Liberating Rivers

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Abstract

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Holistic approaches suggest that a resilient way to manage rivers is by giving them enough room to fulfill their hydrogeomorphological processes. In the Pacific Northwest, a major barrier to the implementation of holistic river management is the agricultural use of floodplains, which is still largely reliant on bank stabilization and channelization to control flooding and erosion. To reconcile these two seemingly opposing demands, it will be necessary to change agricultural methods so that they become compatible with functioning river ecologies. However, these methods will require more testing to determine their economic viability before they can be implemented at a regional scale. This thesis explores using Peri-urban areas, such as the Sammamish River Valley in Washington State, as test sites for agricultural methods compatible with functioning floodplains. The objective of this study is to demonstrate that the ecological demands of floodplains can be compatible with an agriculturally productive landscape.

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The Salmon People

Raven traveled by canoe from the River to the Salmon People's village in the Pacific Ocean. The chief invited Raven for dinner, but warned him not to eat any of the bones of the salmon. Raven was mischievous and hid a bone in his mouth. After dinner, when the chief threw the bones into the river, they turned into salmon, but the people knew something was wrong. Raven reluctantly returned the missing bone and the fish transformed into the chief's daughter. Raven grabbed the girl, brought her aboard his canoe and returned to the Bentick Arm. There he made her promise to return each year with salmon and released her. Ever since, sockeye come to the River and the Salish return their salmon bones to the water.

(Kirk, 1986)

CRITICAL STANCE

The story of the Salmon People is common amongst different indigenous communities across the Pacific Northwest that rely on salmon as their staple food source. It showcases the deeply intertwined relationship these communities fostered between environment, culture, and sustenance. This worldview contrasts the Euro-American perspective which has attempted to dominate natural systems as a strategy to promote health and well-being.

Euro-American patterns of development throughout the last century have enormously affected the ecological health of the planet. While used for millennia, the proliferation of dams to control water flow across the landscape and to facilitate agriculture have altered the hydrological regimes of most rivers. The resulting agricultural practices have industrialized and commodified food production, the development of human settlement has fragmented habitat, resource extraction has polluted entire watersheds, and carbon emissions have altered the chemistry of the atmosphere. These human-caused impacts have both catalyzed large-scale patterns of change in climate and removed the habitat complexity and connectivity that allow species to adapt to these changes. We now face an era of unprecedented mass extinction where humans risk compromising the ecological integrity of the planet - an era recently defined as the Anthropocene, the age of man.

The contemporary industrial food system is exemplary of this harmful relationship that people have developed towards ecology. The system is based on a small variety of specialized crops such as corn and soy, which are mainly products of monocultures that are heavily reliant on artificial fertilizers and pesticides. Despite achieving a high economic and caloric efficiency, these methods of agriculture are damaging to the ecological systems upon which they depend. It is widely recognized that while these methods currently provide large quantities of food, they compromise the sustainability of the

< Figure 1.1

Indigenous drawings of the salmon people made up the fish's body, illustrating the importance of the relationship between the two species.

environment as well as the health of people. Industrial farming practices degrade soil quality over time, becoming increasingly reliant on artificial fertilizers, which runoff into waterways causing eutrophication and other issues (Horrigan Leo et al., 2002). Monocultures also decrease habitat complexity and biodiversity of farmland, requiring the increased use of pesticides that are responsible for the collapse of bee and other pollinator populations (Goulson, 2015). The contemporary industrial food system has also resulted in the mechanization of agricultural tools that make crops increasingly energy intensive, and this leads to increased carbon emissions that significantly contribute to climate change (McMichael, 2007). To meet the needs of industrial agriculture, water is dammed, channeled, and redistributed, starving ecosystems of the dynamic processes that encourage their complexity and support their biodiversity (Power, 2010). These are some of the most prevalent environmental issues caused by industrial agriculture, but the consequences also extend to the cultural understanding of food and affect the human relationship with natural ecosystems.

With the rise of capitalism and globalization, the Western worldview of “nature” has become increasingly prevalent across the globe. This attitude promotes the view that humans are separate from the ecological systems they inhabit. Any problem that arises from this way of interacting with the Earth can be solved through innovations that aim to control natural processes to better serve people. This perspective has created cultural practices that ultimately cause as much harm to society as they do to the environment. A primary example is how the industrialization of the food system has managed to convert food into a commodity, a phenomenon especially prevalent in contemporary America. Upon interviewing elementary and middle school students in California, researchers found that more than half were unaware of the origin of the food they consumed. For example, 40% didn’t know hamburgers came from cows, 30% didn’t know cheese is made from milk, and more than half of them were not aware that pickles came from cucumbers (Hess & Trexler, 2011).

This is evidence that the United States suffers from a spatial and cultural barrier between production in rural areas and consumption in urban areas, which creates a disconnect between people and their understanding of food. The result is that contemporary food culture in the United States is based primarily on the short-term economic efficiency of crop production, not on the ecological systems on which it depends. Food is the most direct way through which a species can participate in an ecosystem: you either eat food or are food.

The Salish story of the salmon is a cultural mechanism developed to help understand the importance of ecological processes to the well-being of the community, and to perpetuate this understanding across generations. Contemporary societies need to foster an equally close relationship to their food and habitat if they are to reestablish a resilient relationship between people and existing ecological systems. In order to achieve this, it is essential to address the stark divide between ecology, people, and contemporary agricultural practices. A systems-based approach to design can help humanity reimagine its relationship to food and the landscapes that support it.

INTRODUCTION

Since the 1970s the predominant strategy for addressing global nutritional issue such as droughts and famine has been focused on the idea of food security. This approach to the global food system has done little to address hunger and malnutrition (The State of Food Insecurity in the world, 2006). Food sovereignty was developed in response to these failures,it is defined as:

> *“The right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods and their right to define their own food and agriculture systems…It puts the aspirations, needs and livelihoods of those who produce, distribute and consume food at the heart of food systems and policies rather than the demands of markets and corporations.” (La Via Campesina, 2008).*

Food sovereignty is complementary, yet fundamentally different to the idea of food security. “Food Security seeks to address the issue of food and hunger through the current dominant food regime, whereas Food Sovereignty challenges this paradigm and seeks to build alternatives, and attempts to address the root causes through a bottom-up, grass-roots approach” (Eddis, 2014). This thesis will focus on the potential of embracing holistic river management approaches as a strategy to increase the food sovereignty of communities across the globe.

In order to maximize food sovereignty within river systems it will be necessary to change the predominant approach to river management reliant on the infrastructural manipulation of waterways. This is especially pressing as patterns of changing climate threaten the global food supply and the ecological systems they support. The following discussion will analyze how changing our perspective on agriculture could enable the adoption of holistic river management strategies. This will take understanding both global and regional issues associated with river management.

Global Issue: Reconciling River Ecology With Agriculture

Rivers are centers for ecological abundance and biodiversity; for millennia humans have relied on rivers for settlement, hunting, fishing, and farming floodplains (Way, 2018.) Historically, floodplains were mainly able to accommodate human food production needs without inhibiting the temporal cycles of flooding, channel migration, and sediment deposition that enable ecological productivity and diversity in rivers. However, following the industrial revolution, human ability and readiness to manipulate rivers began to significantly affect their hydromorphological characteristics. Dikes were constructed to separate floodplains from the river channel, wetlands were drained, and canals were dug to drain water in wet periods and bring it to the farms in dry periods (Nienhuis, 2008). Despite successfully increasing the land available for human use, these interventions severely impacted environmental quality.

Over the course of the last century the extent and scale of river manipulation has dramatically increased. Heavy engineering of waterways has been adopted across the world, and as technology improved so did the size and complexity of these interventions: larger dams were built, displacing entire ecosystems along with the people that depended on them, massive efforts in bank reinforcement fossilized river channels, and industrial agriculture practices contaminated waterways with excess fertilizers and pesticides. While this relationship between people and rivers has been able to thus far meet food demands for a growing world population, it has been realized at the expense of major losses in biodiversity, disruption of global element cycles, problematic eutrophication and toxification of our freshwater resources, and loss of regulating ecosystem functions (Hassan et al., 2005). The United Nations has identified this as the century of fresh water and acknowledges that "agriculture is the largest consumer of the world's freshwater resources" (International Decade for Action, 2016).

In the coming decades it will become necessary to implement less stringent flood control and, at minimum, partial restoration of river functioning. This will make agricultural use of flood plains and estuaries far more sustainable, better reconcilable with river fisheries, and even more secure, given the threats posed by global climate change (Rijsberman and De Silva, 2006). Achieving these goals will require a global shift in perspective. We need to move away from prioritizing and funding a "command and control" approach to river management and instead view waterways as social ecological systems which can simultaneously address safety, infrastructural, economic, and cultural benefit (Pingram et al., 2019). Although a global shift in attitudes towards river management is necessary, the implementation of new approaches needs to be addressed at the local level.

Regional Approach: Pacific Northwest River Landscapes

In the Pacific Northwest, heavy hydrologic manipulation of waterways to allow for the development of urban areas, industry, and agriculture restricted the dynamic processes that enabled rivers to be rich and diverse ecological systems. Before European settlement, the region's rivers were complex and dynamic environments. Tides and floods constantly changed the spatial qualities of the habitat and they generated an interconnected system with enough complexity and continuity to support a great diversity of plants and animals. This biological abundance and diversity enabled many indigenous communities across the region to sustain themselves and, in many cases, the central nutritional component to their livelihood was salmon. Salmon are a keystone species; they are integral to the health of ecosystems in the Pacific Northwest. Their lifecycle acts like a pump that transfers nutrients from the sea back to terrestrial habitats, supporting a great abundance and diversity of life. When the First People settled the Pacific Northwest, they built their culture and society around maintaining the health of salmon populations (White, 1995). They recognized how their survival was deeply tied to the life of salmon, and in order to accomplish this, they had to obtain a deep ecological knowledge.

The lifecycle of salmon is key to understanding the rhythms of river ecology of the Pacific Northwest and how habitat continuity and complexity enabled the productivity of these landscapes. Though the life history of each salmon species is distinct, in general, salmon are born in small tributaries and then descend to the sea. On this journey, wetlands provide refuge from predators as well as nourishment, and riparian vegetation keeps the water cool and well oxygenated. As the river floods in the winter, they migrate onto the seasonal floodplains to shelter from the heavy flows and take advantage of the rich nutrients. By springtime, the salmon then begin to get larger and stronger as they gradually make their way downriver. Upon the first taste of salt they begin the process we understand as smolting. In this first metamorphosis, the salmon change to enable their survival in saltwater - a crucial stage in the journey into the Pacific Ocean. After spending some time in the estuary of the river to feed, the salmon then journey further into the sea passing by tidal beaches and kelp forests which provide more food and protection from predators. As they continue on their journey they begin to grow at a faster rate, sometimes traveling thousands of miles to satisfy their ever-growing appetites. By this stage, much of the salmon will have been preyed upon by orcas, kingfishers, herons, seals, and otters, thereby nourishing the ecosystem's predators.

After several years at sea, the salmon embark on a journey towards home – the tributaries in which they were born. As they make their way back into freshwater salmon no longer retain the urge to eat, and their bodies shift once again: they grow frailer but retain enough strength to surmount rapids and waterfalls. More predators – bears, wolves, and eagles, primarily – continue to prey on the returning salmon, but many still return to their tributaries of origin. Once arrived, the salmon locate suitable sites to dig a depression in the riverbed in which to lay and fertilize their eggs. The remaining salmon's lives end shortly thereafter, and the nutrients accumulated from their lifetimes in the ocean are dispersed to the ecosystem's flora and fauna (Muller, 2017).

The entirety of this lifecycle shows that throughout their lives, salmon occupy many different habitats which are continuous to one another. This continuity between land, river and sea is critical to their survival. The Euro-American approach to development did not value salmon as much as the indigenous settlements they replaced (White, 1995). As Euro-Americans colonized the area, they began to manipulate the hydrology of rivers to promote the settling of the region, but without the ecological consciousness that was so prevalent in indigneous communities. Their actions systematically removed both the habitat continuity and complexity salmon evolved to take advantage of. Dams and levees were built to limit flooding and control river flow, shorelines were armored to prevent erosion and protect private land, roads were built to facilitate resource extraction and trade. These changes enabled the intensification of agricultural production in floodplains, the settlement of agricultural valleys, and facilitated the extraction of natural resources; however, they also disconnected floodplains from river channels, blocked salmon access to spawning tributaries and contributed to the overall toxification of the region's waterways. As a result, salmon populations began to decline. Today only a fraction of historic salmon populations remain in the Pacific Northwest – several historically abundant runs are now extinct and many more are endangered (Ford et al., 2011).

In addition to decreasing ecological productivity, the systems of infrastructure erected to manage rivers over the course of the twentieth century also pose a risk to public safety and the agricultural viability of valleys - the combination of inadequate management, insufficient funding, and increased precipitation patterns are putting dams and levees at risk of failure (Neumann et al., 2015). The combined threats of climate change, aging infrastructure, and ecological degradation will put pressure on both salmon populations and the food systems across the world (Wheeler & Braun, 2013.) These threats suggest the adoption of holistic river management strategies across the region. Holistic approaches to river management can oftentimes be the most socially, economically, and ecologically effective ways to manage rivers (Biron et al. 2014). That said, it is important to understand that over the last century rivers in the Pacific Northwest have been drastically changed. As we look to alter our river management strategies, "returning to pre-settlement conditions is neither feasible nor would it sustain our current population" (Dittbrenner et. al 2015, 2).

In order to meet the needs of our current population, a holistic approach needs to enable the restoration of the dynamic qualities of rivers necessary for the recovery of salmon populations. It also needs to simultaneously maintain agricultural production of floodplains. Salmon were the primary source of food for many indigenous people; whereas they alone could not support the current population, they remain a critical cultural, economic and nutritional resource key to preserving the identity of the region. On the other hand, while the method in which agriculture has been developed in the Pacific Northwest is directly responsible for the decline of salmon populations, it has also allowed for the development of vibrant agricultural communities. These communities and the agricultural goods they produce are both a large economic resource for the region, as well as the backbone of regional food security. Combining viable agriculture and salmon habitat into a single landscape has the potential to transform Pacific Northwest river valleys into highly diverse and productive landscapes. This could increase the resilience of the regional food system. To realize this objective, we must ask: *How can economically viable agriculture be weaved into the dynamic hydrologic regimes of river environments in order to maximize food sovereignty in the Pacific Northwest?*

Methods: Developing The Framework

Researching this question has required an in-depth analysis of several disciplines in order to understand how they are related and affect rivers. This section provides a brief overview of the research questions that are discussed and how they relate to one another. First, I discuss the need for river management in the Pacific Northwest to move away from fixed width riparian restoration and shift towards emerging holistic strategies of river management. This is critical in restoring salmon habitat. Central to this discussion is The Freedom Space Approach, which was developed by Pascale Biron, a professor in the Department of Geography, Planning, and Environment at Concordia University in Montreal Canada. She and her colleagues developed this approach with the intent of facilitating the adoption of holistic river management across North America. To do this, they delineate zones within a river corridor most prone to the natural processes of flooding and erosion, and suggest adjusting human development accordingly. The foundation of their argument is that, compared to existing river management strategies which focus on bank stabilization and other hard engineering approaches, managing rivers by enabling natural processes instead of controlling them is more economically sustainable and also provides more opportunity to restore river ecologies (Biron et al., 2014). This research leads to addressing the barriers to holistic river management.

One of the main barriers to adopting holistic approaches to river management is agricultural land use. Agriculture and habitat restoration often compete for the same land, hampering the implementation of holistic river restoration approaches that attempt to restore floodplain function. In response to this concern, I research and propose several agricultural strategies that have the potential to meet restoration goals, while also producing food and income to farmers.

These strategies are 'working buffers' and the use of fallow rice fields as winter nursing grounds for juvenile salmon. Both of these approaches manage to integrate agricultural land use within the dynamic river processes necessary for the survival of juvenile salmon - they demonstrate the attitude that needs to be taken to reconcile Pacific Northwest agriculture with river ecology. I then propose that the Freedom Space Approach developed by professor Biron and her team can be used as a framework to reimagine agricultural landscapes so that they are compatible with dynamic river functions. In this discussion it becomes apparent that there are several barriers to implementing this vision for an agricultural landscape across the Pacific Northwest.

Agricultural strategies that have potential to simultaneously restore salmon habitat and provide income to farmers are showing success in achieving desired results within their specific contexts; however, they remain exceptions to standard contemporary agricultural practices. Ultimately, for these practices to become alternatives to contemporary agriculture they must be economically viable. To achieve this, it is necessary to create greater demand for the products they generate while also improving the methods of production. Recent studies suggest that addressing the disconnect between people living in urban areas and the process of growing food could help promote regionally produced agricultural goods and promote sustainable agricultural practices (Codon et al., 2010).

A publication from the University of British Columbia School of Architecture, articulates the idea that developing the Peri-Urban agriculture around Vancouver, British Columbia could both benefit the agricultural community and help reconnect urban dwellers to the process of food production (Codon et al., 2010). This, they argue, could drive up the demand for regional agricultural products and thus promote sustainable agricultural practices. This proposal constitutes an ideal framework to begin experimenting with and promoting agricultural strategies that reconcile the relationship between river ecology and agriculture. The Puget Sound region is experiencing patterns of land speculation similar to the Vancouver BC metropolitan area. Land speculation is prompting many farmers to sell their land, compromising the vitality of agricultural communities as well as regional food security. Like in Vancouver, it would be beneficial to integrate our peri-urban agricultural areas with the fabric of our cities and promote regionally produced agricultural goods. The Sammamish River Agricultural Production District (SRAPD) has all the necessary components to be an ideal testing ground for this theory.

The SRAPD is an agriculturally protected area that sits in the heart of the Seattle metropolitan region and connects the cities of Redmond, Kirkland, Woodinville, Bothell, and Seattle through a network of heavily frequented bike and pedestrian trails, as well as a future light rail link. Currently, the proximity to urbanity and public interface of the trails is being used by wineries as a way to promote their regionally produced products; however, much of the wine they sell is not produced on site and the success of their operations risks further opening the valley to commercial development, threatening its agricultural viability (Friends of Sammamish Valley). Additionally, this river valley has suffered dramatic environmental damage as part of the replumbing of the Cedar River Watershed, and the dredging and channelization of the Sammamish River. These changes have heavily contributed to the decline of salmon in the watershed. Today, some of the best opportunities for land restoration in the valley happen within the agricultural production district; however, like elsewhere in the region, they are hindered by current policy in both habitat restoration and agricultural production.

This situation creates the opportunity to repurpose the mechanism already in use by wineries to promote their regional products. The valley's proximity to urbanity can be used to fund, test, develop, and promote agricultural strategies that enable the restoration of critical salmon habitat. This would turn the Sammamish river agricultural production district into a functioning case study for an agricultural landscape that simultaneously addresses the needs of salmon and those of people. The following chapters are a compilation of my research, as well as my vision for how we could reimagine the Sammamish River valley.

PART 1: RECONCILING AGRICULTURE WITH RIVERS

Holistic approaches to river restoration demonstrate that the safest and most economically sustainable way to manage our rivers is by liberating them from the confines that we have restricted them to and adjusting our development and land use to respect their hydromorphological requirements. Applying this theory to our current system of river management requires changing the way we think about agriculture. Currently we are asking: 'how can we alter the river to enable our existing agricultural methods?' What we should be asking is: how can we change existing agricultural methods to ensure the functional capacity of rivers? The reframing of this question is critical to enabling an agricultural landscape that can coexist with salmon.

CHAPTER 1: ADOPTING A NEW APPROACH TO RIVER MANAGEMENT

How does the current approach to river management and restoration shape landscapes across the Pacific Northwest?

Emerging Approaches of River Management

Over the last century, the predominant method of river management in the Pacific Northwest has relied on bank stabilization and channelization. This approach has contributed to the fossilization of river channels across the region (Mongomery, 2003). Several salmon runs are now listed under the Endangered Species Act, meaning that restoring salmon habitat is a federal obligation (Crozier et al., 2019). For some time, it has been recognized that the engineered changes to rivers contributed to the decrease of salmon populations, and that restoring rivers is critical in order to recover their stocks .
The primary strategies to recover salmon populations have focused on restoring riparian vegetation and removing barriers to fish migration, such as culverts. Riparian restoration involves creating vegetated buffers of a predetermined width adjacent to waterways. These buffers are planted with species native to the region which help filter toxic pollutants from runoff, provide shade and create habitat for salmon as the vegetation falls and decomposes into the water. While these changes are undoubtedly beneficial, they do not address the fossilization of river channels. This means that even after riparian restoration efforts are completed, rivers still remain largely disconnected from their floodplains. Floodplain restoration needs to be combined with existing riparian restoration targets to ensure the recovery of salmon across the region (Hall et al., 2007).

In the last thirty years, scientists have been further understanding the importance of reconnecting rivers to their floodplains. Today, it is widely believed that the restoration of dynamic river processes such as bank erosion and flooding are critical to the health of salmon populations. Several studies have shown how floodplains connected to the main river channel are necessary to maximize health and survival of juvenile salmon (Hall et al., 2007, Jeffres et al., 2008, Bond et al., 2018). These studies demonstrate the need to restore floodplain habitat and highlight how focusing only on riparian restoration will inherently limit the potential for freshwater habitat resources for salmon. Restoring floodplain habitat requires much more land than riparian restoration and is often limited by existing land use of river corridors . The main challenge remains procuring enough land to meaningfully restore floodplains across the region. While this will be difficult, to meaningfully restore salmon populations it is necessary to try and increase salmon survival by maximizing full potential of freshwater resources.

While there exist several barriers to its implementation, the idea of floodplain restoration has recently started to gain traction, and there have been several initiatives across Washington state that address the need to reconnect and restore floodplain habitat as well as riparian zones. These approaches are in line with the trend in river management that has "transitioned away from individual subdisciplines towards interdisciplinary approaches and an increased focus on viewing riverine landscapes as social ecological systems...that can address safety, infrastructural, economic, ecological, and cultural benefits" (Pingram et al., 2019). Floodplains by Design is one of the leaders in holistic floodplain management and restoration across the Puget Sound. They are carrying out several restoration projects while trying to create the best compromise between floodplain restoration and existing land use. Their goal "is to improve the resiliency of floodplains for the protection of human communities and the health of the ecosystem, while supporting values important in the state such as agriculture, clean water, a vibrant economy, and outdoor recreation" (Our Work | Floodplains by Design, 2014).

