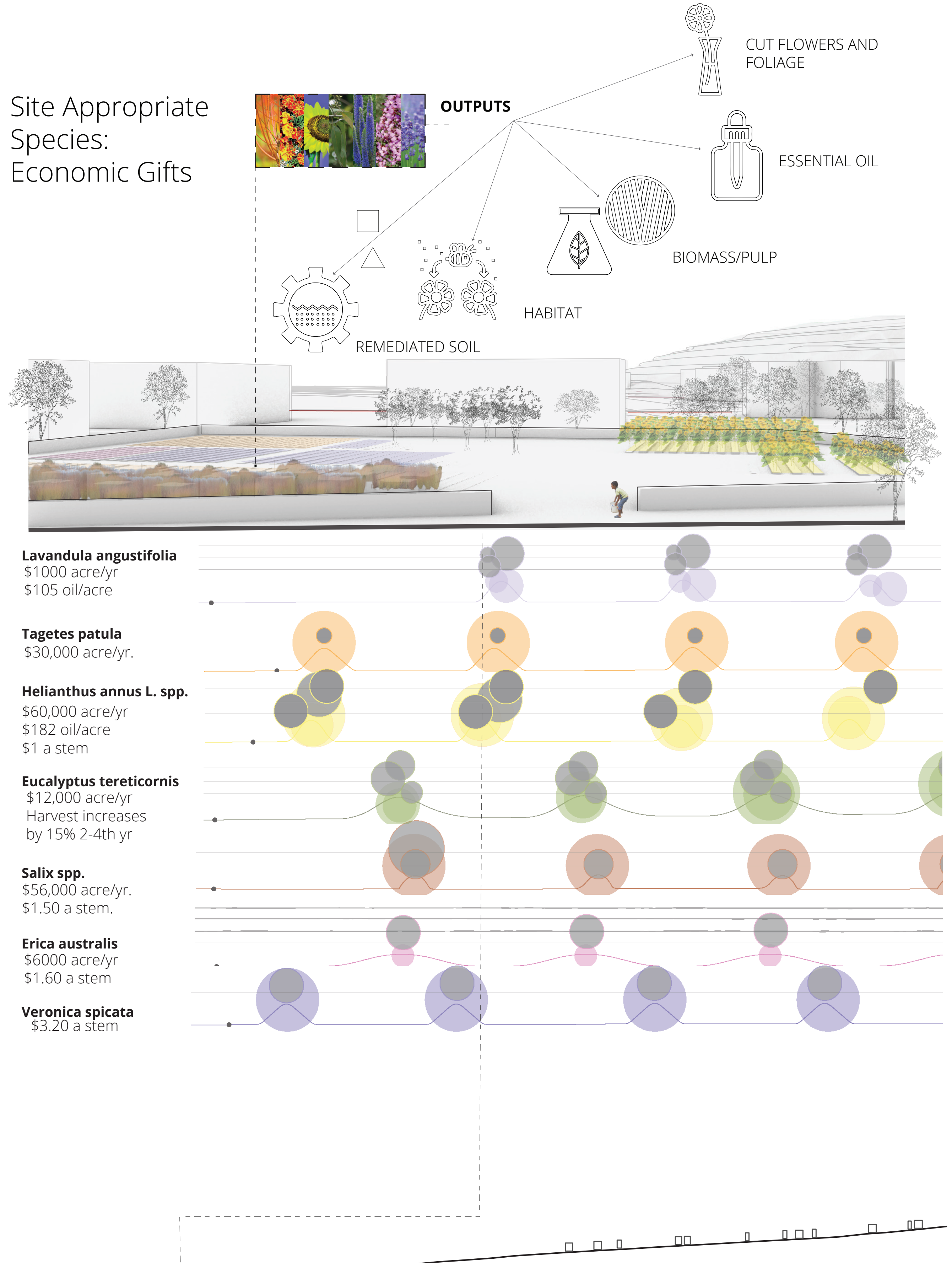
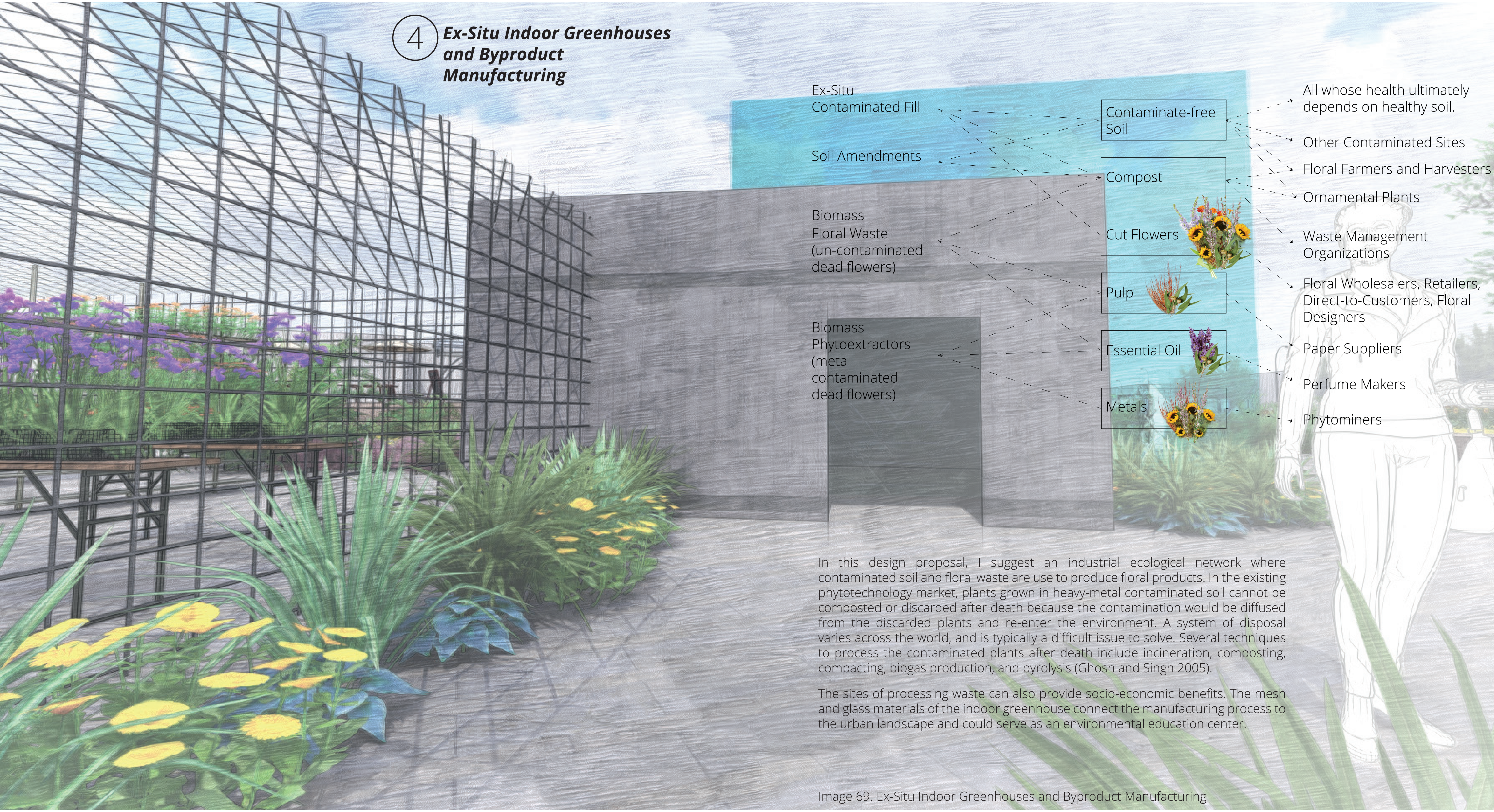