Applying this concept of holistic river management to the Pacific Northwest is necessary to protect salmon, because it addresses the need to reconcile different stakeholders that have historically been at odds. One of the main stakeholder standoffs is happening between farmers and restoration advocates. In the Puget Sound lowlands, productive agricultural land occupies many of the floodplains that are vital for the recovery of the chinook salmon (Mongomery et al., 2003).

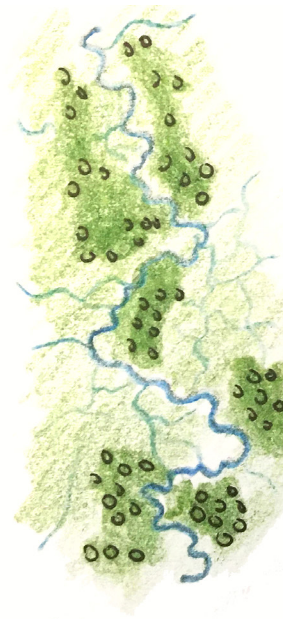
The Floodplains by Design initiative recognizes the relationship between agricultural land and functioning floodplains as key to achieving a vision for holistic river management. They are addressing this issue primarily by making the point that a network of restored floodplains can act as equally effective, if not better, flood control than the existing system of engineered levees and channelized waterways. In addition to providing flood control which can better serve agricultural production, restored floodplains are also able to restore salmon populations (Our Work | Floodplains by Design, 2014).
The vision of a hybrid landscape of restored floodplains and farms that is able to simultaneously protect farmland and restore salmon habitat is far more resilient than the existing system of infrastructure; however, it is often difficult to achieve in practice. In their evaluation of the Nooksack River as a potential floodplain restoration project, Floodplains by Design recognizes that "increased demand for agricultural property... has made it harder and more expensive to implement both flood and salmon recovery projects... additional understanding of how to maximize floodplain restoration for salmon capacity and productivity is still necessary" (Our Work | Floodplains by Design, 2014, 28). This statement shows that agricultural land use is directly at odds with floodplain restoration strategies where the demand for agricultural land is high.

The alternative strategy for addressing this issue is a System-Wide Improvement Framework (SWIF) project with the U.S. Army Corps of Engineers for the Nooksack River. The SWIF planning process is integrating goals for flood risk reduction, salmon recovery, and agriculture (Our Work | Floodplains by Design, 2014, 28). This approach actively addresses the needs of stakeholders, namely agricultural interests and salmon restoration interests; however, the potential to restore habitat within agriculturally productive portions of the valley is limited to primarily riparian restoration. This is largely due to the underlying assumption that a single piece of land cannot be agriculturally viable while simultaneously being an ecologically beneficial component to a floodplain. This assumption is largely responsible for the limited success of existing restoration initiatives throughout the state (Dittbrenner et. al., 2015).

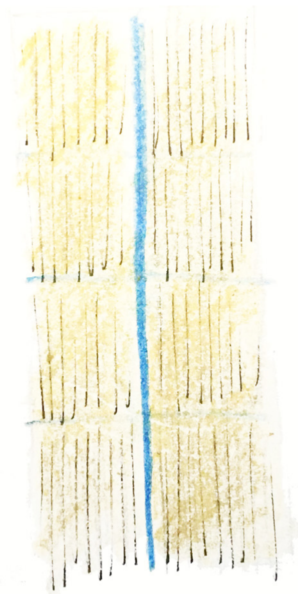
Separation Of Agriculture and River Ecology

The primary issue with understanding agricultural land as spatially incompatible with functioning floodplains is that it frames restoration projects as being in direct competition with farmers for their land. This often limits restoration within viable agricultural areas to riparian zones. As we discussed in the last section, riparian restoration alone will not be sufficient to aid salmon recovery. Given that floodplain restoration is more land intensive than riparian restoration, it would be unreasonable to think that we could implement it by using the same framework that sees agricultural production and salmon habitat as spatially incompatible. As is evidenced by the Floodplains by Design analysis of the Nooksack River, this issue is part of the reason holistic river management strategies focused on floodplain restoration are having a hard time being implemented in watersheds that are dominated by agricultural land. Understanding how to address this issue will require a more in-depth look at the mechanisms of this conflict of interest between farmers and restoration.

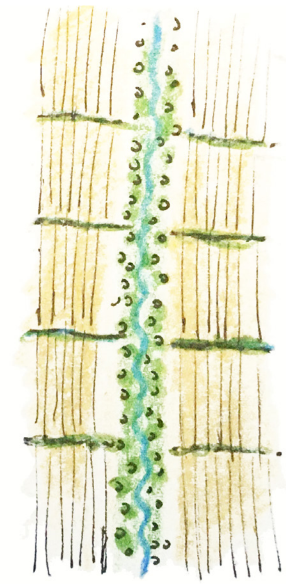
The current approach to restoration establishes a fixed-width buffer adjacent to all waterways which is meant to protect streambanks from the effects of agricultural use. This streambank easement is planted with native riparian vegetation and is off-limits for any agricultural use. To procure it, different land trust foundations partner with the state to compensate farmers for an easement which buffers waterways on their land. However, this funding is typically not enough to offset farmers' revenue loss from the productive land taken away (Dittbrenner et. al., 2015). This is especially true for smaller farms that make up a majority of the agricultural landscape in Puget Sound River Basins. Since farmers are neither properly compensated, nor allowed to use this easement, it leads them to perceive restoration as a threat to their livelihoods.



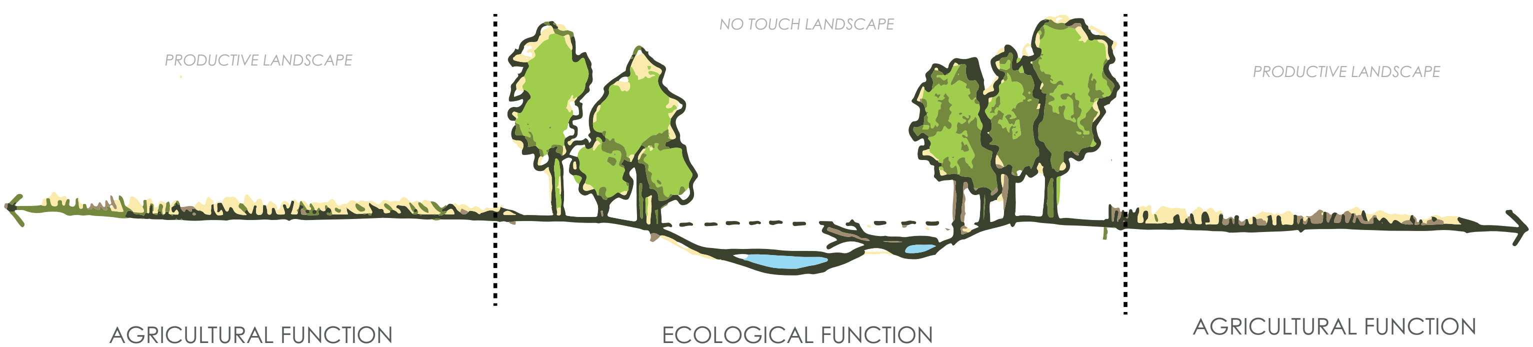
Historic
Condition



Existing Agricultural
Landscape



Riparian Restoration
Agricultural Landscape



< Figure 1.2

Diagram illustrating a comparison between historic conditions (right), current conditions (middle) and the conditions if a riparian restoration was applied (left). Notice how riparian restoration is not able to restore the habitat complexity of historic conditions.

< Figure 1.3

Diagrammatic section showing the ideological separation between habitat and agriculturally productive land. This perceived separation only allows for the riparian restoration of rivers as is illustrated in Figure 2.1.

"Farmers face painstakingly simple economics; they must make a profit to survive and the easiest way out is to sell land for development" (Dittbrenner et al., 2015). Despite pushback from conservationists, farmers have valid concerns when it comes to this matter. The fundamental problem of both existing and proposed restoration policy in the Puget Sound is that river management is being treated as spatially incompatible with agricultural use because of its traditional "no-touch approach". Therefore, fish habitat advocates and farmers are competing for the same land that is already under threat from speculation due to urbanization, placing them in conflict with each other.

Population growth has been putting increasing pressure on the conversion of working farms into rural estates. The Puget Sound region has lost 60% of its farmland in the last 65 years (Canty et al., 2012). "If we recognize the importance of agricultural land: 1) to our economy, 2) as an alternative to urbanization, 3) as part of our cultural heritage, and 4) as our primary source of food security, we must figure out how to improve fish habitat while increasing agricultural viability. These two activities must occur on the same landscape" (Dittbrenner et al., 2015).

Implementing holistic river management strategies using this 'no touch' approach to restoration is at odds with farmers' livelihoods, as well as with the general food security of the region - it limits the amount of agriculturally productive area within a river corridor. To procure enough land for the implementation of holistic river management strategies, it will be necessary to reconcile agricultural land-use with the ecology of a functioning floodplain. This requires us to change perspective on agriculture and rivers. Instead of manipulating rivers to fit our current agricultural strategies, it is critical that we shift our agricultural strategies to fit within the ecological needs of rivers. To achieve this, I propose using the Freedom Space approach as a framework for reimagining Pacific Northwest Floodplains as simultaneously ecologically and agriculturally productive landscapes.

Integrating Agriculture with Floodplains

Creating an agricultural landscape that is both economically viable, and also meets ecological goals for a functioning floodplain will require the collaboration between experts in different disciplines. Economists and farmers will need to work together to understand the viability of different crops and farming techniques. They will need to collaborate with engineers and river ecologists to understand how these practices can be applied in order to meet agricultural, flood control, and ecological goals. The purpose of the following discussion is not to replace the framework created by Floodplains by Design, and other holistic river management initiatives. Rather, it is a vision for how changing our assumptions about agriculture and ecology can enable the adoption and proliferation of these holistic approaches across the region.

In my research of different holistic river management methodologies, I was particularly intrigued by the Freedom Space approach developed by professor Biron and her colleagues at Concordia University. I found this to be a framework for thinking about river management and restoration that could facilitate agricultural strategies which are compatible with functioning floodplains.

THE FREEDOM SPACE APPROACH

The concept of Freedom Space is primarily based on elevation and uses different methods such as LIDAR analysis to predict the risk of flooding and bank erosion for a specific river. Instead of trying to predict exact timelines of projected channel migration, flooding, and erosion this approach relies on the identification of the necessary spaces where human intervention should be limited because the risks of these events happening outweigh the economic and safety benefits posed by them. In addition to providing safety and economic benefits, adopting this approach also enables the restoration of river fisheries which play an important role in supporting food security in many regions. The following paragraphs outline its fundamental principles:

The concept of Freedom Space revolves around the hydrogeomorphology of rivers. The space delineation method combines two spaces related to the two main river processes: the mobility space and the flooding space, the latter also including riparian wetlands. These are then grouped into three zones, namely the minimum (L_{min}), functional (L_{func}), and rare (L_{rare}) freedom spaces (Biron et al., 2014).

A. L_{min} *delineates the minimum space that must be given to the river to preserve the most basic ecological functions-these are areas within the floodplain that pose the highest risk to agriculture and development and are most environmentally critical.*

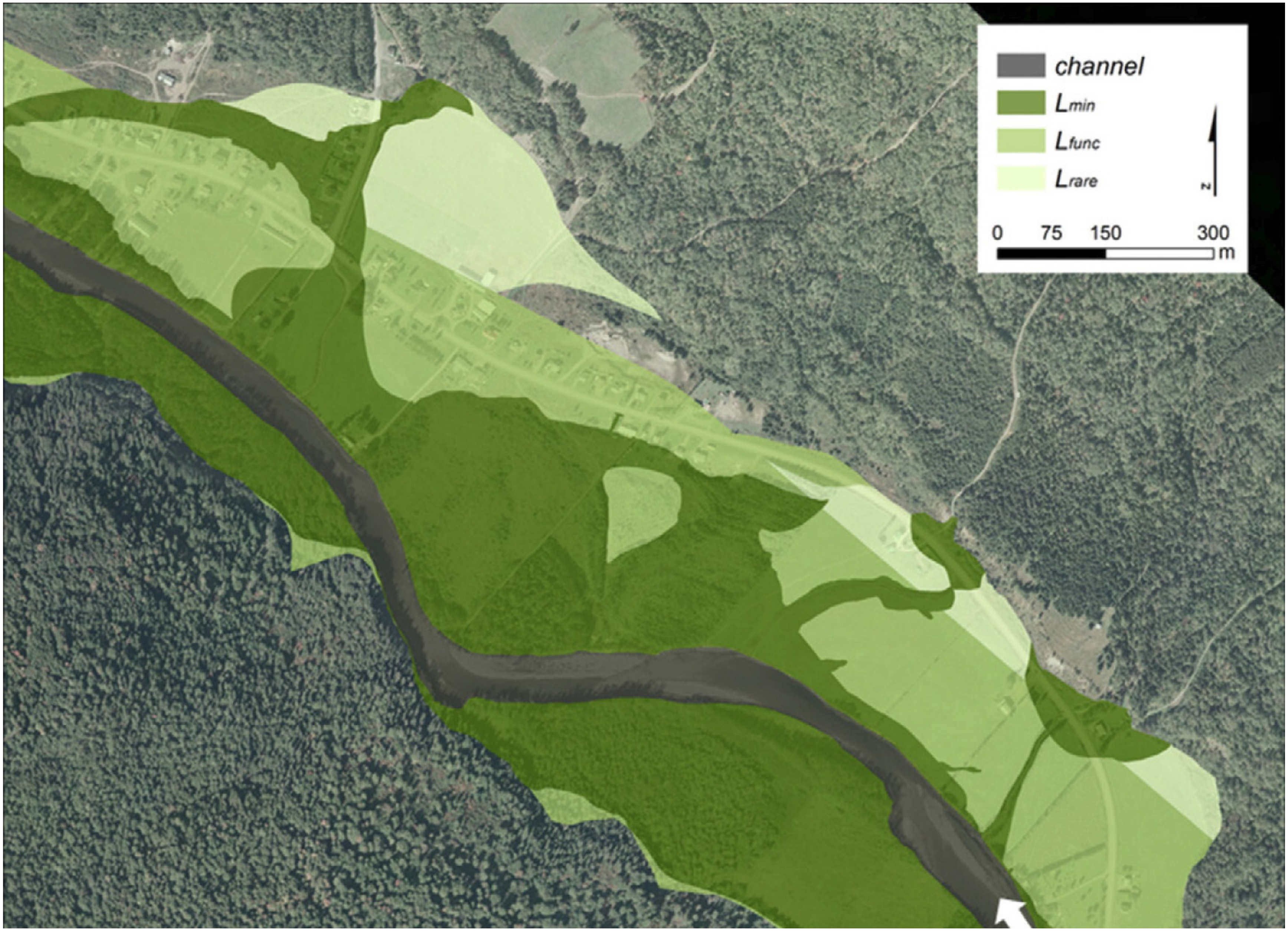
B. L_{func} *delineates spaces the river needs to maintain full ecological function – these areas can be developed but they must be developed carefully as they retain environmentally sensitive areas and they are prone to flooding/erosion in the future.*

C. L_{rare} *is the space where there is a risk of flooding during extreme events – these areas can be developed, but with an awareness that extreme weather events can generate a flood threat.*

APPLYING THE FREEDOM SPACE APPROACH TO AN AGRICULTURAL LANDSCAPE

The methodology of this approach is attractive to floodplain design because it simplifies a mixture of complex processes into a digestible spatial framework. The two main takeaways from this approach are: 1. It's less costly and more ecologically beneficial than existing strategies of river management that focus on infrastructure. 2. It frames river corridors based on a gradient of susceptibility to flooding and bank erosion. This enables human use of river corridors to be evaluated based on their ability to withstand risks and gives us the opportunity to evaluate the feasibility of different agricultural strategies based on their abilities to withstand processes of flooding and bank erosion.

When describing barriers to implementing the Freedom Space approach, Biron and her colleagues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Lmin
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recognize that agricultural use of land will need to be reconciled with the dynamic processes of bank erosion and flooding. In response, they cite agricultural policy that is being evaluated as a possible solution. The Vermont department of natural resources, for example, is testing the idea of "River Corridor Easements" (Kline 2010). This approach allows farmers to use the land directly adjacent to rivers for agriculture but prohibits any activities that may prevent flooding or erosion on this land. This example shows that it is possible to use streamside land for agriculture as well as letting the river move without inhibition. This way of thinking about the relationship between agriculture and river ecologies can be translated to rivers across the Puget Sound. Adopting a similar way of thinking about the agricultural use of floodplains could enable more land to become available for floodplain restoration projects, since it would remain viable to farming. The initiative in the state of Vermont developed according to the principles of the Freedom Space approach provides a starting point for finding viable ways to produce food that are compatible with flooding and bank erosion. This could be achieved by arranging a pallet of agricultural strategies according to their resilience to dynamic river processes.

Strategies that are most resilient to frequent flooding and bank erosion can be implemented closest to the river corridor in the (L_{min}) zone. Those that are resistant to periodic flooding could be placed in the (L_{func}) zone, and those that are least resilient to dynamic river processes could be placed in the (L_{rare}) zone of the river valley. Arranging agriculture in river valleys according to these delineations allows an opportunity to merge the idea of productive land with ecologically functional floodplains, thus blurring the perceived line between salmon habitat and agriculturally viable land. This would facilitate the realization of floodplain restoration projects within agriculturally productive areas.

< Figure 1.4

Illustration of the Freedom Space approach. Image shows the three zones delineation for a river corridor in Canada.

In this discussion it is important to remember that interpreting river landscapes as socio-ecological systems is not a new idea – "indigenous knowledge systems consistently place[d] humans within the natural world. Integrating environmental knowledge, in its various forms, [will play] a key role in understanding issues and developing solutions for freshwater managers, especially in the context of rivers as social-ecological systems" (Pingram et al., 2019). In the Pacific Northwest, indigenous people relied on a combination of wild salmon harvesting, hunting, and agroforestry techniques to maintain a landscape that was able to support their population.

These practices were deeply intertwined in their culture and aimed to maintain the ecological processes that ensured their survival in the region. While these practices alone would not be able to support the current population, they offer insights and strategies for managing landscapes in ways that are both ecologically and agriculturally productive. These are especially applicable in areas that are most prone to flooding and bank erosion. For example, we could learn from indigenous management practices to harvest wetland plants like wapato and wild rice. Already, in Oregon, several farmers have started to turn to wild rice as a crop that can provide both habitat for salmon, as well as an income to farmers (associated press, 2002). The key to being able to implement these agricultural strategies is ultimately their economic viability. As we will discuss more in depth later in this document, the ability for farmers to make a profit from agricultural goods compatible with functioning floodplains is based on their ability to process and market them.

The economic element is crucial both to food security and to protect the vitality of agricultural communities. Washington State ranks 17th in the nation for agricultural production, reaching $9.89 billion in products in 2012, supporting at least 18,000 jobs in the state and $2.2 billion in personal income (USDA, 2014). Population growth has been continuously increasing pressure for the conversion of working farms into rural estates. This accumulation of pressures logically increased farmers' sensitivity to different initiatives that compete for the land they use to make a living. This is why so many view habitat restoration as a threat and are reluctant to negotiate with restoration authorities.

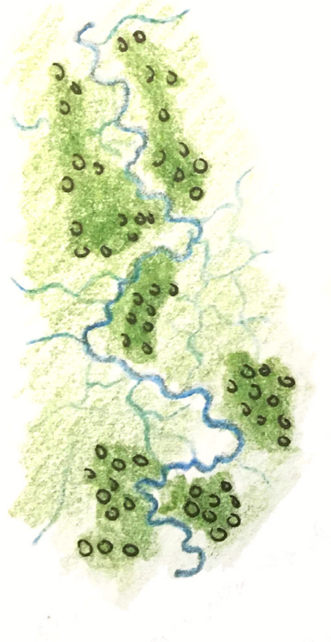
Creating a new agricultural landscape based on the zones delineated by the Freedom Space approach requires the support of farmers and their willingness to work the land. Farmers are not to blame for the agro-economic system's use and promotion of agricultural techniques incompatible with

Figure 1.5 >

Illustration of a hypothetical historic channel (left) that is divided into zones according to the Freedom Space Approach (middle). The zones are then used to define a new agricultural typology (right).

Figure 1.6 >

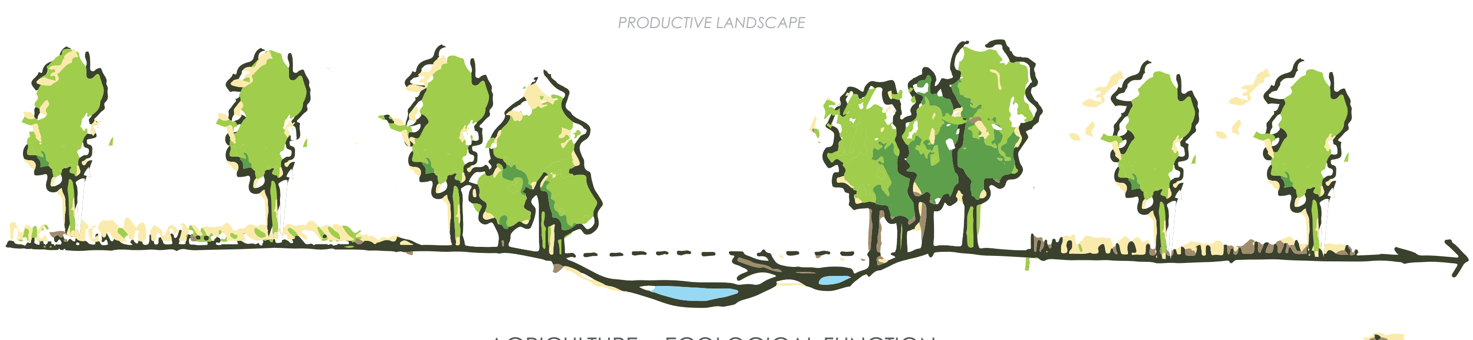
The premise for being able to achieve holistic river management is based on our ability to view agriculture and ecological function as part of the same spatial landscape.



HISTORIC CONDITIONS

FREEDOM SPACE
DELINEATION

FREEDOM SPACE
AGRICULTURAL LANDSCAPE



AGRICULTURE + ECOLOGICAL FUNCTION

habitat restoration. Therefore, while it is essential that we adopt holistic strategies of river management, it is important to do so in a way that can reconcile the relationship between farmers and river ecology as opposed to making them compete with each other. The key to achieving this is largely economic; it is necessary to empower farmers so they can adopt new agricultural strategies without reducing their ability to generate income. There are several agricultural strategies being experimented with in the Pacific Northwest that show promise in being able to achieve this goal. The next chapter will analyze these strategies, along with barriers to their implementation.