Image 68. Urban Floral Farm: Example Species

4 *Ex-Situ Indoor Greenhouses and Byproduct Manufacturing*



In this design proposal, I suggest an industrial ecological network where contaminated soil and floral waste are use to produce floral products. In the existing phytotechnology market, plants grown in heavy-metal contaminated soil cannot be composted or discarded after death because the contamination would be diffused from the discarded plants and re-enter the environment. A system of disposal varies across the world, and is typically a difficult issue to solve. Several techniques to process the contaminated plants after death include incineration, composting, compacting, biogas production, and pyrolysis (Ghosh and Singh 2005).

The sites of processing waste can also provide socio-economic benefits. The mesh and glass materials of the indoor greenhouse connect the manufacturing process to the urban landscape and could serve as an environmental education center.

Image 69. Ex-Situ Indoor Greenhouses and Byproduct Manufacturing

In this design proposal, I suggest a phyto-to-market system where heavy-metal contaminated soil is used to produce floral products for phytomining, essential oils, or biomass. These products would not re-introduce contamination into the landscape or human bodies. Manufacturing within the flower district could occur in adjacent buildings connected by a pedestrian plaza. Features such as bollards, lighting, seating, planters and brick surface textures create a safe and human scale area within the industrial zone.

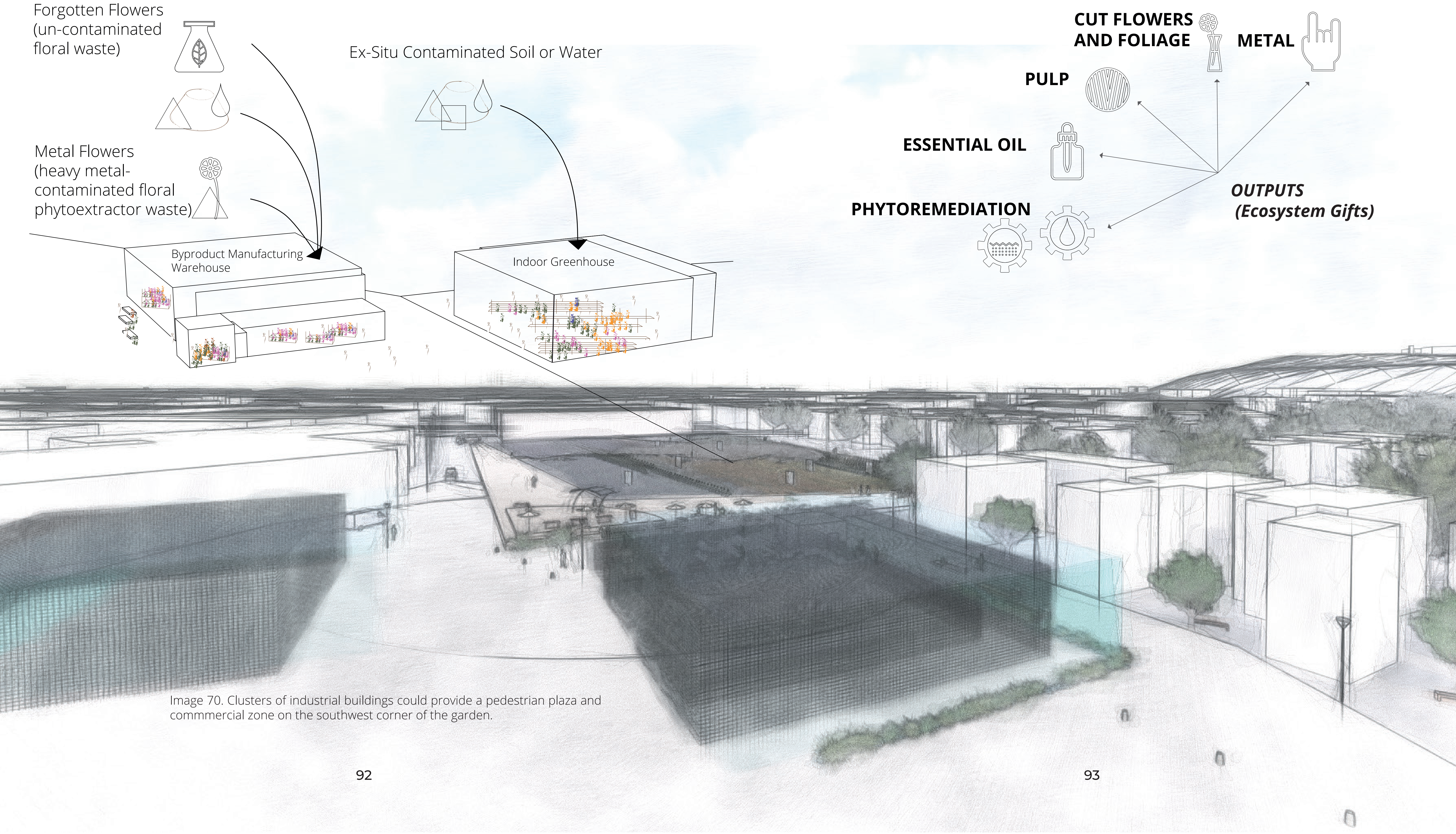


Image 70. Clusters of industrial buildings could provide a pedestrian plaza and commmercial zone on the southwest corner of the garden.

Indoor Greenhouse Remediation

Contaminated fill from off site is used as soil medium in tolerant ornamental species.

Waste ByProduct Production

Warehouse floral waste, urban farm floral waste, and ex-situ (off site) phytoextractors can be converted into pulp, metal aggregate, and essential oils. Light manufacturing such as essential oil production are best suited for this flower district.

Existing markets process waste into compost and byproducts. For example, plants contaminated with heavy-metals are heated or combusted to break down and aggregate metals for a variety of beneficiaries. This is called phytomining. Plant waste from ex-situ contaminated sites can be safely converted into pulps and fibers to create furniture, baskets, mats.

Contaminated soil can be transferred out of a contaminated site (as is a common practice) and “dumped” into an urban greenhouse for use as a soil medium. The greenhouse acts as a holding area for this soil. Contamination tolerant ornamental plants grown in contaminated soil could produce cut-flowers or essential oils (Pandey and Bauddh 2019). For heavy-metal contaminated soil, there is a strong post-remediation potential of ornamental plants for perfume production. Perfume obtained through distillation was found to be safe for human use and met criteria for essential oil certification (Nakbanpote et. al. 2016; Asgari Lajayer et. al. 2017a).

The artisan and manufacturing community in Georgetown would be an appropriate area for fiber and oil industries.