LESSONS LEARNED:

1. Farmers are at odds with advocates of river conservation because under the current approach to river restoration they are both competing for the same land.

2. The primary reason for this conflict of interest between farmers and advocates of river conservation is that current agricultural strategies are not compatible with river restoration.

3. Given that current riparian restoration strategies are struggling to find traction in Puget Sound Agricultural communities, it is necessary to change our approach to agriculture in order to implement a holistic approach to river management that allows for the restoration of floodplains.

CHAPTER 2: IDEAS FOR AN INTEGRATED APPROACH

The strategies described in the next chapter are the most promising in terms of being able to provide income to farmers while also meeting restoration goals. With that said, they are by no means all-encompassing. Implementing large-scale agricultural landscapes hinges on our ability to further improve these agricultural methods as well as to develop new ones. The following case studies illustrate the way in which we need to start viewing agricultural methods in order to adapt them to the dynamic processes rivers need to sustain salmon populations.

CASE STUDY 1: Working Buffers

The idea of Working Buffers seeks to reconcile the currently tense relationship between farmers and riparian restoration by using Agroforestry techniques. This case study analysis is based on the information available for working buffers from the document "The Working Buffer Opportunity" released by Snohomish County in collaboration with NOAA and Puget Sound Partnership (Dittbrenner et al., 2015). Additionally, this case study will incorporate feedback and site analysis from one of the first pilot projects of this initiative: Rising Crane Ranch in Snohomish County.

< Figure 2.1

Silvopasture, cows grazing amongst a sparse forest canopy.

Agroforestry techniques are the foundation of Working Buffers. They allow farms to increase their economic resilience by providing different income streams and creating habitats for beneficial species that can reduce the needs for inputs like fertilizers while simultaneously increasing crop yields (Dittbrenner et. al., 2015). They also can benefit salmon by fulfilling the same ecosystem functions as the native species they are replacing. While working buffers were designed to address the issues directly related to riparian buffers, their design principle is to recreate an ecologically useful habitat that is also able to generate agricultural production and favorable economics for farmers. This means that these tech-

niques could be reapplied to fit the framework of floodplain management proposed in the Freedom Space approach.

The four main agroforestry practices used in working buffers are forest farming, alley cropping, silvopasture, and short-rotation biomass. These practices can be combined to fit the economic need of individual farms as well as the habitat requirements for conservation efforts.

Forest Farming

Forest Farming is the cultivation of specialty crops under a forest canopy. These crops usually consist of mushrooms, medical plants, nursery cuttings, and ornamental plants. They can be managed to provide appropriate amounts of shade additionally to timber products by periodic thinning (Mosquera-Losada et al., 2018).

Alley Cropping

Alley Cropping is the process of growing an annual or perennial agricultural crop simultaneously with a long-term woody crop, both in rows, on contour. In this scheme, the shrubs offer high-value fruits/nuts or can be harvested for lumber/veneer. The crops in between the rows of trees can be hay, corn, or any cultivated crops chosen by farmers (Wolz et al., 2018).

< Figure 2.2

Forest farming.

Silvopasture

This is the process of grazing livestock under a wooden canopy. The trees in the canopy provide fruit/nut production or high-value timber, and the understory provides seasonal forage for cattle (Gordon et al., 2018).

Short Rotation Biomass

Short rotation biomass is the growing and frequent harvesting of fast-growing trees and shrubs that stump sprout and are harvested for biomass. Willow, cottonwood, and hybrid poplar can provide biomass for biofuel, combustion, paper pulp, or livestock bedding feed (Dittbrenner et. al., 2015).

The success of implementing these practices as a viable alternative to current habitat restoration is ultimately dependent on proving their effectiveness in existing agricultural landscapes. Rising Crane Ranch is one of the first farms to experiment with these methods to see how much value they can add to both their agricultural operation as well as the surrounding habitat. Analyzing the benefits and hurdles this farm has faced thus far will shed light on how to improve the effectiveness of agroforestry practices in the Pacific Northwest.

RISING CRANE RANCH

Rising Crane Ranch started using a combination of Forest Farming, Silvopasture, and Alley Cropping to expand the income streams available to the farm and improve the habitat quality of the adjacent slough. Even though the ranch borders the Snohomish River on its southern side, these strategies are applied along the bank of a slough that drains into the river and borders the northern and eastern sides of the property.

< Figure 2.3

Alley cropping with potatoes and hazelnut trees.

The northern edge of the farm is made up of food forests including aronia berries, currants, huckleberries, hazelnuts, chestnuts, and walnuts. Overall, this part of the ranch has been "pretty darn successful" – although elderberries and black currants did not grow, the walnuts and huckleberries are doing well. The farmer also decided to maintain a small portion of farmland as an "unproductive buffer" to establish a baseline of fast-growing riparian vegetation since many productive forest species such as walnut take at least ten years to reach maturity. Additionally, the farmer mentioned that he still decided to plant these forest species in rows to facilitate production. While this was one of the areas he was most excited about, his main concern was that it would take at least ten years for some plants to begin providing him with income streams.

The eastern edge of the farm employs the tactic of alley cropping and grows a combination of cider trees and hay. Hay is fed to Scottish Highland cattle and cider apples are processed on-site to make apple cider. In the short-term, this has been the most fruitful operation. The cider apple trees quickly started producing fruit, thus enabling the farmer to start processing and selling cider on-site for an additional profit stream that has proven to be very successful.

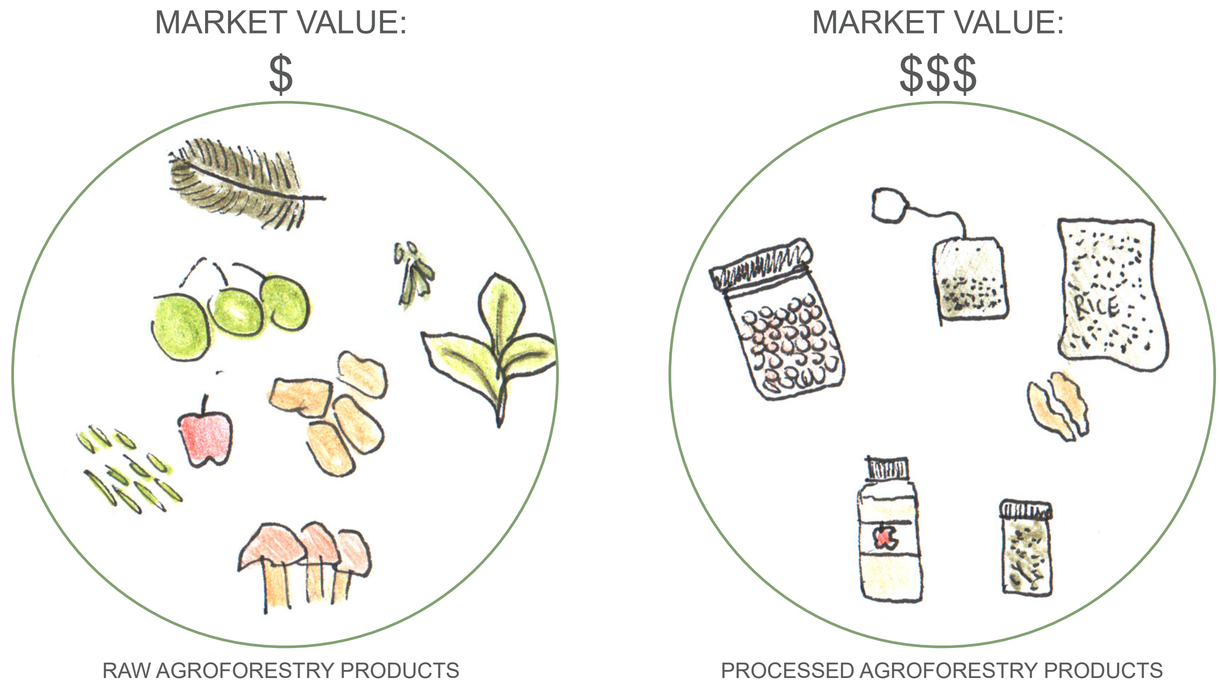
The northwestern edge of the farm uses Silvopasture with a mix of alder, walnut, willow, and locust. Forage for his Scottish Highland cattle is spread in between the trees. Whilst Nick initially enabled this area to be able to be periodically grazed, he quickly discovered that allowing grazing while trees were still young would result in them being eaten by the livestock. Much like for the food forest, the farmer's main criticism leveled at Silvopasture was that generally, at least ten years are required before the land begins to generate income streams. This prompted the transition of our conversation from a description of his operation and evaluation of the specific crops, to what could be done to allow for this strategy to be adopted more widely and reap better advantages for farmers.

The farmer started by expressing that any approaches recommended need to be first and foremost in farmers' interests. For example, to suggest planting a crop that takes ten years to reach maturity, you need to be able to ensure adequate compensation mechanisms are in place to compensate farmers until they can bear the fruits of these endeavors.

Another important issue the farmer raised was that, although the food forests would take ten to years to become productive, once it happens, he believes they will be an asset with the "you pick" method, allowing people to gather their own foods there. He envisions people dragging their own pick-

Figure 2.4 >

Agroforestry products are worth more after they have been processed.



ing wagons through this area to gather goods; however, he notes that a lot of these agroforestry products such as walnuts require additional processing, and it is not economically feasible for every farmer to have a processing plant dedicated to each species he grows.

One of the reasons his cider apple alley cropping has been so successful is that it provides an immediate asset to his farm: firstly because of the hay he can grow for his cattle, and secondly because of the high-value product generated by the cider apples from which he can produce cider since he owns a cider press. This, he believes, is the key to rendering many agroforestry methods viable for farmers in his region. The farmer believes that one possible solution to enable this is to create large-scale plans for all farmers in an agricultural district, which would enable sharing processing equipment as well as creating a unified marketing strategy for promoting agricultural products.

For example, if one of the plants that did best in Snohomish valley conditions was walnuts, then farmers would be incentivized to plant walnuts along stream banks. Walnuts, like many other agro-forestry products, require additional processing before they are valuable enough to provide a stable income stream. Since most farmers would now be planting walnuts, they could form cooperatives to share expensive processing equipment. This wouldn't necessarily mean creating a river-wide monoculture of walnuts, rather it would mean that farmers, conservation officials, and policymakers would have to agree on a district-wide pallet of species to plant. The diversity of this pallet should be determined based on economic viability for farmers.

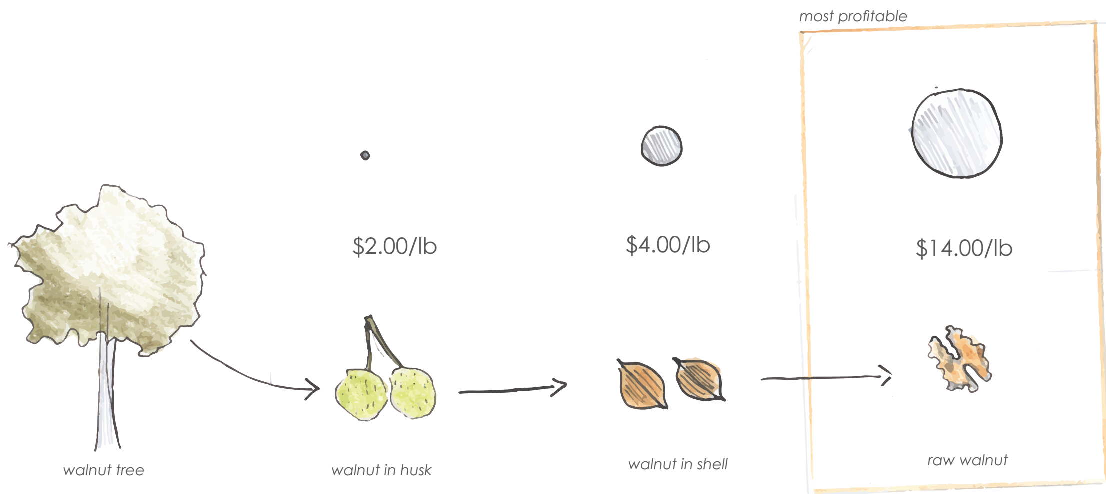
The other advantage of this type of large-scale approach is that it allows farmers to feel like they are making a real difference. Despite his enthusiasm for the overarching idea, the farmer understood that his farm only represented a small benefit for the overall ecosystem and that for a real difference to be made these tactics would need to be implemented on a much larger scale. For this farmer's vision to become a reality, more experimentation needs to be conducted regarding what plants can offer the best combination of restoration benefits and additional income stream to farmers. As is outlined by The Working Buffer Opportunity:

> *"We may need to identify specific areas where we test the viability of working buffers. Those trial areas will need to decide who designs and manages working buffers. We will need to consider who bears the costs and risks, and who earns the profits. We need to evaluate if we are being effective. These explorations ultimately offer us an irreplaceable value—cultivating and placing the responsibility of stewardship among the people that actually live next to our streams" (Dittbrenner et al., 2015).*

According to the Working Buffer Opportunity, there are several other hurdles to address in order to implement agroforestry practices as riparian restoration across the Pacific Northwest: "Agroforestry prac-

Figure 2.5 >

Agroforestry products are worth more after they have been processed.



tices are unfamiliar amongst the farm community and few experts exist that are able to help farmers implement these strategies. The markets for many of the agricultural goods are unproven, untested, or require development. Many farm businesses cannot afford to invest in a new product line without financial assistance" (Dittbrenner et al., 2015).

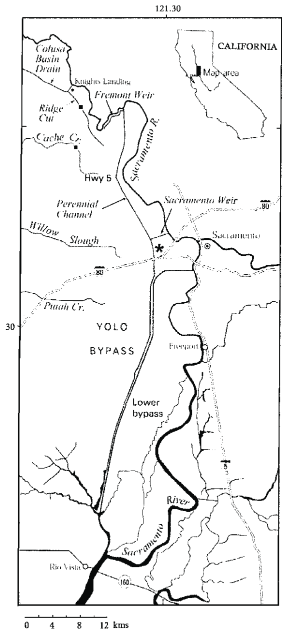


Figure 2.7

Context map of YOLO Bypass.

< Figure 2.6

Areal view of the YOLO Bypass near Sacramento, California. This is an example of flood control and agriculture being able to also create wildlife habitat.

CASE STUDY 2: Flooding Rice Fields for Salmon Rearing Habitat

The Yolo Bypass is a heavily engineered system to divert floodwaters from affecting the city of Sacramento. The Sacramento River has levees that run its course, before the river reaches the city there is an overflow that empties into agricultural land. If the water level gets too high, it exceeds the overflow and spills into the Yolo Bypass. Along the bypass is a large agricultural area devoted to rice agriculture, which lends itself well to the seasonal flooding in the river. Recent studies have shown that flooded rice fields can provide excellent winter nurseries for juvenile salmon, thus showing promise in establishing a system that, if properly managed, can support both agriculture and rehabilitate salmon habitat (Corline et al., 2017, Katz et al., 2017).

Before the bypass was constructed, the region was home to large wetland areas. These wetlands were an important component of the Sacramento River Valley, a flat expanse of land flanked by mountains where salmon flourished. Throughout the twentieth century, twenty major dams and 1600 miles of levees increasingly restricted salmon's access both to tributaries where they could spawn and to wetland habitats important for the rearing of their juveniles. The massive infrastructural intervention and importance of existing agriculture to both the food security and economy of the region makes it impractical to restore these floodplains to their pre-development conditions. That said, whilst "we can't restore these floodplains, we can recover their functionality" (Duggan, 2019). Recent scientific research shows that repurposing rice fields to flood in months when they would otherwise lie fallow could be the key to restoring populations of endangered chinook salmon (Katz et al., 2017).

Biologists used to view floodplains as a liability for salmon survival, because they thought that it stranded them. This conventional wisdom has been overturned in the last few decades, as the importance of floodplain habitat became better understood in the salmon lifecycle. Recent publications found that salmon which went through the bypass instead of remaining in the river had better chances of survival. This led researchers to conduct an experiment in which they released juvenile salmon in a flooded rice field and evaluated their growth and survival in comparison to salmon in the mainstem of the Sacramento River. This experiment took part in the Knaggs Ranch's rice fields.

KNAGGS RANCH

In winter 2012, five acres of the Knaggs Ranch rice field were flooded, and 10,000 juvenile salmon were released. When releasing the fish in the barren flooded fields, researchers were skeptical this plan would work fearing that the water would get too warm and anoxic for these fry to survive; however, after capturing the salmon the following spring they were astounded at the results. On average, the salmon reared in the rice fields weighed 12 times more than those that grew in the Sacramento River during that same period (Katz et al., 2017). The reason for this was that rice fields had enormous invertebrate populations which fed on the decomposing organic matter that remained on the fields. Juvenile salmon then capitalized on the large invertebrate populations that supplied them with a nutritious diet which spurred their growth and has also been shown to increase their chances of survival. "Managed inundation of winter fields appears to mimic natural prolonged residence times and hydrologic patterns under which central valley salmon evolved and to which they are adapted. Creation of an artificial flood on a managed agricultural landscape appears to have supported a robust aquatic food web and provided floodplain habitat conditions conducive to rapid growth of juvenile salmon" (Duggan, 2019). Because of this research there are now several plans to facilitate the access of juvenile salmon to flooded rice field habitats in the Yolo Bypass. Experts believe that this new habitat could significantly improve the chances of survival of endangered chinook salmon populations in the Sacramento River Basin.

This initiative attracted the attention of many farmers who were interested in improving salmon habitat, even some whose farms were directly connected to the river. This interest helped spark another

Figure 2.8 >

Flooded rice field. Although it looks inhospitable to fish, it provides valuable rearing habitat for juvenile Chinook salmon.

Figure 2.9 >

(Left) Juvenile Salmon reared in rice field.

Figure 2.10 >

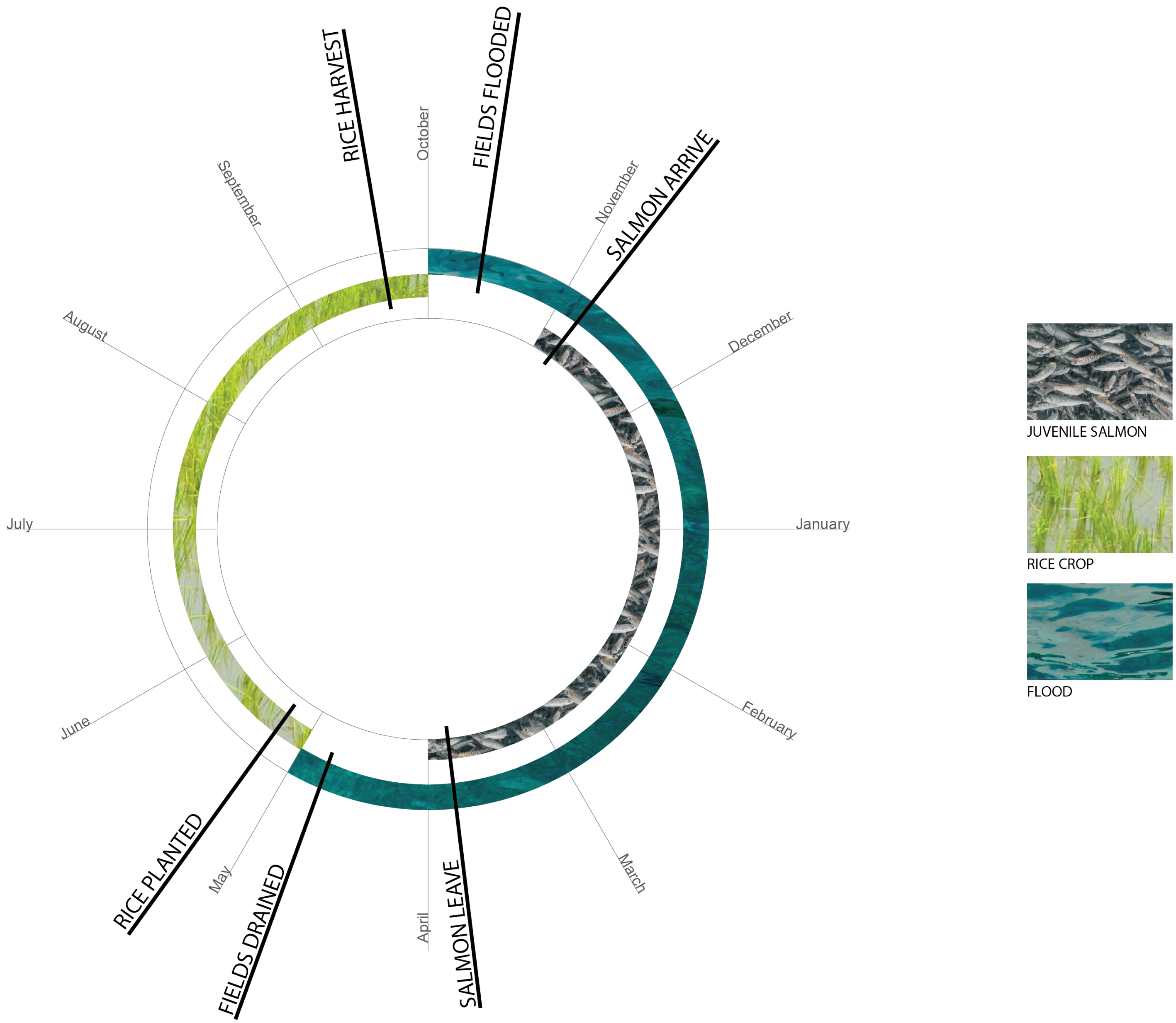
(Right) Sample of water from rice fields showing abundance of inverte-brates.

idea which functioned on the premise that "if you can't bring the salmon to the floodplain, you can at least bring the floodplain to the salmon" (Duggan, 2019). Rice farms that are not in the bypass but are adjacent to the river are still able to produce invertebrates on their flooded fields. Since these farms do not have a way to bring salmon to rear in their waters, they simply pump the water and invertebrates back into the river. While this arrangement does not provide salmon the habitat necessary to shelter from heavy floods it does increase the amount of food available for them in the main river channel and therefore increases their chances of survival.

Overall, this study shows that it is not necessary to recreate historic conditions in order to restore salmon and other wildlife habitats. It is more important to understand hydrologic river processes and to recreate the dynamic conditions under which the organisms you are trying to protect evolved. By strategically applying these conditions, it is possible to reconcile agricultural use of these floodplains, which is so necessary to the region's economic and food security, with habitats that are critical to preservation of salmon and other species. Further research to understand and refine such opportunities to combine agricultural production with floodplain habitat should be encouraged.