Image 71. Indoor Greenhouse

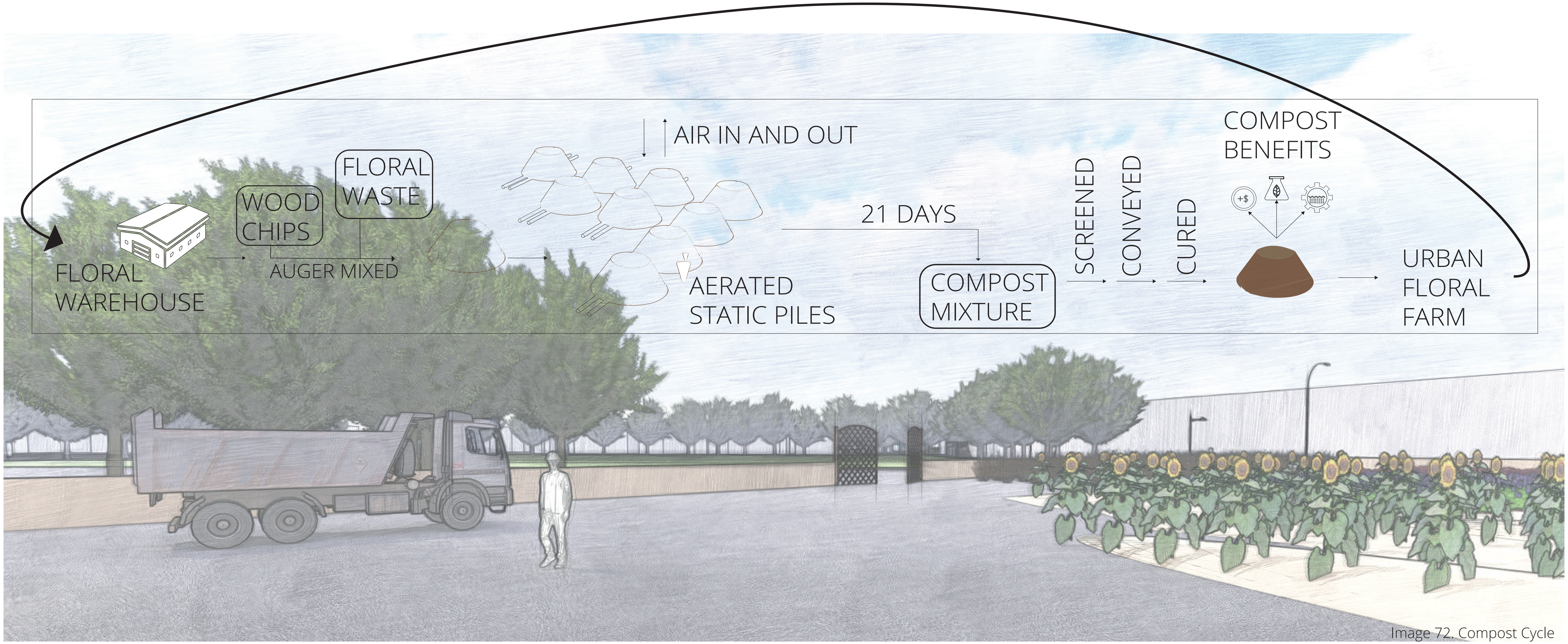


Image 72. Compost Cycle

5 *Compost Facility and the Floral Waste Cycle*

In existing floral industry and phytoremediation scenarios, floral and foliage waste are disposed of in a municipal compost or dump site, or a dump site for contaminated waste. In this proposal, a resource exchange occurs between the floral warehouses, compost facility, and the floral farm. Compost facilities already exist in Georgetown, but a formal exchange between these sites as a component of a flower district does not. Compost facilities also provide an example of cut and filll material creating temporary mounds and valleys through this urban industrial zone. It is a productive and mobile landscape that does not exist as a static landscape design.

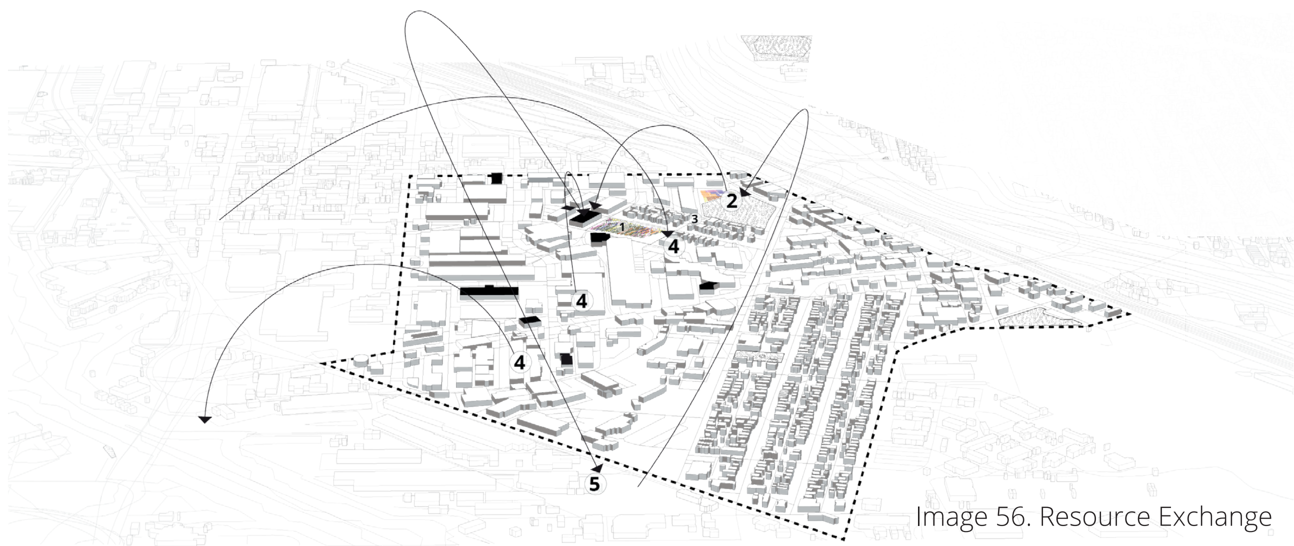


Image 56. Resource Exchange

Reflection

The floral industry is at once global and personal. The global market is continually shifting landscapes of production towards areas with favorable growing conditions, and those conditions are slowly beginning to include considerations for ethical environment and labor outcomes. The gift of the cut-flower provides positive emotions, and can represent a variety of cultural meanings. This thesis proposes a local network of production coupling phytotechnologies and the floral industry, ultimately contributing to a reduction in waste and providing new opportunities for gift exchange and the floral industry. The seven suitable floral species for a "phyto-to-market system" introduced here are a few possibilities, with a local market and site conditions ultimately determining appropriate flowers. If this market were implemented in Seattle it could be a testing bed for phytoremediation, provide a unique local relationship to bouquets, provide safer routes for pedestrians, and provide an opportunity for urban farmers to remediate their soil while making a profit (Image 58).

Designing in the wake of Covid-19

This design research process generated many ideas but I wonder what I would have developed if I had been in the physical studio with my peers during the final quarter at UW. Although many of us connected online, the value of being in a shared physical space where designers are passively seeing and hearing each other's designs is more valuable than I realized. Many of my peers in this 2020 UW cohort included designs similar to mine such as phytoremediation, stormwater management, and environmental education, and we all could have benefitted from more overlap and exchange.

If access to resources would have been more complete, examples of "ecosystem gifts" would have also included a postcard of my design for those who participated in the interviews, a "sculptural bouquet" incorporating found Georgetown industrial pieces, soil, and phytoremediating floral species, a 3d model of a floral bouquet, made out of a strata of materials representative of phytomining products. Additionally, a florist design challenge using phytoremediating plants and displayed in a gallery was originally considered for a final thesis exhibition. Many possibilities exist to extend my thesis into the future.