Figure 2.11 >

Diagram of salmon and rice sharing time in an agriculturally productive floodplain. Rice is planted in the spring and harvested at the end of the summer. Salmon arrive with the first floods of the season. They spend the winter nursing in the rice fields and continue their migration towards the sea before rice is planted again the following spring.


RICE HARVEST
October
FIELDS FLOODED
November
SALMON ARRIVE
December
January
February
March
SALMON LEAVE
April
FIELDS DRAINED
May
RICE PLANTED
June
July
August
September
JUVENILE SALMON
RICE CROP
FLOOD

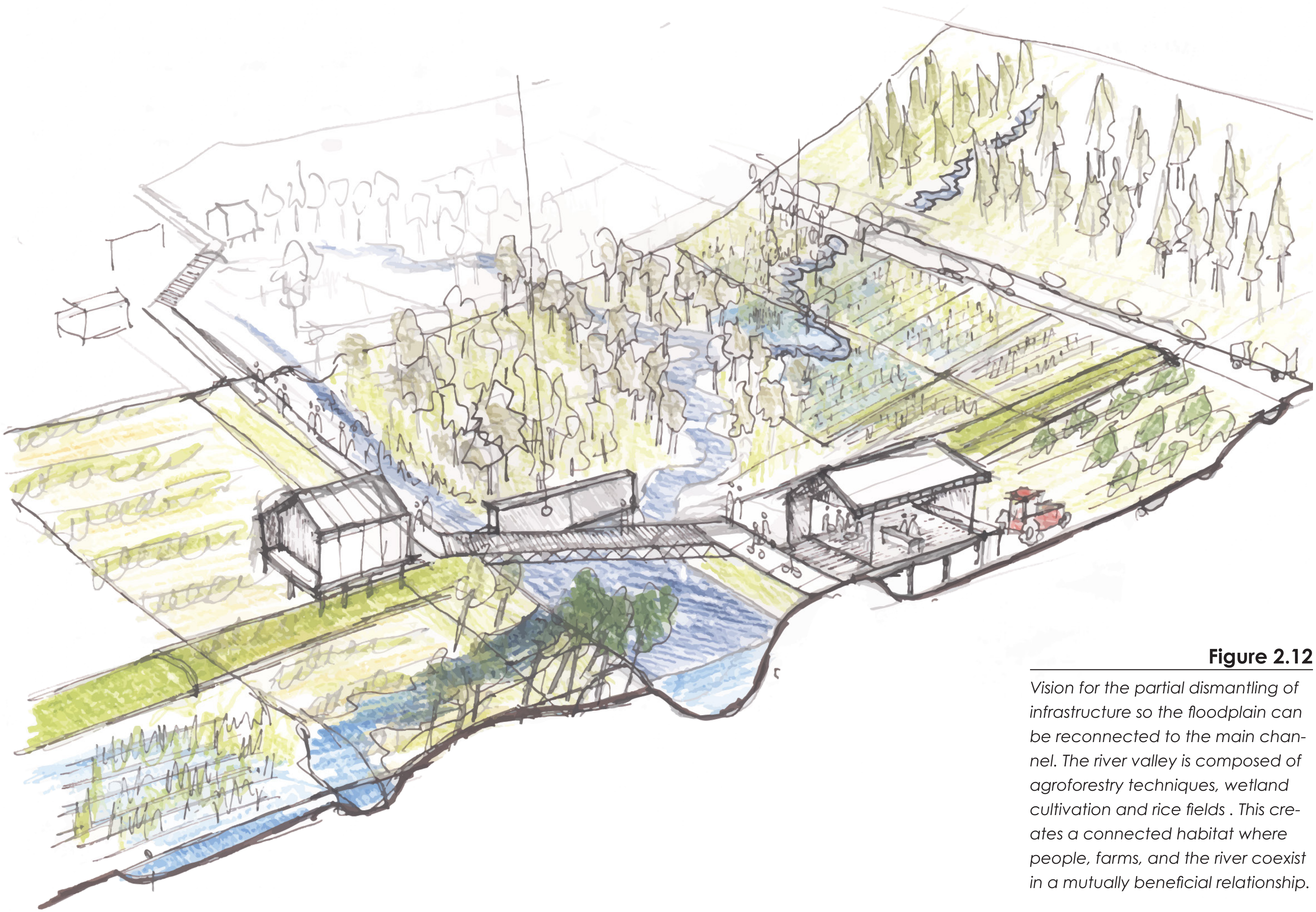
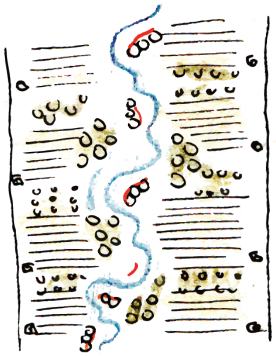


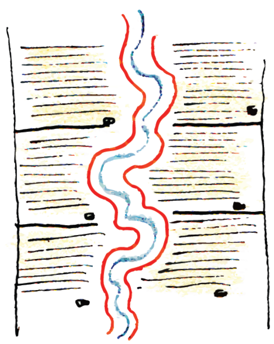
Figure 2.12

Vision for the partial dismantling of infrastructure so the floodplain can be reconnected to the main channel. The river valley is composed of agroforestry techniques, wetland cultivation and rice fields . This creates a connected habitat where people, farms, and the river coexist in a mutually beneficial relationship.

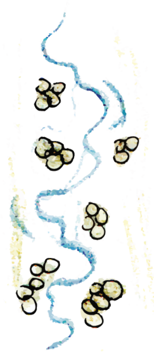
COMBINING METHODS: Making a New Landscape



Proposed



Existing



Historic

Imagine if agroforestry and rice farming were combined to create a new agricultural typology in the river valleys of the Pacific Northwest. This typology would enable the creation of fluvial landscapes that maximized the ecological potential of rivers, while still maintaining agriculturally productive land. Adjusting agricultural landscapes to embrace this approach to river management could help reestablish viable salmon populations and decrease flooding risks, while simultaneously enabling agricultural productivity. This would increase the region's food security, especially in light of climate change.

In order for these practices to become viable alternatives to contemporary agriculture, they must first be refined, supported by policy, and enabled by a strong regional market developed for these products. As the last section highlighted, the key to this is ensuring that they are economically viable for farmers. Only then can they be considered a viable alternative to contemporary agricultural practices. The case studies of wetland agriculture and working buffers were analyzed because they had the most potential for profitability. Part of the reason for this is that they represent strategies for the two most common farm sizes in the United States. Currently, the most profitable agricultural businesses in the US are large farms relying on industrial monocultures and small farms that make a living from diversification of income (Mishra et al., 2012). The cultivation of large monoculture crops, such as rice, to the rhythms of seasonal flooding enables large agricultural operations to produce high yields that are in turn able to feed our growing population. On the other hand, agroforestry approaches can empower the small farmer who wants to maximize their income streams by growing and processing high-value products. Our agricultural landscape will need to maintain this mosaic of small and large farms to ensure the profitability, productivity, and resilience of our food system.

These case studies show that developing opportunities for both large and small farms to reconcile agricultural use with floodplain habitat already exist. There will certainly need to be more research devoted to refining ecologically mindful methods and developing new ones, but the technical groundwork is well within our ability. With limited research and funding, rearing salmon in flooded fields that simulate wetland habitats and using agroforestry to recreate riparian habitat have shown ample promise of success. As we discussed, the main barriers to implementing these strategies are primarily social and economic. Given that the general population is unaware of river processes and their functions, it is necessary to change the common perception about rivers and flooding.

Persuading farmers to change their practices so they enable dynamic river processes, whilst also building the markets and policy that supports them, is not a shift that can happen overnight. It requires a change in the culture of agricultural production and consumption. Working buffers and rice farming have shown promise in reconciling the relationship between agriculture and river processes, but in order to demonstrate their feasibility on a large scale, it will be essential to implement pilot projects that determine how these approaches can fit the specific restoration and agricultural needs of different watersheds. Working examples of these landscapes are the necessary proof of concept to enable their implementation across the region.

THE VALUE OF PERI-URBAN AGRICULTURE

In selecting a trial site for the experimental implementation of this novel agricultural and river management approach, it is necessary to consider that many of the issues with promoting sustainable agricultural policy and developing demand for their agricultural products are deeply rooted in the disconnect between people living in urban areas and the process of growing food. In our current food system, policy perpetuates unsustainable farming practices because their products are most in demand. Therefore, if we wish to implement ecologically mindful agricultural methods, it becomes essential to create a demand for local products by reconnecting people to the process and meaning of growing

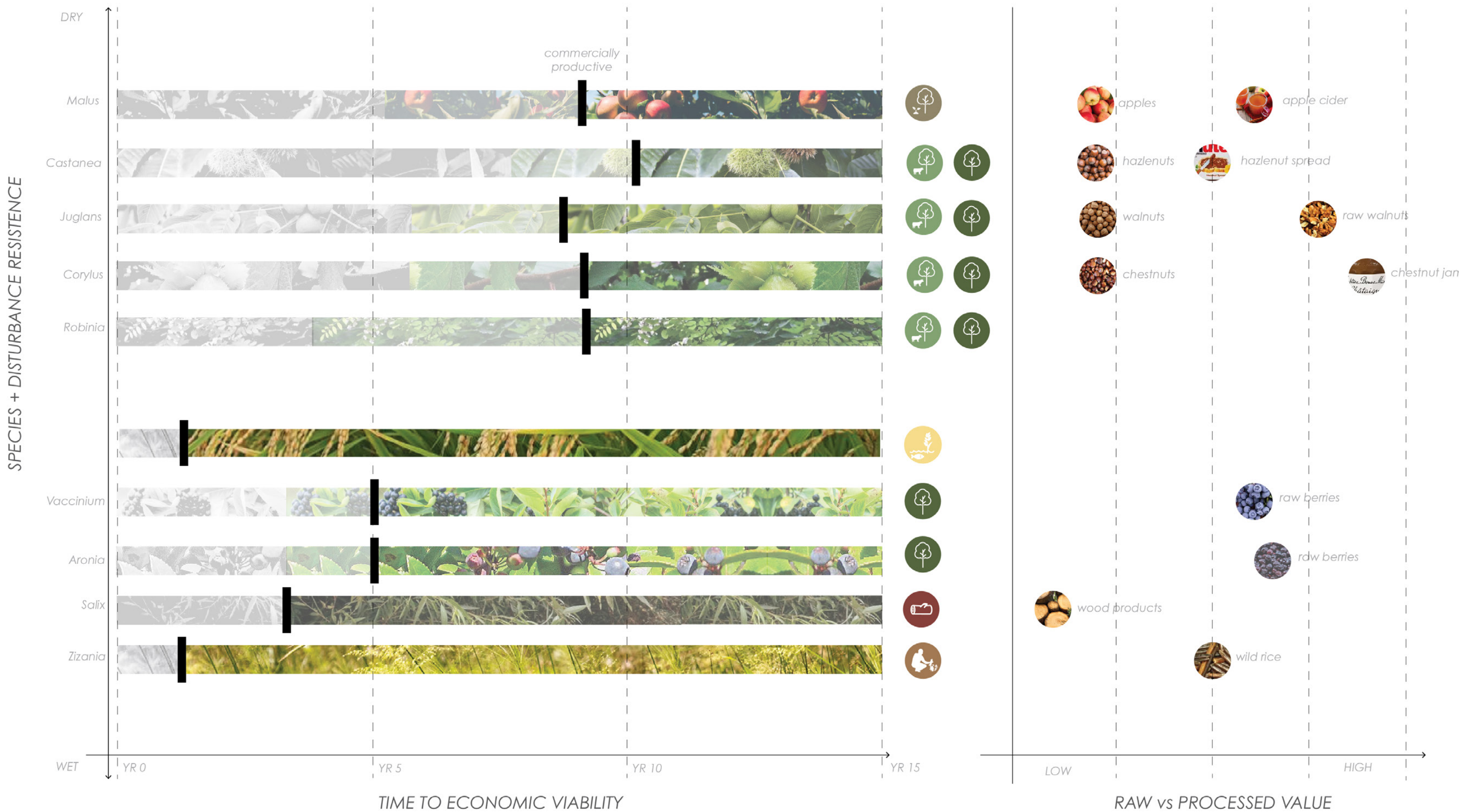


Figure 2.13

To enable the adoption of agricultural methods compatible with floodplain ecology it will be necessary to interpret the landscape based on crops' ability to withstand disturbance. It will also be necessary to understand how farmers can make a profit from their harvest. This matrix shows how to start approaching plant pallets based on the resistence to disturbance, as well as the economic value and harvest dynamics of each plant species.

food.

The project 'Agriculture on the Edge' from the University of British Columbia (UBC) School of Architecture hypothesizes that developing peri-urban agriculture around Vancouver BC could both benefit the agricultural community and help to reconnect urban-dwellers to the process of food production. They argue that such reconnections could drive demand for regional agriculture and promote sustainable agricultural practices (Codon et al., 2010). Thus, peri-urban areas have the necessary characteristics for a trial site that could help further develop and promote agricultural strategies that are compatible with a functioning floodplain. The Puget Sound region has several sites that fit these characteristics.

Washington State is experiencing patterns of land speculation similar to the Vancouver BC metropolitan area. Land speculation is prompting many farmers to sell their land, compromising the vitality of agricultural communities as well as regional food security. Like in Vancouver, it could be beneficial to integrate Washington state's peri-urban agricultural areas with the fabric of cities and promote regionally produced agricultural goods. One of the peri-urban zones in Washington State that has the greatest potential to act as a trial site for holistic river management is the agriculturally protected land within the Sammamish River Valley.

The Sammamish River Valley is a river corridor that connects two large urban lakes in the Seattle metropolitan area. In many ways, the valley is a peri-urban mirror to the issues that affect rural river drainages across the region. Just like in rural areas, development, habitat restoration, and river management are competing with agricultural use. As such, implementing holistic river management will face many of the same issues that halt these approaches in other more rural river valleys.

With that said, unlike rural valleys, the Sammamish River Valley has significant pedestrian and public transit access from Seattle, making it a highly used recreational area for biking, walking, and as of recent wine tasting. This means that the site's proximity to urbanity would enable a much more accessible and direct exposure to the public, facilitating the funding and proliferation of new ideas. When de-

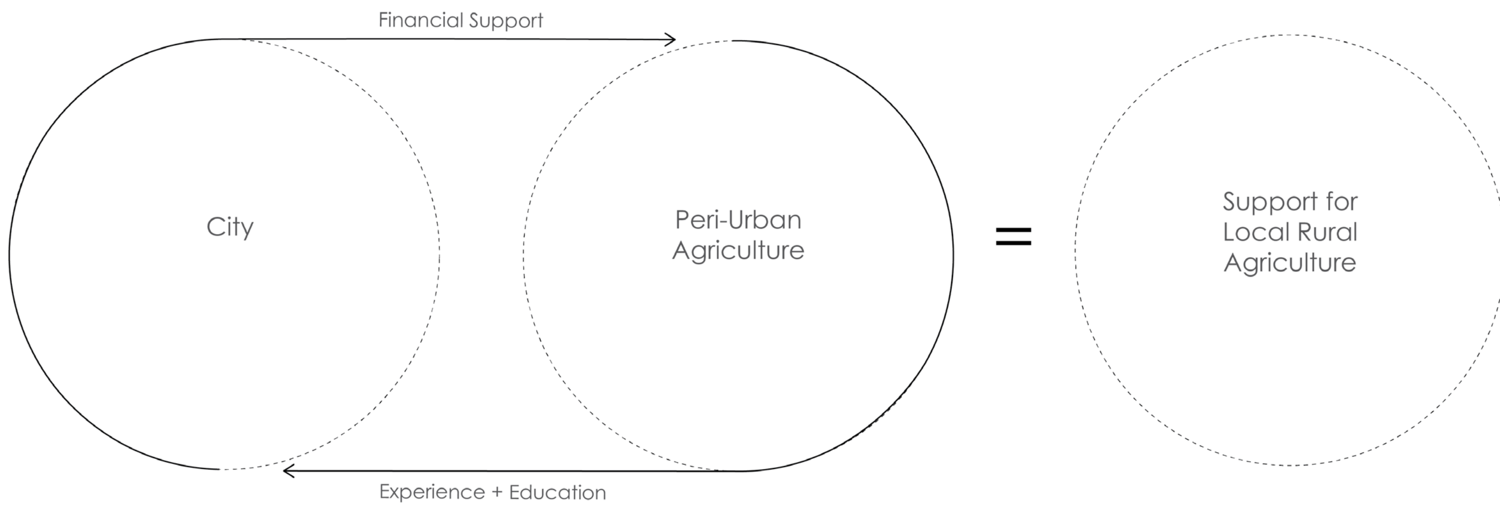


Figure 2.14

Connecting urban areas to peri-urban agricultural zones has the potential to support regionally produced goods. We can use this same strategy to promote and test agricultural methods that are compatible with floodplain ecology.

manding that we radically shift our way of thinking around the management of a resource, there is no replacement for proof of concept. The vibrant public interface of the Sammamish River Valley can help it become a living, breathing example of a new agricultural landscape typology. The next chapter will look further into the possibility of converting the Sammamish River Valley into a test site for an alternative approach to agriculture in floodplains.

LESSONS LEARNED:

1. In order to be able to make agroforestry more accessible and widespread, it will be necessary to create cohesive basin-wide approaches to enable large scale habitat impacts and facilitate the processing of specialty agricultural goods.
2. Farmers will need help in order to both plan and execute successful agroforestry supplementations to their existing crops. Creating these opportunities is not out of reach, but "this process will require experimentation, flexibility and accountability" (Dittbrenner et al., 2015).
3. Markets for agroforestry goods will need to be expanded and tested to enable enough demand for a region-wide adoption of these methods.
4. Conventional agriculture and wildlife habitat is compatible under the right circumstances.
5. Peri-urban areas are ideal testing sites for new agricultural methods because they provide a direct connection to the city and its markets.

PART 2: PEOPLE AND AGRICULTURE

Strategies that reconcile the relationship between agriculture and river ecology already exist; however, to become economically viable for farmers, they require the support of urban populations. Peri-urban areas create an opportunity to bridge the spatial divide between cities and farms. By reconnecting people to food production, farmers can be empowered to implement agricultural strategies compatible with river ecology.

CHAPTER 3: PERI-URBAN AGRICULTURE IN THE SEATTLE METROPOLITAN AREA

The Seattle metropolitan region is rapidly expanding due to an economic boom related to the technology industry. This is increasing local population and pressure on existing infrastructure, whilst also raising living costs and demand for housing. As the demand for land and housing spills outside the city, the survival of the region's agricultural communities is being threatened by land speculation (McCrate, 2019). Despite the designation of many protected zones for agricultural production (APDs), land speculation is increasing property value and threatening the viability of farm operations across the region, especially those closest to urban centers (Dittbrenner et. al., 2015). Losing agricultural land to the forces of development is damaging to regional food security, as well as human wellbeing.

As previously discussed, developing a more resilient and sustainable food system is at least partly dependent on involving urban-dwellers in the process of growing food. Seattle recognizes these benefits of urban food production and has been a global leader in developing legislation that encourages agricultural uses within its urban core (Seattle.Gov, 2015). While urban agriculture is effective, it does not replace the need for peri-urban and rural agriculture.

Peri-urban agriculture is particularly important because it mediates the transition between urban and rural, and - if properly supported by legislature - it could create even more opportunities for urban dwellers to connect with the process of food production. Connecting Seattle's growing urban agriculture movement to peri-urban agriculture around the city could enable the realization of "a municipal focused agriculture in which agriculture and urbanity are inextricably linked via planning and economic study" (Codon et al., 2010). This system would have health and wellbeing benefits for the region's residents, whilst also supporting the vitality of the state's agricultural community and driving the demand for sustainably grown products. (diagram showing urban rural peri urban)

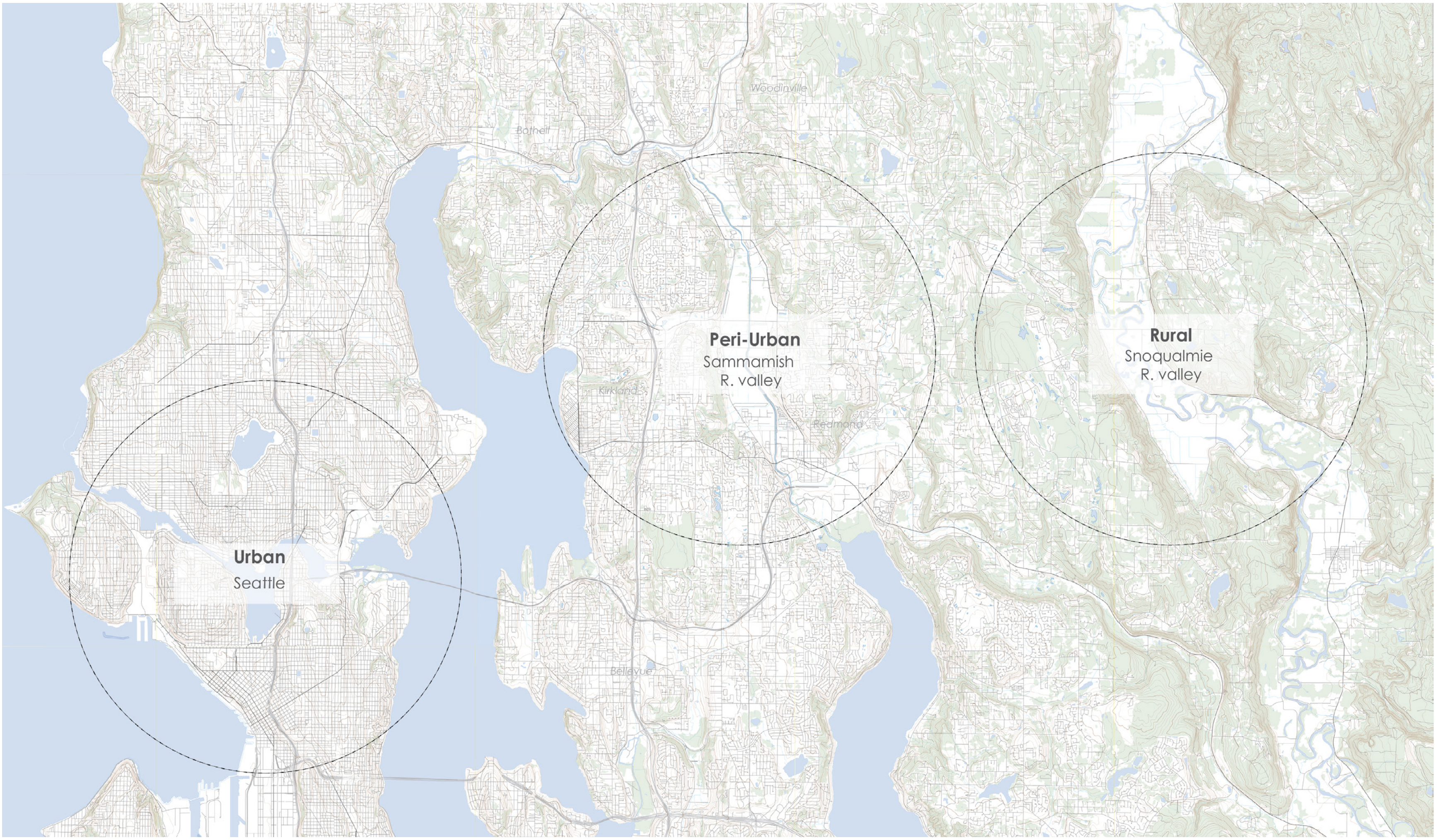


Figure 3.1

Context map of the Seattle metropolitan area. In this map we can see Seattle's urban core (left), then the Sammamish River Valley peri-urban area (middle) and the rural Snoqualmie Valley (right). This sets up a typology similar to what is discussed in Agriculture on the Edge, allowing the connection between urban agriculture and peri-urban agriculture to support regional agriculture. In many ways the Sammamish River valley is a mirror to the Snoqualmie Valley, this similarity enables using this peri-urban area as a testing site for agricultural methods compatible with a functioning floodplain ecology.

The Sammamish River Valley

One of the areas most suited to the peri-urban extension to Seattle's growing agriculture movement is the Sammamish River Valley. This valley is connected to Seattle by a bike trail which runs from the Puget Sound, through Seattle's metropolitan region and connects the cities of Bothell, Woodinville, and Redmond, before snaking its way to Issaquah and into the Cascade Foothills. The City Link light rail is also planning a connection between Seattle and Redmond, further increasing pedestrian access to the valley.

The Sammamish River Agricultural Production District is designated as a protected agricultural area. This agricultural zone is already home to several farms that are engaging with the urban interface to support the livelihood and enrich the lives of urban-dwellers. Viva Farms is one of these operations. It functions similarly to 'p-patches' common in the city, which offer land for people to grow their own crops. This favorable attitude to engaging in ecologically sustainable agriculture, shared by many farms, as well as the valley's strategic positioning in relation to Seattle are what make it a prime location to both test and propagate new agricultural techniques.

In addition to being a viable testing ground for new agricultural techniques, the Sammamish River Valley is also a prime location to experiment with holistic river management strategies that use floodplains as flood control infrastructure. The Sammamish River Valley has been subject to similar hydrologic manipulation as the rest of the Pacific Northwest. The Sammamish River is managed by King County and regarded as a flood conveyance facility by the Army Corps of Engineers. This means that its objective is to limit flooding in the valley and, like the rest of the region, it does this through a combination channelization and bank stabilization (King County, 2002).

The maintenance and upkeep of this infrastructure costs the county substantially and, since flooding is forecast to become more frequent and severe, these maintenance costs will only increase.

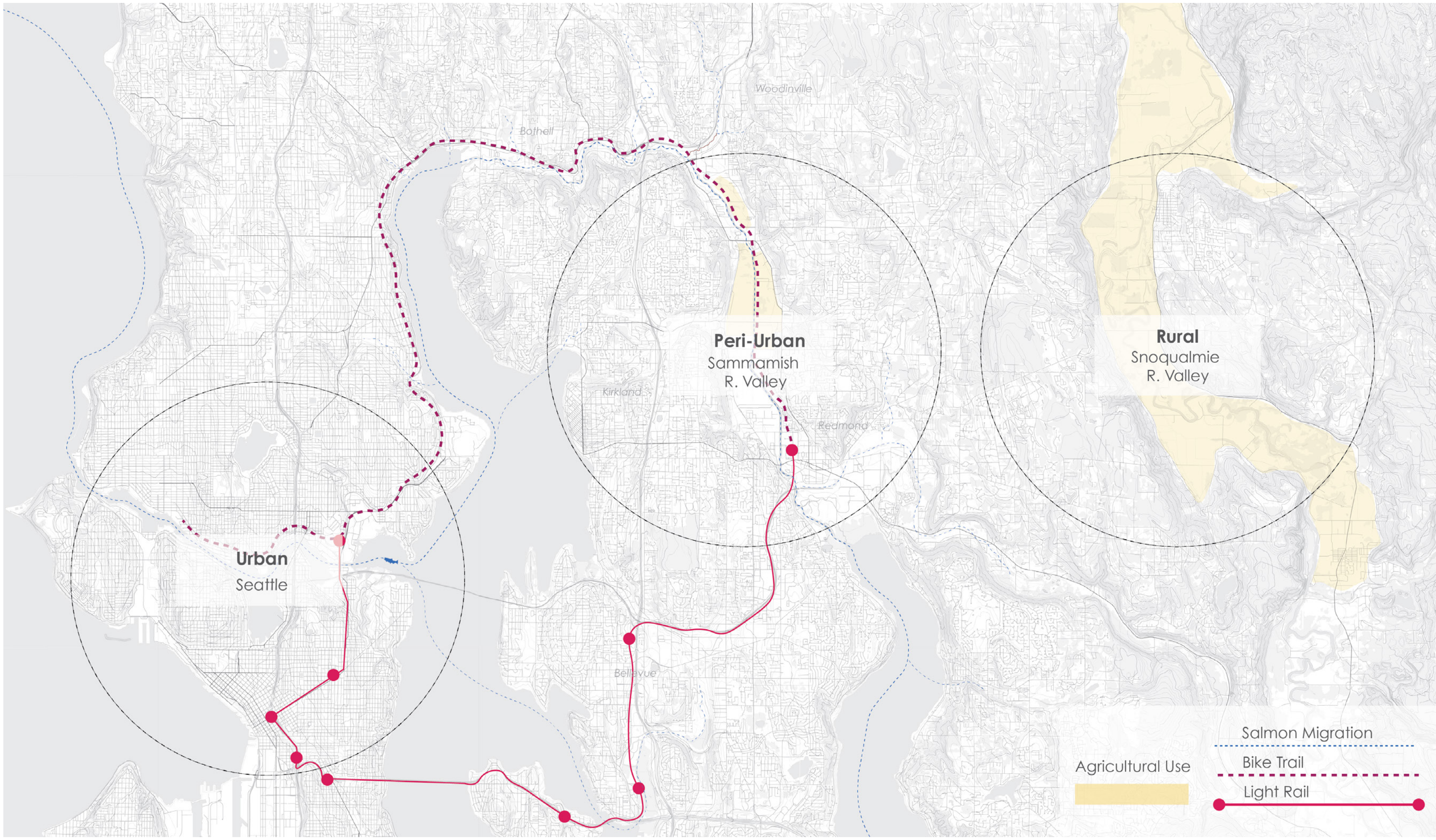


Figure 3.2

Context map highlighting the pedestrian and public transit connectivity between the Sammamish River Valley and the Seattle metropolitan area. The agricultural zone of the valley is directly accessible by a light rail station, as well as a network of bike trails that follow the path of migrating salmon through the watershed.

This struggle between infrastructure costs and flooding can be addressed by implementing a holistic approach to river management. Historically, the Sammamish River Valley was a perpetually wet environment dominated by riparian forests and seasonal wetlands (King County, 2002). This environment functioned as a natural sponge and absorbed much of the energy of floods. Restoring the patterns of riparian vegetation and seasonal wetlands by giving rivers more room has the potential to dampen flooding and restore habitat, whilst costing less than the long-term maintenance of existing infrastructure (Biron et al., 2015).

The implementation of a holistic strategy to control flooding in the Sammamish River is an alternative to the existing channelization- it could be less costly and more beneficial to salmon. Like elsewhere in the state, the main challenge to implementing a holistic approach is the agricultural use of the valley. One of the reasons for the construction of the flood conveyance infrastructure was to promote agriculture (King County, 2002).

NEW VISION FOR THE SAMMAMISH RIVER AGRICULTURAL PRODUCTION DISTRICT

Reimagining the agricultural use of the valley, so that it is compatible with a functioning floodplain, could enable the restoration of the floodplains critical to salmon in the watershed. The case studies of rice farming, salmon and working buffers, covered in the last chapter, are tools that can be applied to fit this purpose. To be able to successfully implement them, it is necessary to directly address the flood conveyance needs, the restoration efforts, as well as the agricultural uses of the Sammamish River Valley.

This understanding of the Sammamish River as a living case study frames the valley as both a place to experiment with new agricultural techniques, as well as a place where people can be exposed to them and directly reap the fruits of their benefits. The network of trails that connects Seattle's urban core to this peri-urban agricultural zone, follows the path of salmon from when they enter fresh-

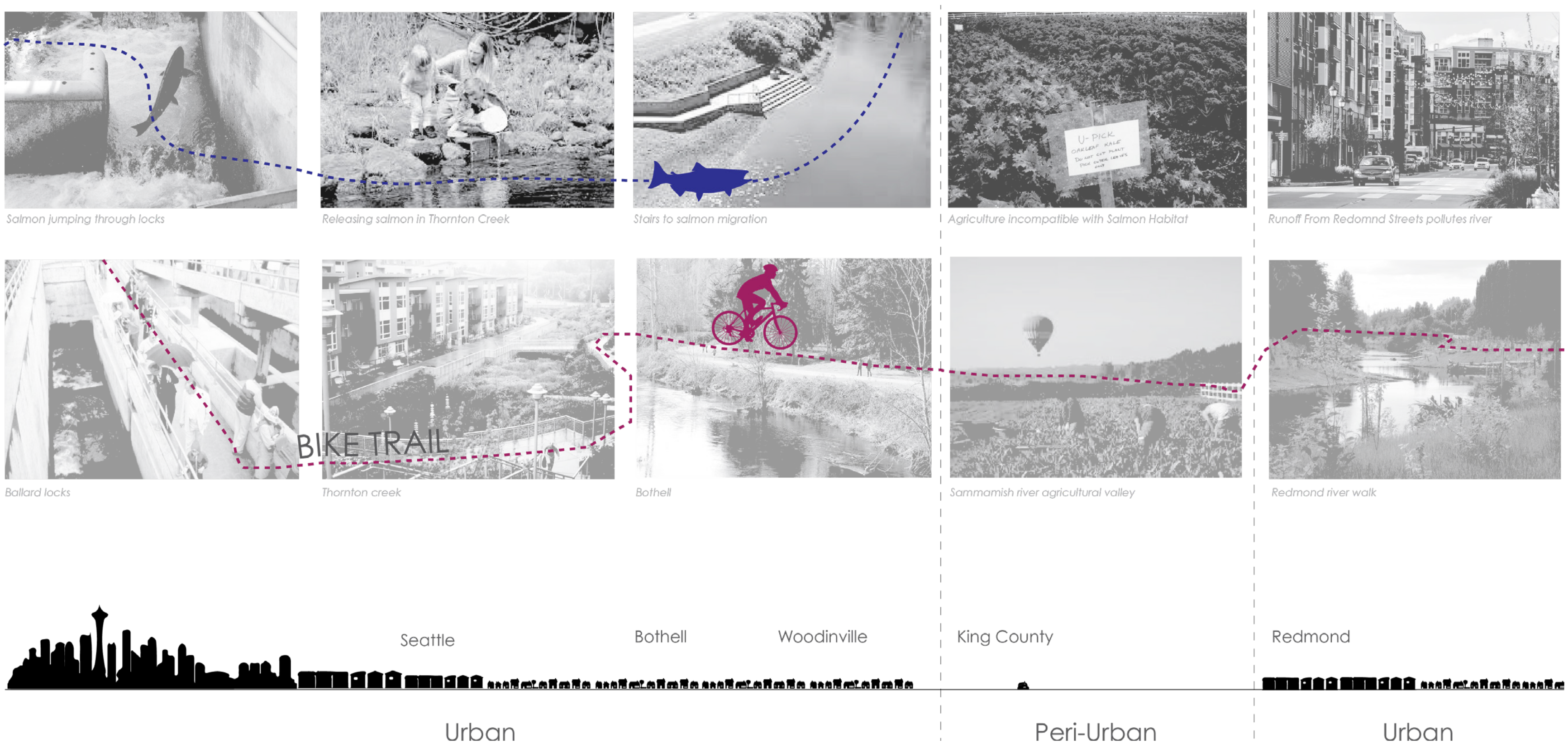


Figure 3.3

The network of trails that connects Seattle to the Sammamish River Valley follows the path of the salmon through the watershed.

water at the Ballard Locks, through the Montlake Cut, Lake Washington, the Sammamish River, and finally to the tributaries which they spawn in. This trail can act as a medium for people to connect both to the process of growing food through agriculture, as well as to the importance of catering agricultural use so that it enables the survival of nutritionally and culturally important species like salmon. By engaging with the story of salmon and agriculture in the Sammamish River valley, people can begin to understand, feel, and experience the sensations associated with this new approach to agricultural landscapes. The fluidity between urbanity, agriculture, and wild sources of food could enable a new kind of understanding of ecology, one that can help reverse approaches to river management strategies across the region to better support holistic strategies. By liberating the Sammamish River from the confines of twentieth-century approaches to flood control and agriculture we can build momentum to liberate other rivers across the region.

Implementing a holistic mentality to the Sammamish River Valley requires an understanding of the story of people, salmon, and agriculture in the Seattle metropolitan region. The following sections will cover these subjects, as well as how the Sammamish River Trail could be used to reconnect people to the process of growing food and to reconnect the process of growing food to the ecology of the watershed. (diagram showing trail)

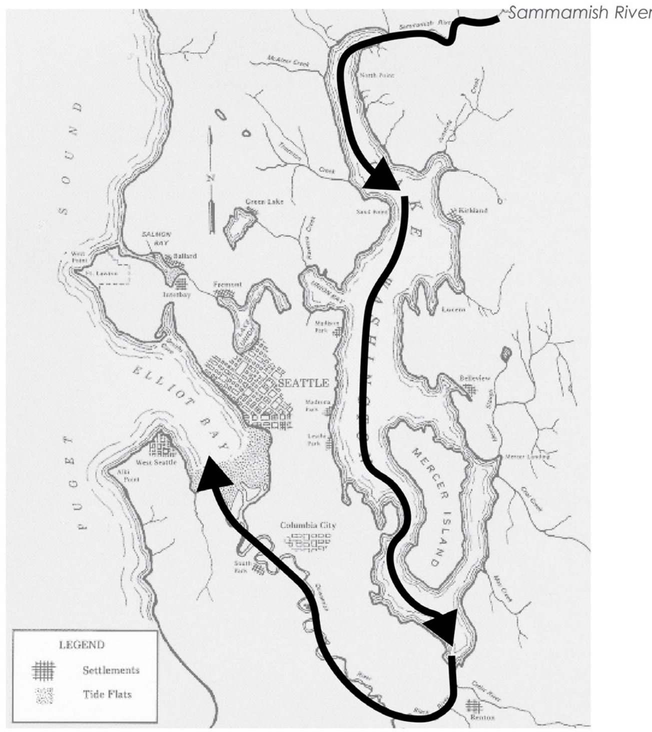
Seattle, Salmon, Flooding, and Agriculture

What we now refer to as the Seattle metropolitan region has always had an intimate connection to salmon. Historically, several groups of indigenous people had settlements around the area and lived primarily off of the abundant salmon runs of the Cedar and Duwamish Watersheds. Today, the city is known internationally as a hub for eating salmon - the Pike Place Market is renowned for its ceremonial fish tossing, and Seattle is also home to one of the largest fishing fleets in the United States. The irony is that to support Seattle's cultural connection to salmon, these fishing vessels have to venture thousands of miles north to Alaska every summer to catch their quota. This is a symptom of the decline of the once abundant Puget Sound Salmon.

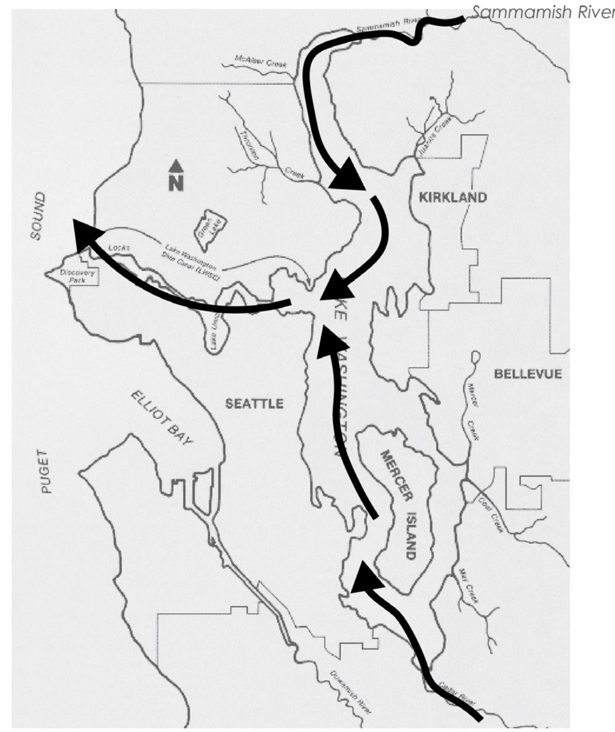
The Lake Washington Watershed is exemplary of how state and county river restoration policies are hindered by the Army Corps of Engineers' management principles. Starting in 1900 the Army Corps of Engineers began several major infrastructure projects aimed at "improving" Settlement to the region by reconstructing its waterways. The primary set of changes was the digging of a network of canals

Figure 3.4 >

Changes in the lake Washington watershed. Arrows show change in the flow of water after the Montlake Cut was completed by the Army Corps of Engineers.



Pre Montlake Cut



Post Montlake Cut

known as the 'Montlake Cut' which connected Lake Washington to Lake Union and then Lake Union to the Puget Sound. This major infrastructure project lowered the Lake Level by 9 feet and completely reconfigured the hydrology of the watershed (Klingle, 2008). Before these changes, Lake Washington drained into the Puget Sound through the Black River on its southern shore. The lowering of the lake through the digging of the Montlake Cut to its west, dried the complex hydrologic environment to the south of the Lake, separating the Duwamish and the Cedar River systems into two separate watersheds. The Black River, which used to carry water from Lake Washington and the Cedar River to the Duwamish, no longer exists. (diagram showing changes to Lake Washington)

Other major "improvement" projects notable to the region's watershed were the armoring of Seattle's shoreline and filling of the Duwamish estuary with sediment from the Denny regrade. This preceded the Montlake Cut and involved re-grading Denny Hill and dumping the extracted material to fill the Duwamish estuary (Klingle, 2008). One of the most recent additions to the major infrastructure projects of the watershed was the dredging, straightening, and bank reinforcement of the Sammamish River, which connects Lake Sammamish to Lake Washington. The combined effects of these changes were extremely detrimental to salmon across the region and contributed to several populations, including the watershed's King Salmon, to become listed as federally endangered. Despite these setbacks and the dramatic decrease of their numbers, some salmon still manage to make their journey through Lake Washington and Lake Sammamish to their spawning grounds. Even though most of these are products of hatcheries, there remain several wild populations (Klingle, 2008). This is a testament to the resilience of the species and is a welcome sign that if we put efforts towards restoring the habitat they require to thrive, the salmon can and will recover.

There are currently many initiatives to restore salmon habitat across the watershed, and King County is a state leader in the implementation of innovative restoration approaches. Several projects aim to remove levees and set back bank stabilization to restore riparian forests and wetlands to give rivers more room to move. These projects are in line with the mentality of holistic approaches to river management and constitute an important part of the restoration of the area's waterways; however, some of the most critical components of ecosystem recovery are hindered by federal regulations surrounding waterways.

The Sammamish RIver is listed as one of the highest restoration priorities for salmon in the Lake Washington watershed; however, restoration activities have been hampered by its delineation as a flood conveyance facility managed by the Army Corps of Engineers. This was a result of a push from agricultural interest to protect the valley from spring flooding and resulted in the further dredging and straightening of the river in 1964 (King County, 2002). This approach to the management of the Sammamish River is emblematic of the United States' federal approach to river management, which over the 20th-century promoted heavy engineering in the management of rivers as a way to protect its societal values. This is also emblematic of the link between agricultural development and the Army Corps of Engineers. Instead of adjusting the agricultural development of flood valleys, agriculture management has demanded the control of rivers to be able to perform agriculture without restraints.

The Sammamish River is a prime example of this relationship between agriculture and river management – agricultural use of the valley was one of the primary reasons for the alterations to the river which resulted in the loss of valuable salmon habitat. This sets up an ideal premise to test the reconciliation between river ecology and agriculture. This is key to implementing holistic approaches to river management across the Pacific Northwest.

As was discussed in the previous section, the opportunity to address this problem in the peri-urban setting of the Sammamish River Valley has enormous potential to simultaneously address the issues of river management and food security, whilst also encouraging public exposure to them. Ironically, the trail network which connects Seattle's urban core to the Sammamish River Valley, tracing the upstream migration of salmon, is built on the very infrastructure responsible for the destruction of salmon habitat in the Sammamish River. This setting allows us to envision what kind of an agricultural landscape is possible if we transition to a holistic approach of river management where agriculture and development are conceived as compatible with the river's dynamic ecological patterns. Additionally, it also forces us to re-imagine the public interface to this project so that it supports the principles of river management scientists are urging us to adopt.

The combination of these factors makes the Sammamish River Valley the ideal location to test, implement, and educate the public about the reconciliation of Agriculture with Dynamic River processes. It also makes the Sammamish River Valley a place where people can connect to the meaning and health benefits of an ecologically conscious system of food production. To achieve this vision, we need to specifically address the agricultural and flood infrastructure requirements of the valley, while also understanding the restoration goals that would enable the reconciliation between river management, agriculture, and salmon. The following section will go through an exemplary site design that reconciles the interests of farmers, people, and river managers to create a holistic approach to the management of the Sammamish River. While this will ultimately require the collaboration from experts within different fields, the following analysis establishes a framework and sets a cohesive vision for what the valley could look like.

CHAPTER 4: ECOLOGY, AGRICULTURE AND PEOPLE

How can the Sammamish River valley become a testing site for agricultural methods that are compatible with a functioning floodplain ecology?