Floriculture response to Covid-19

The floral industry itself responded to Covid-19 in several ways. The local floral industry and the global supply chain both faced challenges in meeting customer needs and processing waste due to change in demand. Because this thesis project proposes a system that supports the local supply chain, it is more relevant than ever to a global supply chain that is increasingly unstable and wasteful. A regional network resilient in the loss of global infrastructure must be considered, not just for the floral industry but agricultural food systems as well. In one example of rapid change, many florists throughout the U.S. turned what would otherwise be unsold floral waste into bouquets for front line workers, and here in Seattle the floral farmers at Pike Place, who are typically competitors, banned together to sell flowers online.

Feasibility and Relevance to the Local System

How might my results be useful to practitioners? In the floriculture history section (p.25) we learned that prior to the 20th century, a florist referred to someone who grew and sold flowers (not just a seller) and that it was common for the public to buy flowers directly from the grower. Floral shops prior to the past 100 years bought flowers from private residences with robust gardens. These "private houses" existed alongside "commercial houses" operating as traditional businesses. In the Context chapter, we see that the west coast of the U.S. has a robust network of floral farmers, people operating just like those prior to the 20th century. And in Georgetown, the small residential community takes pride in their private gardens by hosting a yearly garden tour. As we move nearly a quarter into the 21st century, the role of regional systems may begin to reemerge. Although global networks have their place, I am interested in how local people can begin to address on the ground contamination and demand healthier places for their community of humans and non-humans. I do recognize that the feasibility of a floral farmer becoming a phytoremediation provider is slim. But, the likelihood that urban agriculture will become increasingly needed, and increasingly faced with polluted soils, is very high. I hope that this project provides an example of how one might create a resilient landscape that is both functional and beautiful.

Remaining Questions

Common themes in this project are the production of social, economic, and environmental benefits. The Bouquet of Benefits couples cutting edge phytotechnology with the thousand-year-old human obsession with flowers. The intention in this design was to be flexible enough that it is applied to many urban industrial zones, but ultimately resulting in less emphasis on form. It provides an opportunity for people to love a place and the products that are generated there. Because form was emphasized less, embracing analysis could have been pushed further. I would have liked to use a tool from the Landscape Performance Series, such as the EPA's Waste Reduction Model to actually calculate and communicate how my design would reduce waste more specifically. Image 57 provides a phased plan view of how phytoremediating plants could be incorporated into building edges and right-of-ways to create a buffer zone preventing pollution from increasing or seeping into adjacent waterbodies. A more robust design using the Waste Reduction Model could strengthen this diagram. This image is included in the reflection section because it was not fully developed or included in the design phase.

Areas of design that could be improved are the environmental education component. Although many areas are proposed for gathering space, a narrative of what a daily experience in this eco industrial zone is lacking. The urban floral farm and the location of the garden were implicitly chosen as a way to emphasize the worker. Georgetown is an industrial center, and most people who would walk through these proposed spaces would be farmers, laborers, warehouse owners, and manufacturers. Connecting the space to the laborer could have been emphasized more thoroughly.

Lastly, the Framework chapter included discussion of the gift paradigm, environmental conservation motivations, and landscapes of production. The phyto-to-market analysis considered economic and cultural desire in determining whether a flower could be profitable. If I had interviewed stakeholders at farmers markets and in Georgetown, I think a more holistic sense of the social and cultural aspects of gifts (such as positive emotional response and gift exchange) could have been included in an analysis and design.

I invite you to visualize my project in this linked two-minute video walk through.