Currently, the primary land uses in the Sammamish River corridor are publicly owned land and agriculture. The river then runs through the city of Redmond before winding its way next to the large Willowmore Golf Course and 60-Acres Park. The following segment is the most channelized and degraded, this part of the river runs through the heart of the agricultural production district before finding its way through the towns of Woodinville and Bothell. After meeting with some major tributaries, it then is confined to a narrower topography before spilling into Lake Washington.

Natural History of Sammamish River Valley

Despite the region's culture being deeply connected to salmon, the principles which have dictated the valley's development have also directly contributed to the decline of this species over the past century. This is apparent in the history of the Sammamish River Valley. The Sammamish River hydrologically connects Lake Sammamish to Lake Washington. Before its manipulation in the twentieth century, the Sammamish River Valley was composed of a meandering main channel that snaked its way across a complex mixture of riparian forests, wetlands, and small brooks joining the habitat from the hillsides (King County, 2002).

The relationship between forest, erosion, and water was vital to the system. This habitat supported overhanging vegetation from the riparian forest, which created a microclimate cool enough to support salmon on their uphill journey towards their spawning grounds. Additionally, it supported riparian wetlands which offered an ideal habitat for juvenile salmon to shelter from predators, feed, and grow.

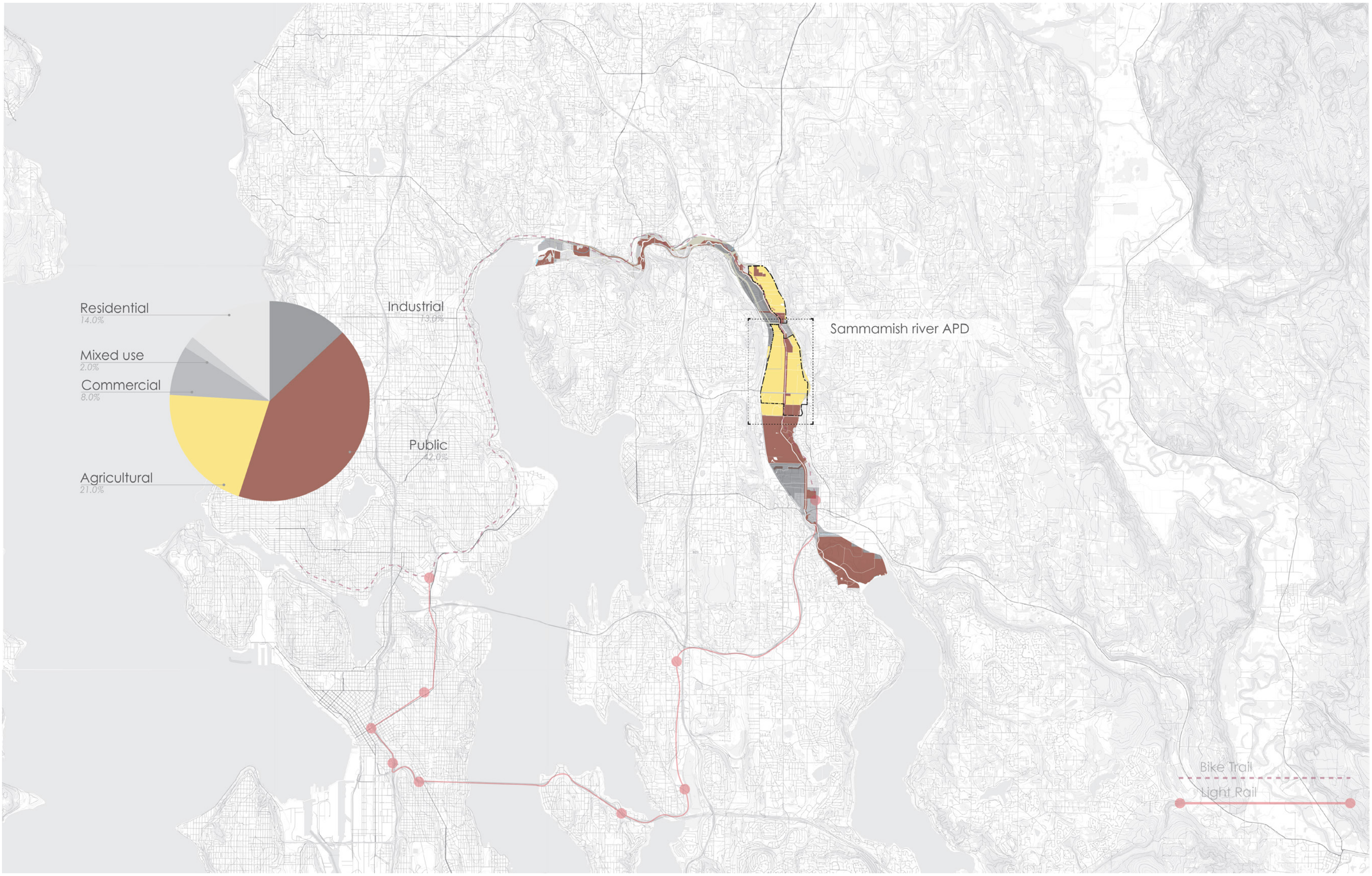


Figure 4.1

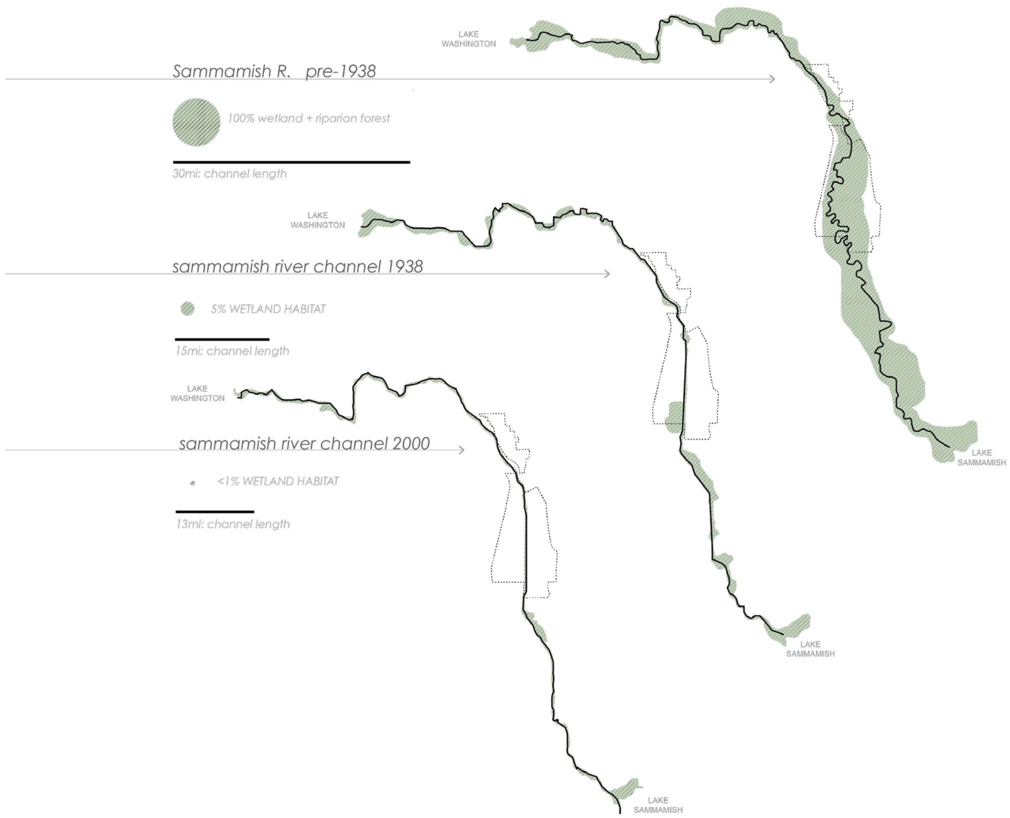
Context map showing the different land uses in the Sammamish River Valley.

Juvenile salmon survival is dictated by the species' ability to obtain proper nutrition throughout their early life stages. This relationship between forest, wetlands, and water made the Sammamish River Valley a highly dynamic habitat, and therefore, enabled it to be one of the most successful rearing grounds for juvenile salmon in the entire watershed (King County, 2002).

In addition to salmon, these processes also supported a large diversity and abundance of waterfowl, woodland birds, predatory birds like hawks, falcons, and eagles, ungulates like deer and elk, as well as cougars, bobcats, bears, wolves, and other predators (King County, 2002). The indigenous people that settled in the valley were known as the Sammamish Tribe and had a central village near the current city of Kenmore. They also had several fishing and hunting camps that were inhabited based on the availability of forage and the levels of the river. These communities took advantage of both the abundance of salmon, as well as the other sources of wildlife and forage, to sustain their people throughout the year.

As European settlers moved into the valley, they quickly began changing its characteristics. After several wars and smallpox outbreaks, the Sammamish settlements were forcibly disbanded and relocated. Then, without understanding the implications of their actions, European settlers began the logging of the valley. Logging greatly reduced the river's ability to sustain its patterns of meandering and wood recruitment that enabled the generation of habitat complexity. Over the first part of the twentieth century, several dredging and channelization operations were conducted by the Army Corps of Engineers to facilitate the extraction and transport of timber, as well as enabling the settlement of the valley (King County, 2002). These changes were seen as improvements from the perspective of the Army Corps of Engineers; however, while they enabled the use of land for agriculture according to Euro-American customs, they also damaged the watershed's ability to sustain salmon populations.

A final round of dredging and straightening of the channel took place in 1963 when the Army Corps of Engineers also designated the Sammamish River as an official 'flood conveyance facility' (King



Sammamish R. est 1938

Figure 4.2

(Left) Change over time of Sammamish river channel. Notice the decrease in habitat as the river was dredged and straightened. (Right) Historic photograph of Sammamish River after the first round of dredging was completed. Notice the old meandering channel on the left side of the valley with pieces of riparian forest and wetlands still intact.

County, 2002). This was done to promote the settlement of the valley, as well as its agricultural use. The nominal objectives in the 1963 document were to:

1) Prevent the overflow of the Sammamish River, especially during springtime flooding events;
2) Maintain Lake Sammamish water levels below 29ft to protect settlements around the lake;
3) Maintain the Sammamish River as a navigable waterway.

The final dredging of the river was conducted in 1963 and completely disconnected the river channel from the Sammamish Valley floodplain, effectively destroying all juvenile rearing habitats and compromising the stream characteristics that enabled the safe return of adult salmon to their spawning grounds. This had palpable effects on the Lake Washington Salmon population and, to make up for the decreased survival rate, the state-funded the budget for the Issaquah Fish Hatchery which remains in operation today.

In addition to decreasing the salmon population, completely draining the riparian wetlands decreased the system's ability to absorb the energy of winter and spring flooding. This means that all the energy from flooding now has to be absorbed and managed by the channel itself. The process that was used to achieve this was the deposition of the dredged material to the banks as pseudo-levees. The combination of a deeper channel, the lowering of the water table from the Montlake Cut, and the deposition of dredged material on the sides of the channel completely disconnected the Sammamish River from its floodplain (King County, 2002). Furthermore, the increased flow from the hardscapes due to development is more likely to both degrade water quality and increase the threat of flooding (King County, 2002). For now, these effects can maintain control of the river; however, as climate change polarizes patterns of precipitation and increases risks of flooding, the continued integrity of this river management system is uncertain. (diagram showing change over time)

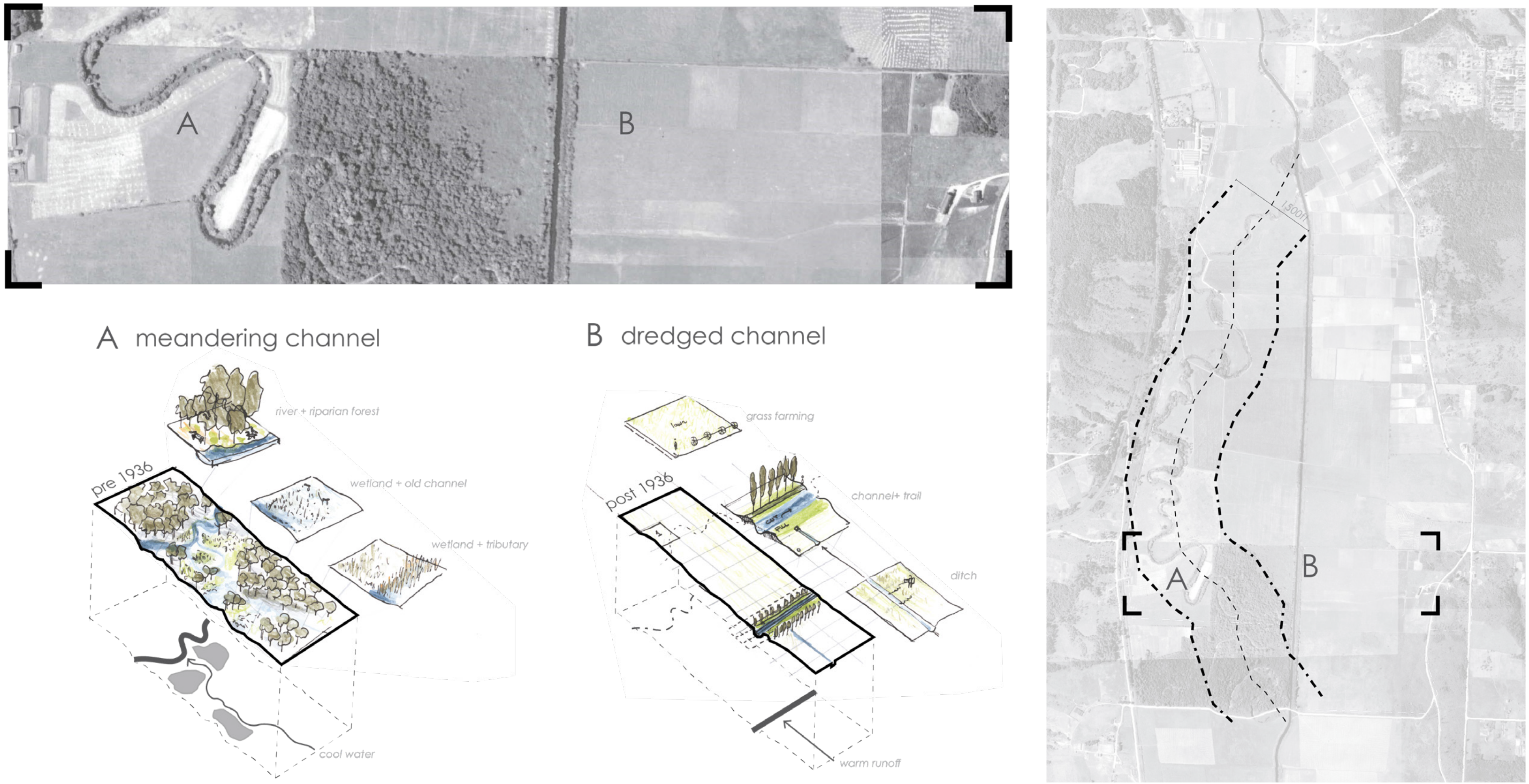


Figure 4.3

Diagram Showing historical conditions vs contemporary conditions. Notice the changes in habitat quality and complexity after the channel was dredged. Dredging and agricultural use transformed the tributaries into ditches. Instead of being a benefit to the ecosystem these waterways now channel warm runoff with pollutants into the main channel. The main channel also lost habitat complexity as a result of the dredging. The combination of these factors have created an environment toxic to salmon.

One of the primary reasons the river channel was dredged was to promote agricultural use of the valley. While there are several farms that focus on growing market vegetables, the vast majority of the land is devoted to sod farming. Sod farming is the growing of grass for lawns and golf courses. While this has a relatively high cash value, it has no use when it comes to ensuring food security, and it is detrimental to salmon habitat. The intensive farming of grass is often detrimental to the local ecology due to its high water and fertilizer needs (King et al., 2001). To leave the majority of existing development as grass farming would thus be a missed opportunity to simultaneously increase the regional food security while also providing the restoration of some highly degraded salmon habitat.

Today most of the agricultural land in the Sammamish River Valley is for the farming of grass. Therefore, what our society has determined is that the farming of grass is more important than the survival of salmon in the watershed or the food security of the region. Granted, these decisions were not necessarily made consciously – they are likely the result of a lack of ecological understanding. Yet, even though today as a society we tend to value salmon more than grass, restoration strategies that are attempting to improve salmon habitat within the river corridor are limited in the agricultural areas of the valley.

Approach to Restoration

Current restoration efforts within the Sammamish River Valley focus on two goals, riparian revegetation and side channel/wetland creation. Most of the river corridor is limited to riparian restoration due to existing land use such as agriculture, but where possible side channels and wetlands are created to improve habitat for salmon. Within this context the two habitat priorities are wetlands as nursing habitat for juvenile salmon and riparian vegetation to cool the water for returning salmon (WRIA 8 2017 Chinook Salmon Conservation Plan Update, 2017). As we discussed, riparian restoration alone is not going to maximize the habitat potential for salmon. This is acknowledged in the Sammamish River Corridor resto-

Figure 4.4

Agricultural use of valley: notice how most land is used for the farming of turf grass, especially within the 100 year floodplain. Turfgrass farming is often times toxic because of its need for pesticides and fertilizers. Despite the strip of land closest to the river being owned by the county, it offers no buffer from the agricultural use. The Army Corps of Engineers have delineated this as a flood conveyance facility. The county is unable to plant riparian vegetation throughout the channek because of its current classificatian.

ration plan; however, land use is cited as a primary barrier to implementing more land intensive floodplain restorations throughout the valley (King County, 2002).

Currently, there are only two examples of floodplain restoration along the river corridor. These are the Bear Creek Restoration Project, and the Willowmore Floodplain Restoration Project. Given the vast changes to the watershed, these restoration efforts do not try to recreate the historic conditions of the channel. Rather, they are attempting to meet both flood control and habitat restoration goals. The primary strategy they use to accomplish this is re-grading the existing river channel to maximize floodplain habitat and restore the dynamics of the historic channel. This is similar to other floodplain restoration projects that are being done across the Puget Sound. These projects consider restored floodplains as part of the flood control measure since they absorb the energy of flooding. The advantage to using restored floodplains as opposed to heavy infrastructure is that they are cheaper to maintain over the long run and provide valuable habitat for fish and other wildlife (Biron et al., 2014). This is also the premise of holistic river management initiatives such as Floodplains by Design.

Like elsewhere in the state, one of the biggest barriers to the implementation of holistic river management strategies within the Sammamish River corridor is agricultural use. In the entire Sammamish River valley the biggest potential for a floodplain restoration project falls within the agricultural production district; however, the designation of the area as an agriculturally protected zone is limiting the proposed restoration to riparian banks (King County, 2002). This is because under the current body of river management agriculture and salmon habitat are understood as spatially incompatible. This scenario is what makes the Sammamish River an ideal location for testing agricultural methods compatible with functioning floodplains. To summarize, if we were able to convert the agricultural use of the valley so that it becomes compatible with a functioning floodplain, then we could simultaneously reduce infrastructure maintenance costs while still meeting flood conveyance requirements, dramatically improving salmon habitat, and increasing the food security of the metropolitan area. Additionally, the proximity to

Figure 4.5 >

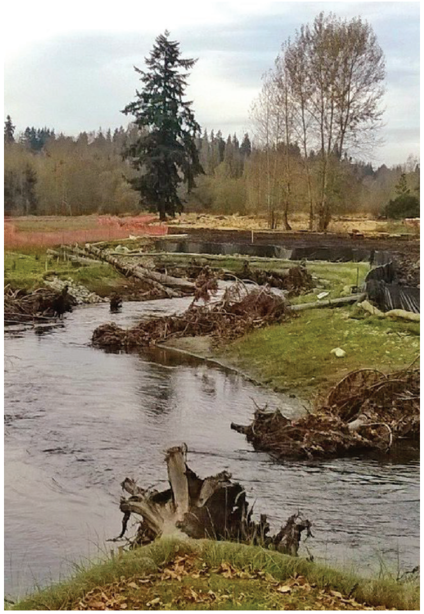
(Upper left) Shows the Bear creek restoration right after its completion.

Figure 4.6 >

(Lower left) Closeup of restored Bear creek channel. Image shows large woody debree which is critical for the improvement of fish habitat.

Figure 4.7 >

(Right) Aereal view of the recently completed Bear Creek restoration. Notice the main channel, as ell as the backwater channel. The cutting of contours to create this habitat complexity ensures both flood storage, as well as an improvement in salmon habitat.




SR 520
Backwater Channel
Restored Channel

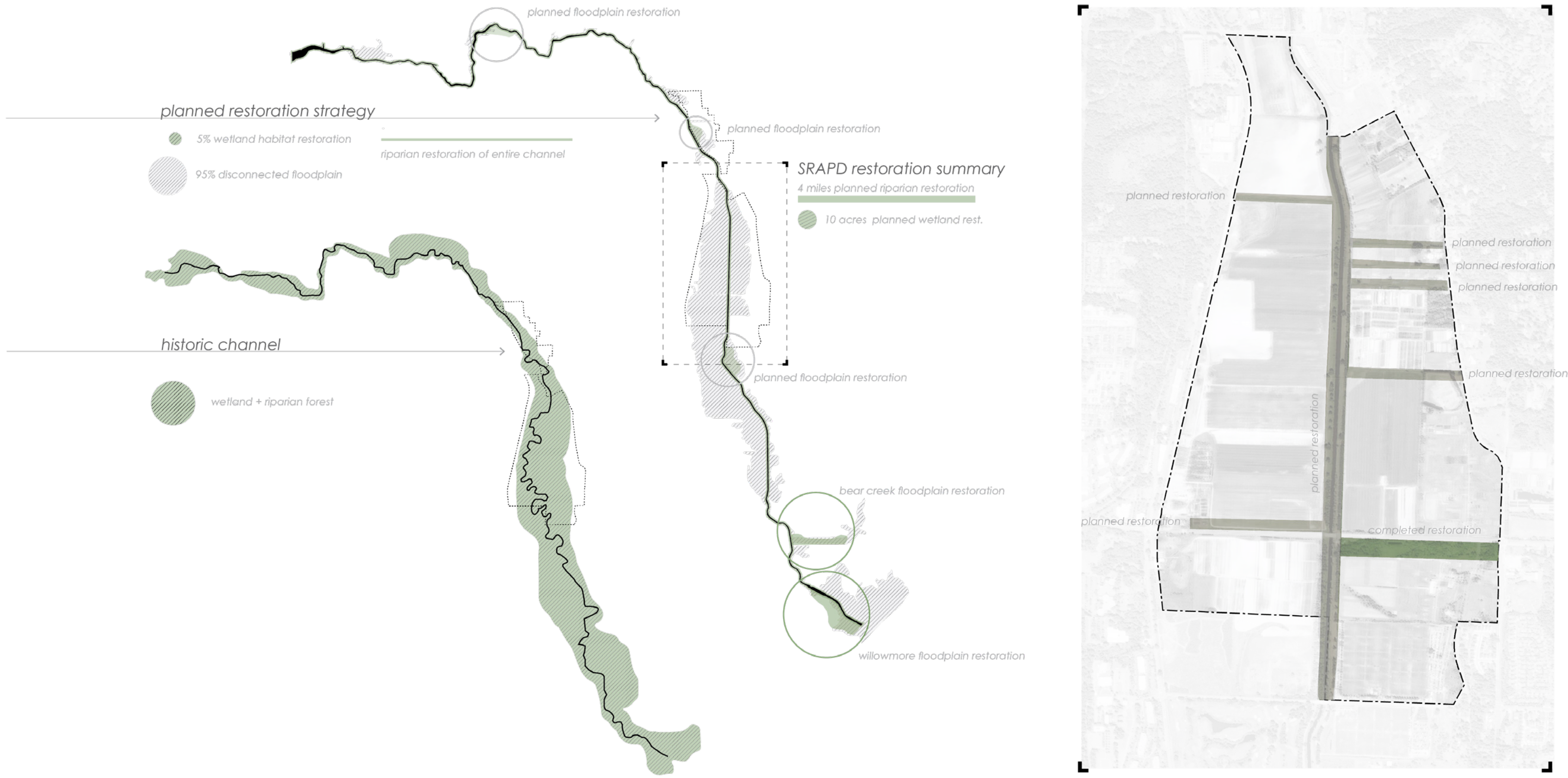


Figure 4.8

This diagram shows that based on the existing topography, and historic conditions, the Agricultural Production District has the single largest potential for habitat restoration within the existing valley. Currently, the agricultural use of the Valley restricts restoration efforts to riparian areas, and only one of the several restoration projects has ben completed. While this strategy will improve habitat, it only recreates a fraction of salmon habitat that historically existed in the Sammamish River Valley.

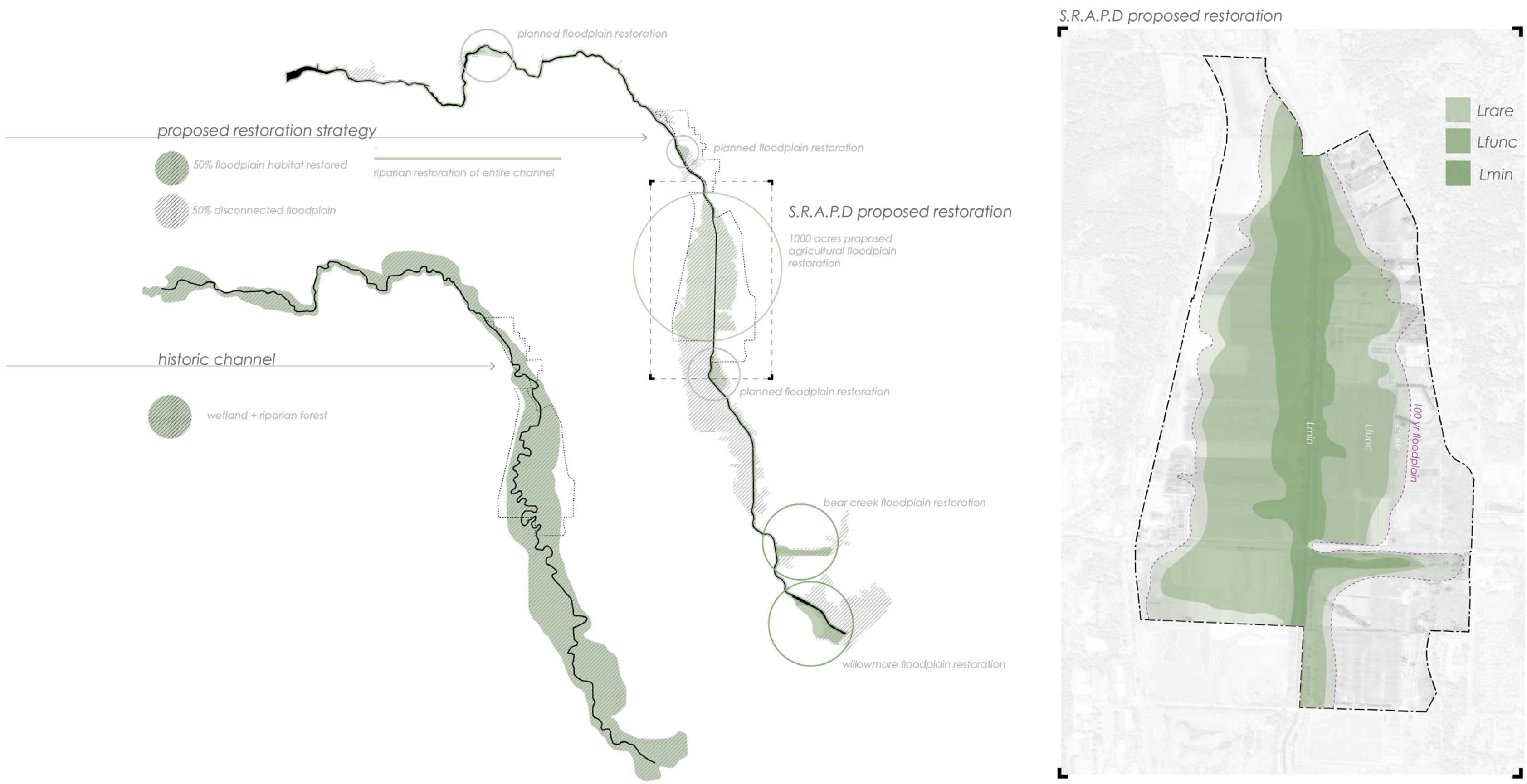
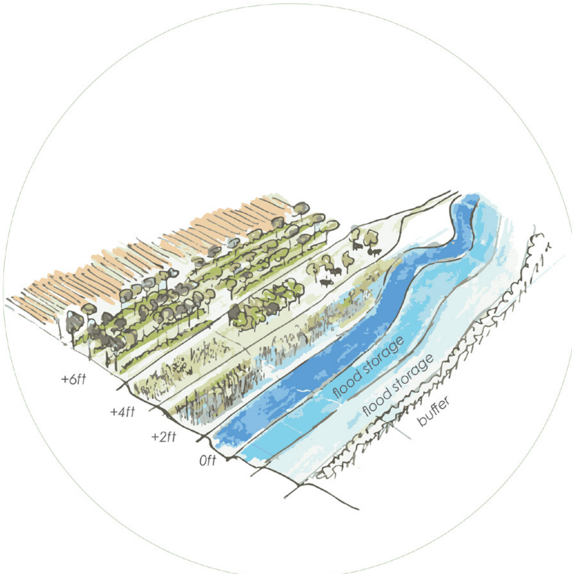
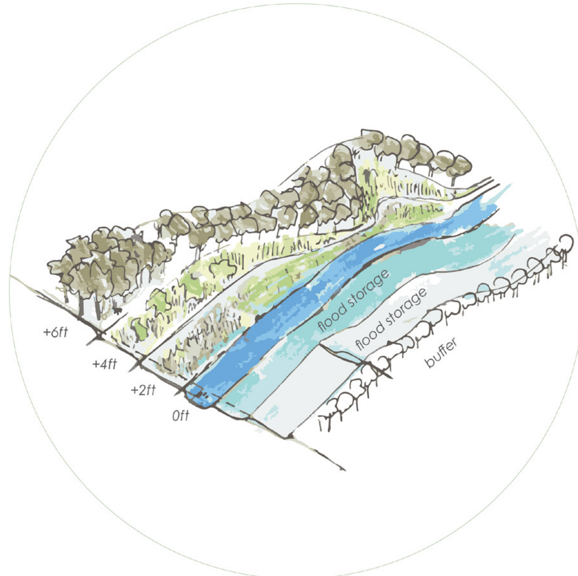


Figure 4.9

If we were to reactivate the floodplain within the Agricultural Production District, we could restore almost 50% of possible salmon habitat within the valley. The diagram on the right shows an estimate (based on topography and the 100yr floodplain) of where the Freedom Space delineation zones would be if the main channel dynamics were restored. For the purpose of this project this analysis remains speculative, the plans I show later in the document are based on this delineation.



agricultural restoration strategy



native ecology restoration strategy

< Figure 4.10

The Bear Creek restoration uses adjustments in topography to recreate the dynamism of the main river channel. Vegetation is then planted according to its resilience towards flooding and erosion (right). This same strategy can be used for the Agricultural Production district, but instead of using native vegetation we can use plant species that also ensure an agricultural productivity.

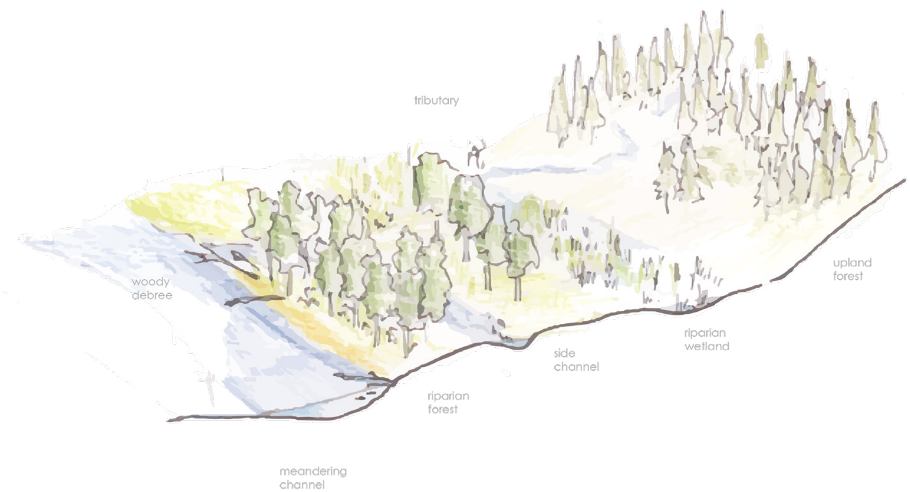
urbanity would facilitate the funding of this project, as well as provide an opportunity for urban dwellers to become more in touch with food production.

While there would be a cost to this, it would likely be offset by the long-term savings in infrastructure maintenance and salmon habitat improvement it would replace. Since this area is zoned for agricultural use, the price of land is still reasonable, the lawn growing operations could be purchased as part of a land acquisition worth less than $20,000,000 for roughly 350 acres of land. This creates the opportunity to purchase and develop a large portion of land in the agricultural production district and devote it to a floodplain restoration. In addition to being a cost effective strategy, this could also resolve the current conflict between development pressure and farms.

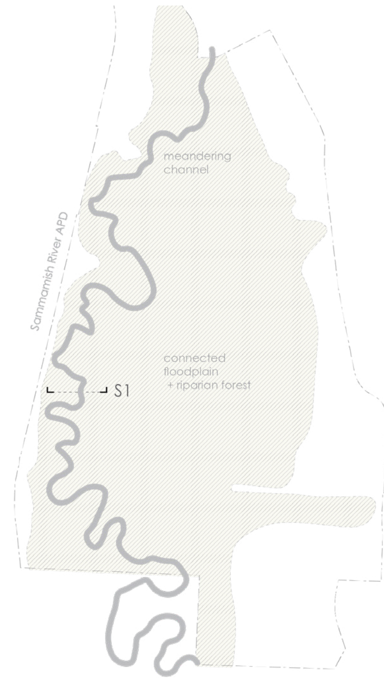
Currently, the viability of Sammamish River agriculture is threatened by land speculation. Recently, an ordinance passed which allowed several wineries to start selling their products to tasting rooms within the agricultural production district (Sammamish Valley Area Wine and Beverage Industry Study - King County, n.d.). The majority of the wine that is sold on-site is not produced in the valley, and these operations act like showrooms to promote a range of products from all over the state. Farmers within the valley are unanimously in opposition to this ordinance, arguing that it could open the doors to commercial development of the valley and risk compromising their operations and the food security of the region (Friends of Sammamish Valley, n.d.).Converting the valley to a productive floodplain would focus the commercial activity on local agriculture. This would contrast the approach taken by wineries which promote products from elsewhere in the state. This vision is aimed at benefiting the operations of local farmers. This would preserve the agricultural character of the valley, while also increasing farmers' exposure to local markets. *What if instead of using on site tasting rooms to promote wine, we envisioned on site tasting rooms to promote agricultural products which are compatible with a functioning floodplain ecology?*

New Vision for the Valley

Throughout this document we have come to several conclusions regarding holistic river management in Washington State: 1) To maximize regional food sovereignty it is necessary to implement holistic methods of river management. 2) Implementing holistic methods of river management is dependent on our ability to reconcile agricultural use with functioning floodplains. 3) Several agricultural strategies that are compatible with functioning floodplains exist. 4) Before we can implement these strategies



S1: Historic Conditions of Sammamish River

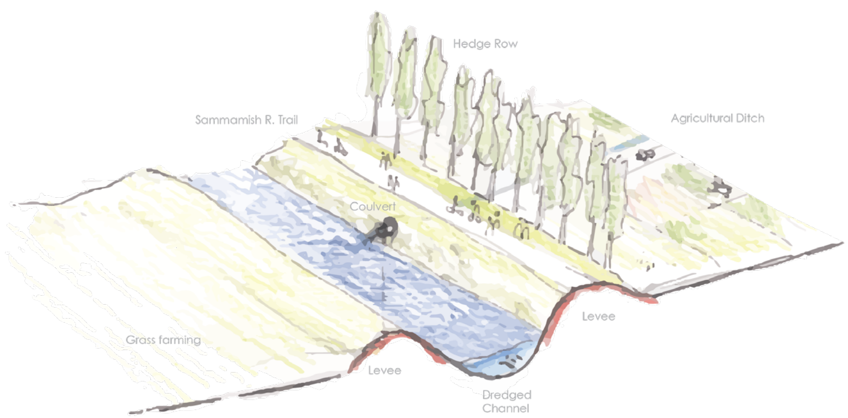


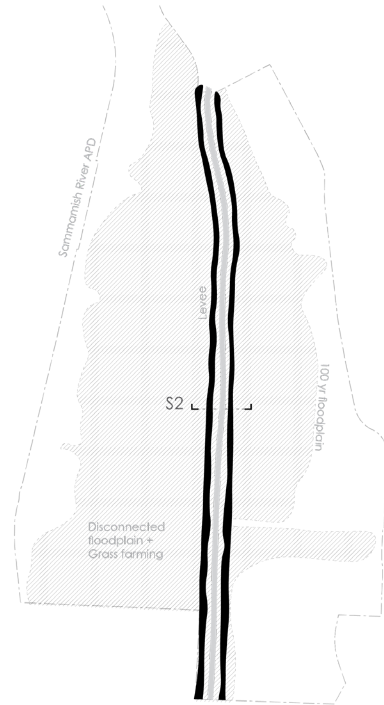
in floodplains across the state, they need to be further tested to make sure that they are economically viable for farmers and that they are able to meet specific restoration goals. 5) This can be achieved by using peri-urban areas as testing sites.

If we are to use the Sammamish River Valley as a testing site for this vision for holistic river management then I would propose the following steps: 1) Dismantle the levees and regrade tributaries to restore the ability of the river to flood and meander. The goal of this is to reconnect the floodplain to the main channel and improve salmon habitat. 2) Use the Freedom Space approach to determine the L_{min}, L_{func} , and L_{rare} zones for the valley after its dynamic processes have been restored. 3) Apply different ag-

Figure 4.11

This diagram shows the historic conditions of the Sammamish River. Despite some restoration advocates suggesting to restore the historic channel, the most recent restoration studies recommend focusing on restoring the function of the stream.





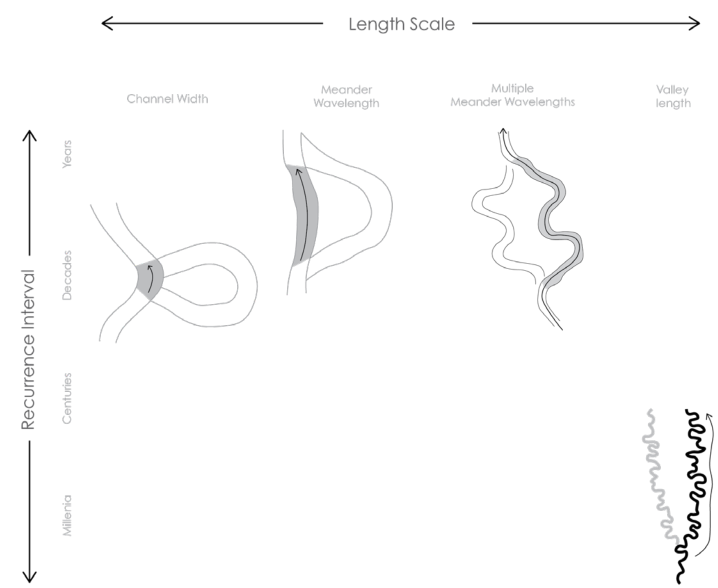
S2: Contemporary Conditions of Sammamish River

Figure 4.12

This is a diagram of the contemporary conditions in the Sammamish River. Notice how the trail is built on top of the levees and that the tributaries are also channelized and enter the river through culverts. It is believed that historically some of these tributaries were also used for spawning by salmon.

ricultural methods to the valley according to their resilience to flooding and bank erosion. 4) Rebuild the Sammamish River Trail so that instead of restricting the river's dynamic movements it enables them, both physically and economically. Along this trail I would place several "food hubs" that allow for the processing of agricultural goods, farmer's markets, farm to table restaurants and gathering spaces. These would increase the viability of implementing experimental agricultural strategies for farmers.

The landscape resulting from these changes would be a gradient that ranges from a public hunting, gathering and foraging area in the L_{min} zone, to a gradually more intensive agricultural landscape incorporating different agroforestry techniques and perhaps experimental rice agriculture in the L_{func} zone.



Enabling Change: Proposed Conditions of Sammamish River

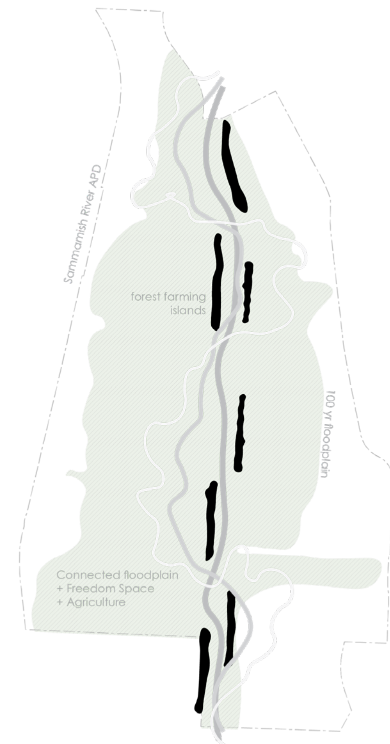


Figure 4.13

In order to restore stream functions I recommend dismantling the levees. The excess material should be added to the remaining bits of levees in order to create mounds suitable for forest farming. Over time this strategy will enable the river to resume its dynamic processes which give it habitat complexity.

The L_{rare} zone could retain its existing agricultural use.

The most critical component to this landscape is the L_{min} zone, here the food hubs would enable farmers to process their goods so they are economically viable, as well as market them to the public. The trail and surrounding landscape managed for foraging would enable city dwellers to access and experience this agricultural landscape. This vision for the Sammamish River valley Agricultural Production District challenges the notion that people are separate from natural ecosystems; it would promote an environment of cohabitation between people and salmon through a productive landscape. The following chapter will examine the process for creating this valley more in depth.

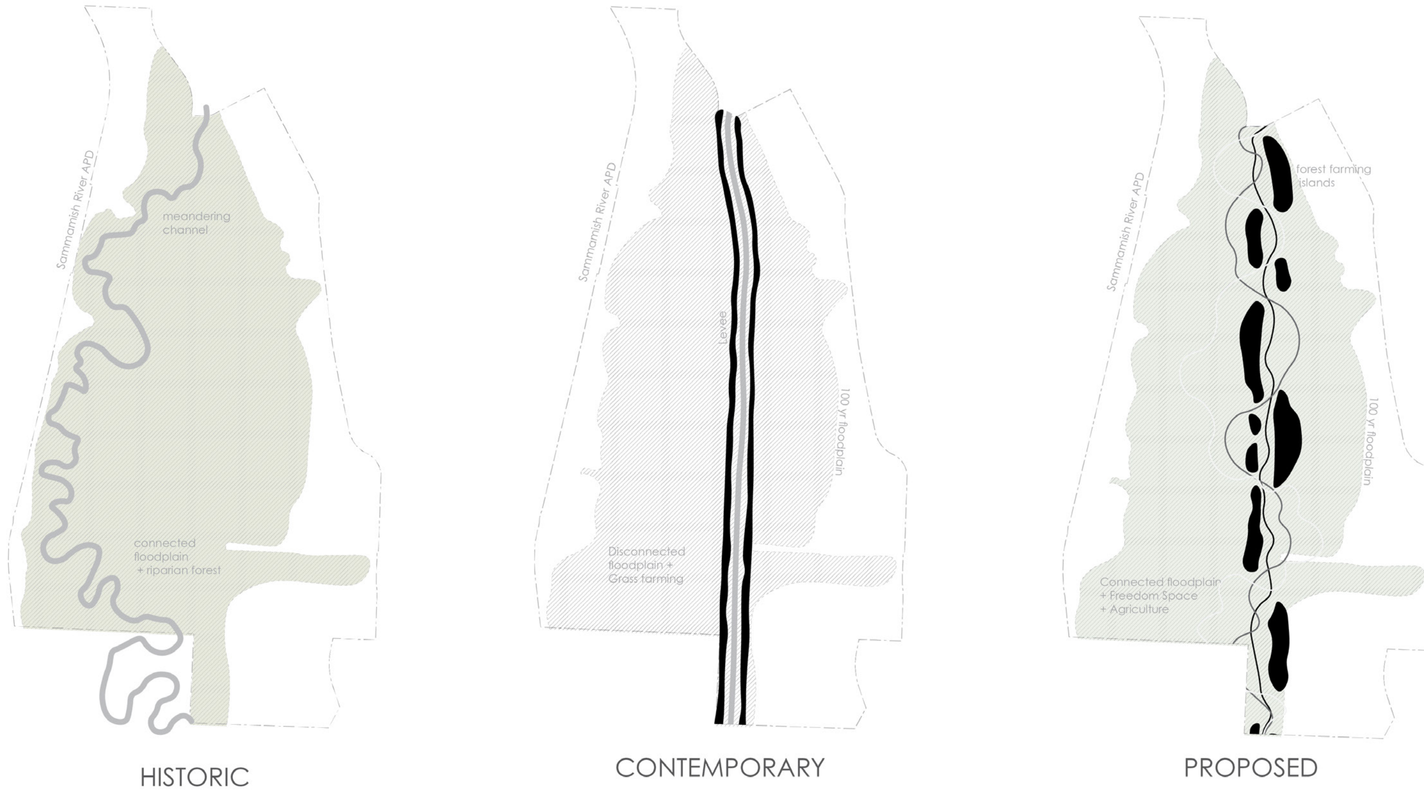


Figure 4.14

Typological comparison of the three stages of the Sammamish River. The purpose of this diagram is to illustrate how through altering the existing infra-structure by cutting and filling the dynamism of the river can be reactivated. This, of course, will happen over decades, centuries and millenia.