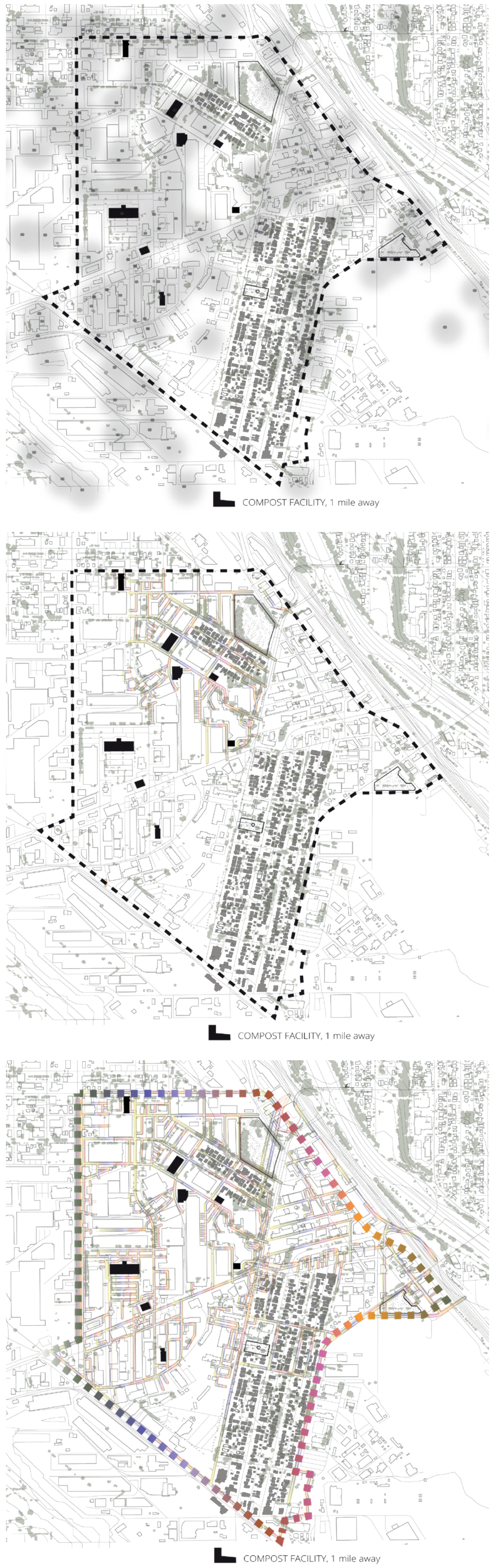
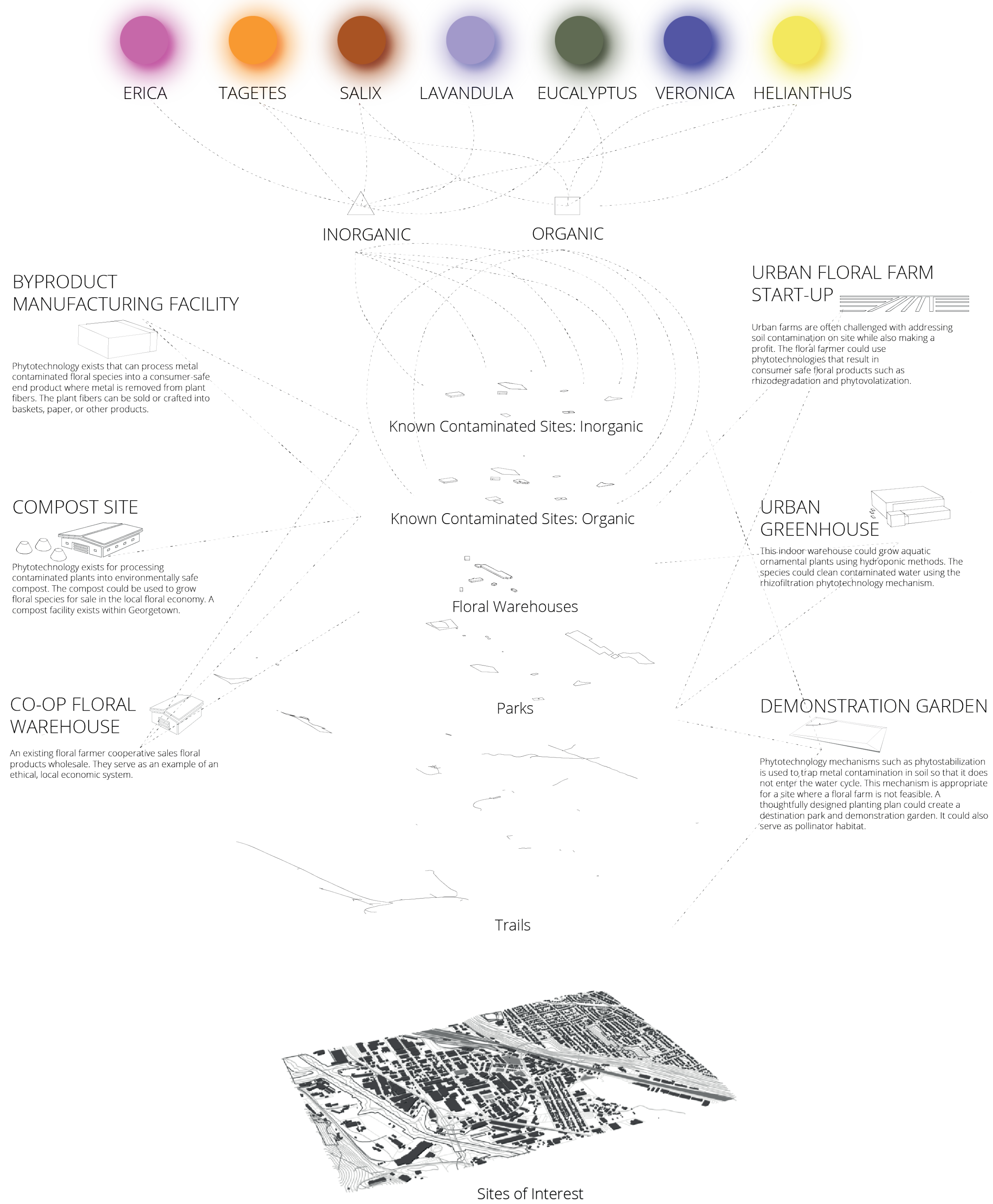


Image 73. Phases of phytoremediating plantings along building edges and right-of-ways extend the Flower District from the core towards the edges of Georgetown. This could create a colorful and productive buffer preventing ongoing accumulation of contamination into the soil and adjacent waterbodies.

Image 74. Project Overview Diagram



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Appendix

A. Plant Cards: Images 46-52 at enlarged scale; originals are 8.5" x 11".

B. Icon Legend

NEEDS/WEAKNESS

LOW WATER ***FREQUENT WATER*** ***VASE LIFE*** ***TIME TO REMEDIATE***

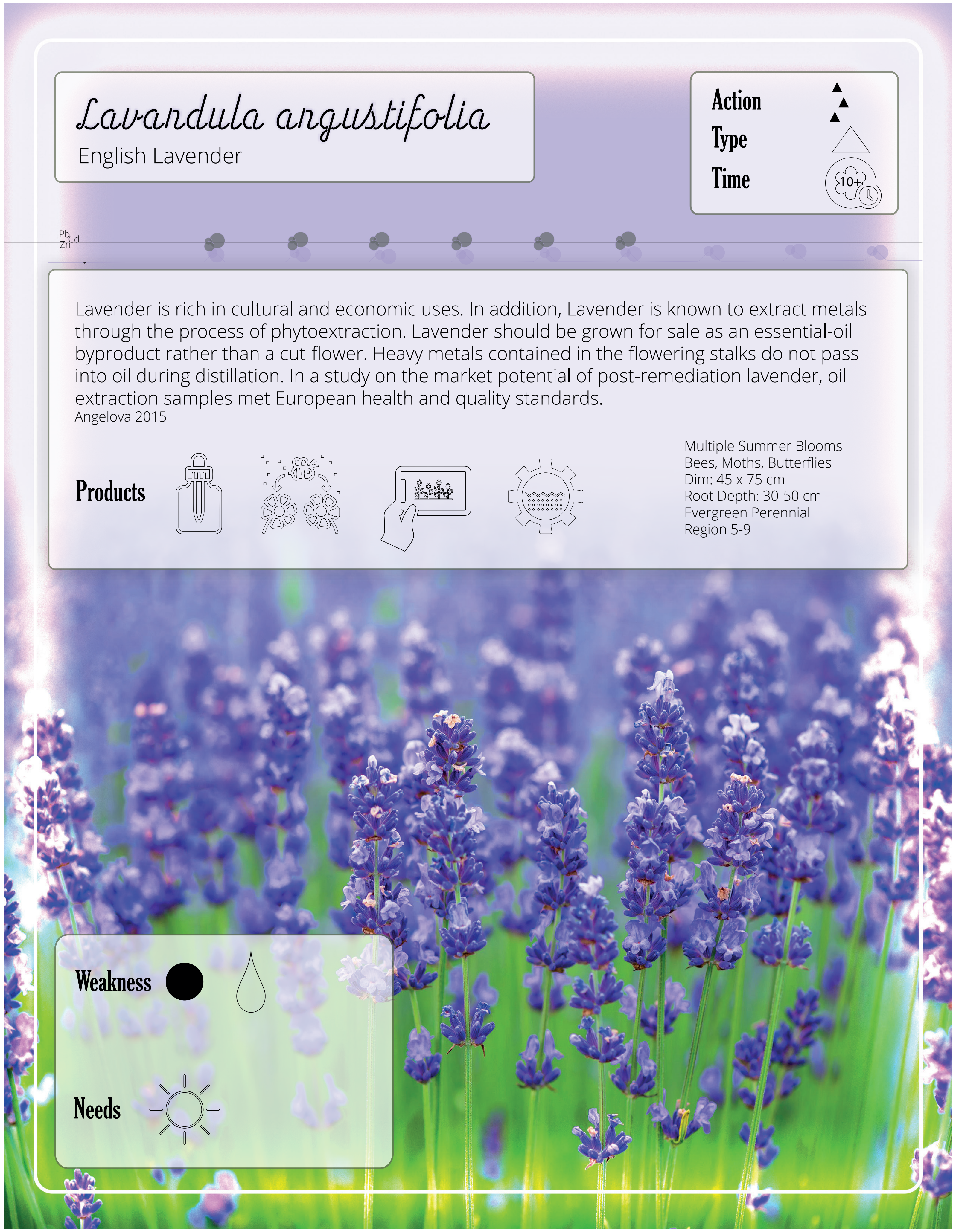
FULL SUN ***PART SHADE*** ***FULL SHADE*** ***OUTSIDE OF ZONE 8/9***

OPEN FIELD ***GREENHOUSE*** ***INDOOR/OUTDOOR*** ***HIGH LABOR COST***

BENEFITS/PRODUCTS

HABITAT ***ECOTOURISM*** ***METAL*** ***ESSENTIAL OIL*** ***CUT-FLOWER***

SOCIAL ***REMEDIATION*** ***PULP*** ***BIOMASS***



Eucalyptus tereticornis

Forest Red Gum

Action

Type

Time

3-8

Mn Zn Fe

Eucalyptus can be grown in compact form on a floral farm, with branches pruned for cut-foliage material in floral arrangements. It also has multiple by-product uses such as furniture and essential oil. Findings indicate remediation is less than 8 years for most soil and water contaminants.

Products

Harvest Increases After Yr3
Dim: 1 x 1 m
Root Depth: 2- 18 m
Evergreen Woody Perennial
Region: 7-9

Weakness

*Frost

Needs

Tagetes patula

French Marigold

Action

Type

Time

10

As

The striking French marigold is most commonly used in cultural and religious ceremonies in South-East Asia. It is more commonly grown as a garden ornamental in the United States. Thailand datasets indicate growers could generate $300,000 acre/year from cut-flower marigolds. Time to remediate may reach almost 60 years in typical arsenic contaminated soil, but substantial profit could make a long term goal achievable.

Products

Quick and Frequent Harvest
Blooms July-Sept
Dim: 20 x 15 cm
Root Depth: 20 cm
Perennial in PNW Coast
All Regions

Weakness

Needs

Veronica spicata

Spike Speedwell

Action

Type

Time 6+

PAH

Spike Speedwell is a profitable cut-flower product and can remove petroleum contamination from the soil in 6-10 years. It is used an accent in a floral arrangement; popping out and towards the sky.

Products

Blooms April to August
Bees, Butterflies
Dim: 60 x 60 cm
Root Depth: 12 cm
Perennial
Region 1-9, 14-21
Vase Life: 6-10 days

Weakness

Needs

Erica australis

Southern Heath

Action

Type

Time 10+

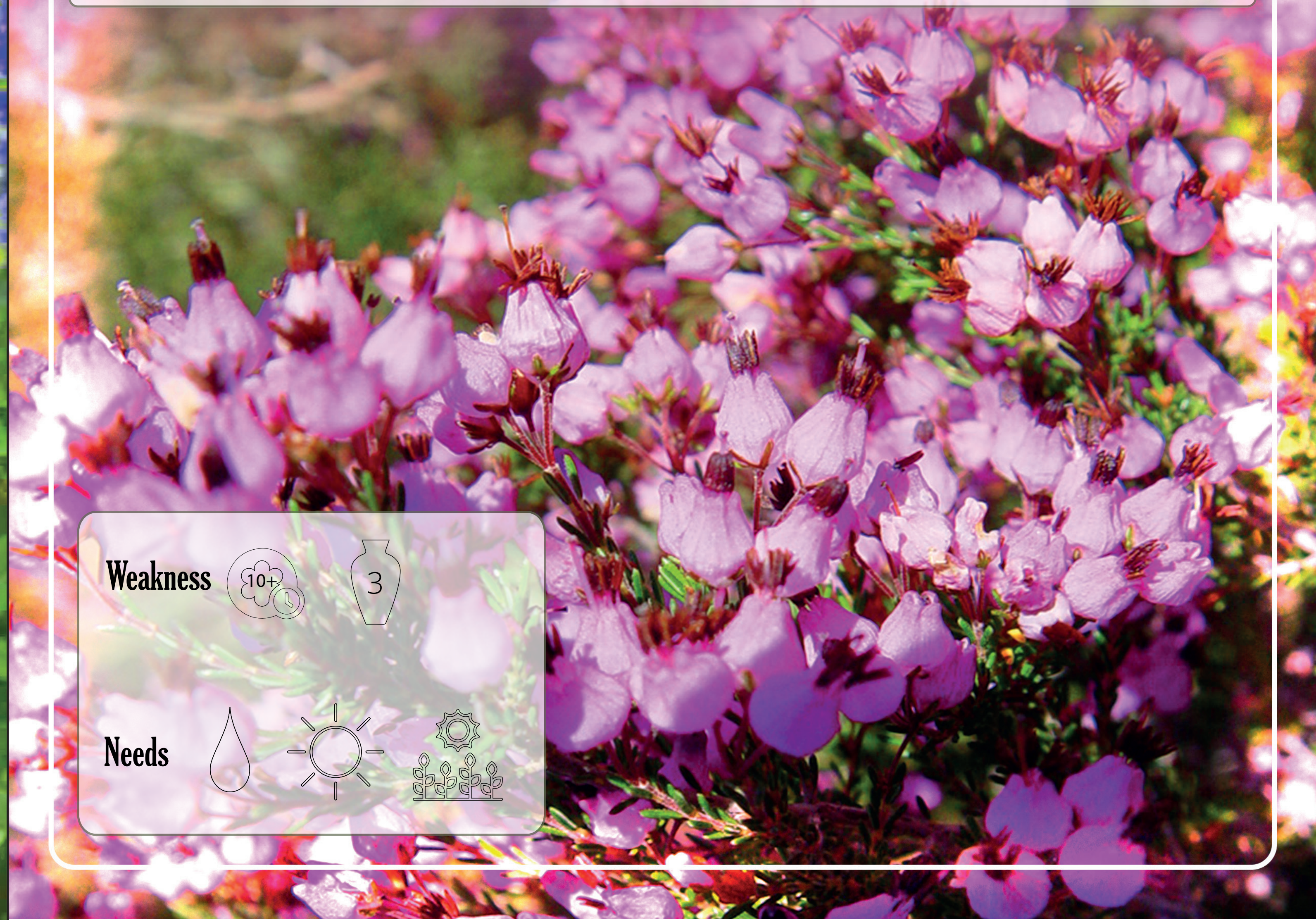
As Fe Mn Al

This flowering shrub, also known simply as Heath, is used in flower bouquets to add fullness. It can be formed into shapes or used as an accent. It is a potentially consumer safe phytoextractor for Mn and a phytostabilizer for acids, Al, As, and Fe. It is a good choice for highly acidic soils. Although phytoremediation data exists for limited species, findings suggest many Erica species may extract or stabilize soil contamination.

Pérez-López et al. 2014

Products

Blooms April-June
Bees
Dim: 2 x 1'm
Root Depth: 12 cm
Perennial
Region 5-9, 14-24



Weakness 10+ 3

Needs

Salix alba L. 'Britzensis'

Coralbark Willow

Action

Type

Time

BTEX Cd

This shrubby, woody plant has striking four-season color. It can be used similarly to dogwood and other willow types in floral arrangements as a flexible filler and structural material. It also removes soil and water contamination through all known accumulation processes. It has a short (3-5) year remediation period and extremely deep roots capable of reaching deep contamination. It's vast range of accumulation processes requires thorough data analysis on specific site conditions to avoid repeat contamination. It can generate $56,000 acre/year as a cut-foliage product, and more as a fiber product. Kuzovkina and Quigley 2005; ProfitablePlants.com

Products

Winter Harvest
Dim: 4.5 x 3 m
Root Depth: 30m !
Woody
Region: 2-8

Weakness

Needs

Helianthus annus L. sp.

Sunflower

Action

Type

Time

Cd Zn PAH

This iconic species is in the top five domestic cut-flower products and USDA (2019) crop datasets. It has a long vase life and is also a lucrative essential oil product. It is known to phytostabilize, phytometabolize, and phytoextract inorganic and organic contamination. Soil amendments increase field scale remediation. A phyto-to-market system would need to ensure the use of seeds from previous phytoremediating subspecies. (Loyola et al 2019; Nakbanpote et al. 2016; Lajayer et al. 2019)

Products

Blooms July to August
Multiple Pollinators
Dim: 180 x 60 cm
Root Depth: 90 cm
Annual, Perennial
Region 2-11
Vase Life: 7-10 days

Weakness

Needs

Thank you to Catherine De Almeida, Ken Yocom, and all of the UW LArch department for their support during a difficult time.

Dedicated to Peaches