CHAPTER 5: LIBERATING THE RIVER

As discussed, the Sammamish River has been heavily modified from its original form and function through decades of manipulation by the Army Corps of Engineers. Looking at historic photographs, it is apparent how the old meandering channel snaked its way through the eastern portion of the valley. While it is tempting to restore its shape, we must realize that it would be difficult to do so given the river's extensive manipulation over the past century. The most recent plans for restoration all acknowledge that the priority is restoring the function of the river based on the habitat requirements of salmon – not its historic channel (WRIA 8 2017 Chinook Salmon Conservation Plan Update, 2017).

The same approach to restoration that prioritizes function should be taken when considering the plant pallet used to revegetate the banks. The agricultural methods discussed in Chapter 2 demonstrate that flora does not need to be native to have ecological value. Therefore, we must not limit the revegetation of this valley to native species. Instead, we need to research, develop, and experiment with plant species that can produce economically viable yields for farmers, while also fulfilling ecosystem services critical for the survival of salmon. The plant species and agricultural methods I outline in this document offer a starting point for this approach to restoration. Instead of being viewed as a comprehensive list, these should act as a framework to evaluate plants based on both their ecological and agricultural potential (plant list).

It is critical that the entirety of this landscape be viewed as productive – that is the only way we can remove the line between what is agricultural land and what is habitat. This principle should extend beyond what is intentionally grown and should also encompass what spontaneously arises from the landscape. Inevitably, an interconnected network of productive habitats will attract an abundance of wildlife, which if left unmanaged, could compromise the agricultural viability of different crops. While this may be seen as a liability, it also presents an opportunity. The United States Department of Fish and Wildlife uses hunters as a way to manage wildlife populations in both agricultural and "natural" areas. This approach can be an important part to maintaining healthy animal populations in our heavily managed landscape (Robinson, 2009).

Waterfowl like ducks and geese, as well as ungulates like deer, are likely to move into the valley after a similar scale of floodplain restoration. There is a large movement toward the consumption of wild foods happening around the world. Many chefs have adopted the idea of "catch and cook" as a strategy to reconnect to where food comes from and build empathy for the process that is required to obtain food from the "wild" (Rae, 2020). This idea of interpreting the entirety of the landscape as productive could enhance its ability to produce food. Like for agroforestry goods, the ability to use wild foods is largely dependent on being able to process them.

For the average person who grew up eating processed foods, the prospects of a basket filled with a wild duck, mushrooms, wild rice, and walnuts may not immediately appeal to their senses. However, if confronted with the final product of a wild rice risotto with mushrooms, duck, and walnuts, they may be more likely to see value in the ingredients. This is the opportunity that would be created if a productive floodplain landscape was connected by a network of ephemeral trails and food hubs. This infrastructure would enable the public to gather and process wild goods. It would also allow farmers the ability to process goods like walnuts and cider apples, then in the same place they could promote and sell their products to the general public. These food hubs would act as sites of connection where farmers, chefs, hunters, gatherers, and the general public could interact and develop a food culture intimately tied to the landscape they inhabit.

As time passes and the river resumes its processes of flooding and erosion, salmon could also return to inhabit the landscape. By sacrificing their bodies, they would give birth to new life, enriching the land and its inhabitants with nutrients they gathered from the sea.

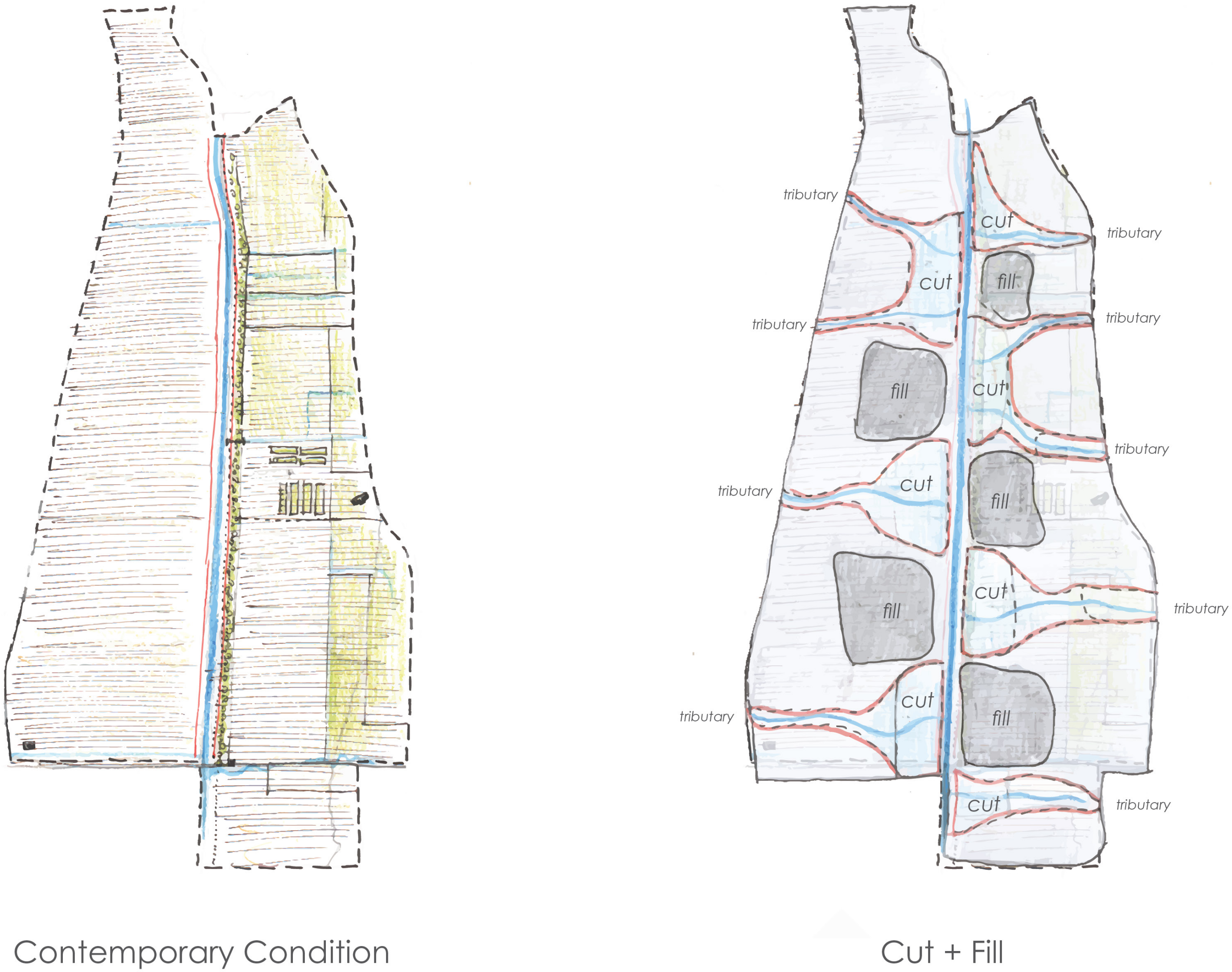


Figure 5.1

This is an elaboration on the concept of cutting and filling to restore river processes. The existing tributaries should be prioritized as restoration sites. By cutting and re-grading them riparian wetland areas can be created. the leftover material builds mounds.

Regraded Landscape

Change Over Time

Figure 5.2

The regraded valley enables a combination of riparian and floodplain restoration. Different species can be planted according to their elevation, as well as their economic viability for farmers. As time passes and the river resumes its meanders, agricultural use will need to adjust to the spatial distribution of the channel

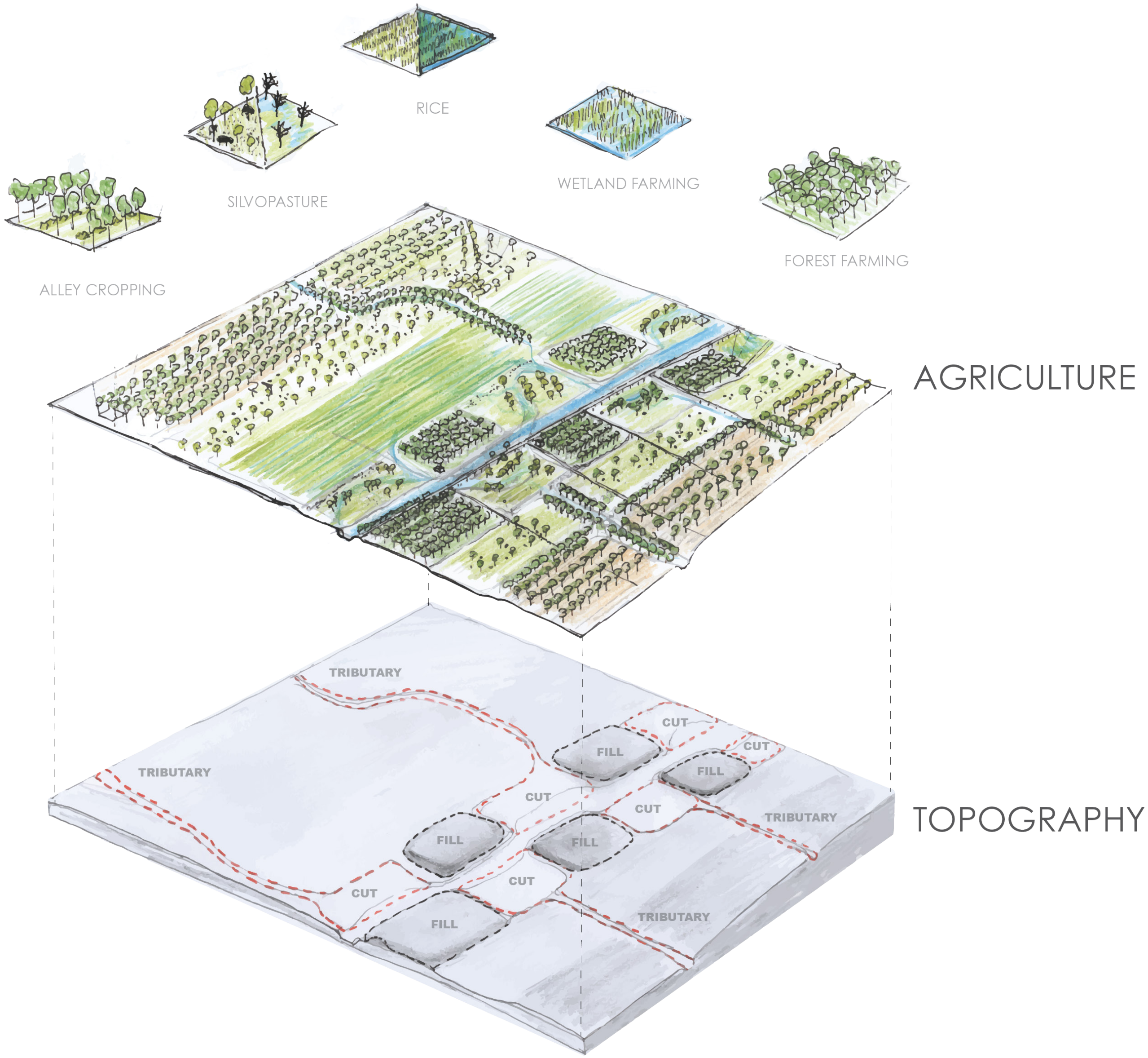


Figure 5.3

Regrading the landscape by cutting and filling also provides the opportunity to experiment with different farming methods. This is a suggested vision for the valley based on the research accumulated in this thesis, it is by no means comprehensive. As was discussed in the last diagrams the areas cut can be imagined as productive riparian wetlands, the mounds made from leftover levees can become forest farming islands. Experimental rice cultivation could be tried on the western side of the channel where the topography is lower. Rice is not yet farmed in Washington, but with the changing climate conditions fro its growth may improve. The remainder of the floodplain can be silvopasture which allows cows to graze in the summer, and can flood during winter storms. Alley cropping can be used to buffer conventional agricultural use outside the 100yr floodplain zone. These agricultural typologies correspond to the Freedom Space delineation zones.

Building a New landscape

Altering the existing landscape of the Sammamish River Valley to become a productive floodplain will require the collaboration of experts from different disciplines, as well as input from the general public. The purpose of the following sections is not to provide a definitive plan, rather it is a framework designed to start thinking about how this process will be carried out. The existing restoration plan prioritizes cool water supplementation and has proposed the revegetation and restoration of incoming tributaries as the preferred solution to restore salmon habitat (WRIA 8 2017 Chinook Salmon Conservation Plan Update, 2017). There is one existing example of this kind of restoration in the SARPD; I would replicate this approach for all the incoming tributaries by regarding their confluence with the Sammamish River. The implementation of this strategy should expand beyond the area adjacent to the tributary mouths – it should also be used to dismantle substantial portions of the levees. The excess material could be used to reinforce the portions of levees that remain.

This process of cutting, regrading, and filling would create a landscape of mounds and depressions surrounding the edge of the main channel, this would make up the L_{min} zone. To promote the vision of a fully productive landscape, the depressions should be planted with wetland species that also have food value. Wapato and wild rice are two viable options for these zones which will be almost always wet and prone to bank erosion. More plants with similar characteristics should be added to the pallet. Most plant species that can be grown in this part of the river will need processing, making processing hubs critical to their use. The mounds as well as the tributaries should be planted with vegetation suitable for forest farming and short-rotation biomass. This approach will enable the shading of waterways necessary to cool them, so they meet the watershed restoration targets for salmon recovery. The areas closest to the water should be planted with faster growing plants like willow. While it doesn't have nutritional value for humans, willow can be harvested and sold as biomass, or it can be used as large woody debris, which is critical to restore aquatic habitat. Areas not directly adjacent to the water can be planted with various fruit and nut trees based on their elevation: walnuts, chestnuts, and hazelnuts are viable options, but more species should be considered.

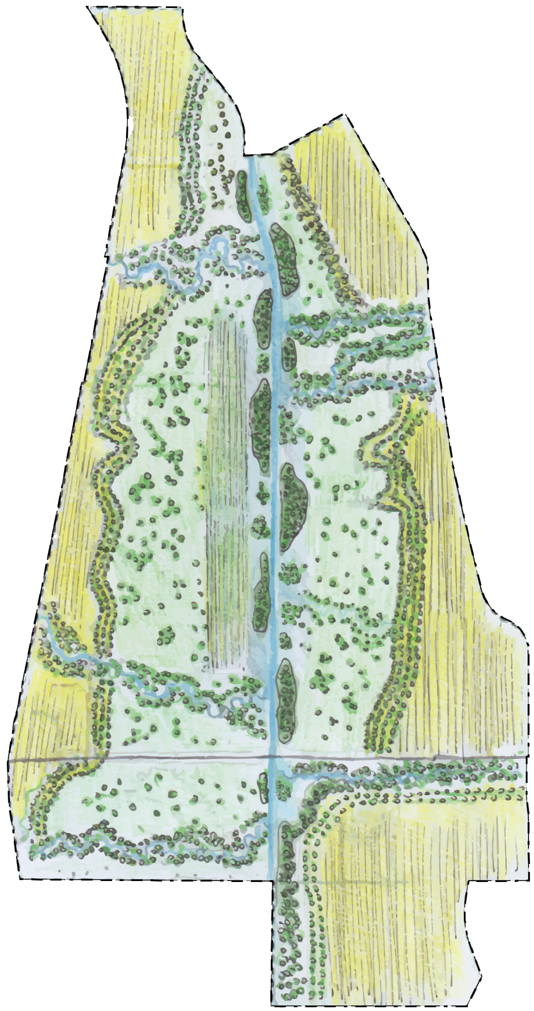
In choosing the plant pallot both diversity and profitability will need to be considered, it will also need to be determined whether land in the zones closest to the river will be public, or a public-private partnership. The priority needs to be the ability of the trail to provide equitable access and effective management to the food resources provided by this landscape of forest farming mounds and wetland foraging depressions. Several schemes could be envisioned to realize this: this could be conceived according to a "u-pick" approach, where farmers are responsible for maintaining the landscape and then charge a fee for the public to pick and harvest the goods. Alternatively, this area could be envisioned as a public commons where the public is responsible for the maintenance and harvesting of individual segments of land according to a predetermined set of principles.

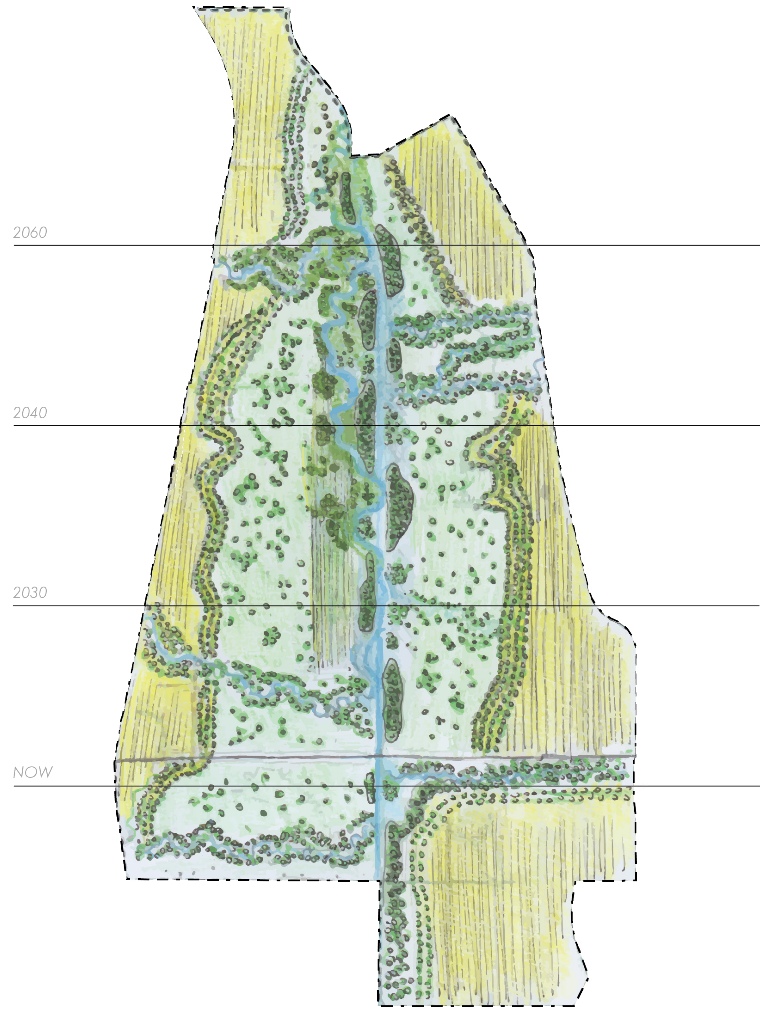
Transitioning away from the immediate edge of the water, no significant regrading will need to be done. This zone, delineated as the L_{func}, will be subject to seasonal flooding, as such it is critical for farmers to test agricultural techniques that are able to cope with this magnitude of disturbance. Silvopasture and rice farming are proven options that could make up the entirety of this zone, other strategies should also be experimented with. Based on my case study analysis and conversion with farmers in the area, the preferred approach for this landscape is to find the balance between having enough diversity to make the landscape resilient, but also keeping a limited enough pallot of plants to facilitate their harvest and processing.

Transitioning from the L_{func} zone to the L_{rare} zone also requires no significant regrading; however I would propose the use of agricultural techniques that are able to buffer the impacts of intensive agricultural use. One technique suited to this role is Alley Cropping on contour. By alternating rows of fruit/nut trees with crops like hay or market vegetables, farmers would be able to both obtain agricultural

Figure 5.4 >

The plans depicted to the right are the result of applying alley cropping, forest farming, wetland foraging, silvopasture and short rotation biomass according to the hypothetical Freedom Space delineations discussed in Figure 3.15. (Left) shows the static plan. (Right) shows how the arrangement of the plan enables the river to start meandering over time.

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efficiency, while simultaneously creating a barrier between their more intensive uses and the floodplains. This barrier would provide erosion protection and habitat for species beneficial to crops, thus having both agricultural and ecological value. It would, however, also allow for porosity between the two different productive landscapes.

The combination of these strategies contrasts the existing typology which interprets the stream, the trail and surrounding agriculture as separate components. Together these strategies will create a gradient which merges various agricultural pieces into a single continuous landscape where the floodplain is connected to the main river channel. This landscape will give the river the opportunity to resume its dynamic processes, and over time it will start to meander across the valley. The food hubs and the trail will need to be built in such a way that they allow the river to move through them. The following is a vision based on a hypothetical analysis of the valley according to the Freedom Space approach.

The proposed vision for the Sammamish River Agricultural Production district is a place where salmon, people and farms are able to coexist within a landscape that promotes mutually beneficial relationships. The economic and ecological potential of this vision is hinged on our ability to interpret the entirety of the landscape as productive. So far we've discussed the theoretical regrading of the landscape and its delineation into zones according to the Freedom Space approach. This framework will need the careful evaluation of river ecologists, engineers and farmers in order to be realized. The plans I've developed are not exact, they are suggestions for determining the layout of the valley. The actual form will be dictated by the hydro-morphological analysis of the river, and the dynamics that are created from dismantling the infrastructure, as well as the river's predicted change over time.

Thefollowing sequence of drawings drawings are meant to display the qualitative feel of an agriculturally productive floodplain. This design responds to the theoretical application of the Freedom Space approachin the valley. They depict the qualities of the landscape that interprets functioning floodplains as entirely productive landscapes. This vision is the result of the research in this document.

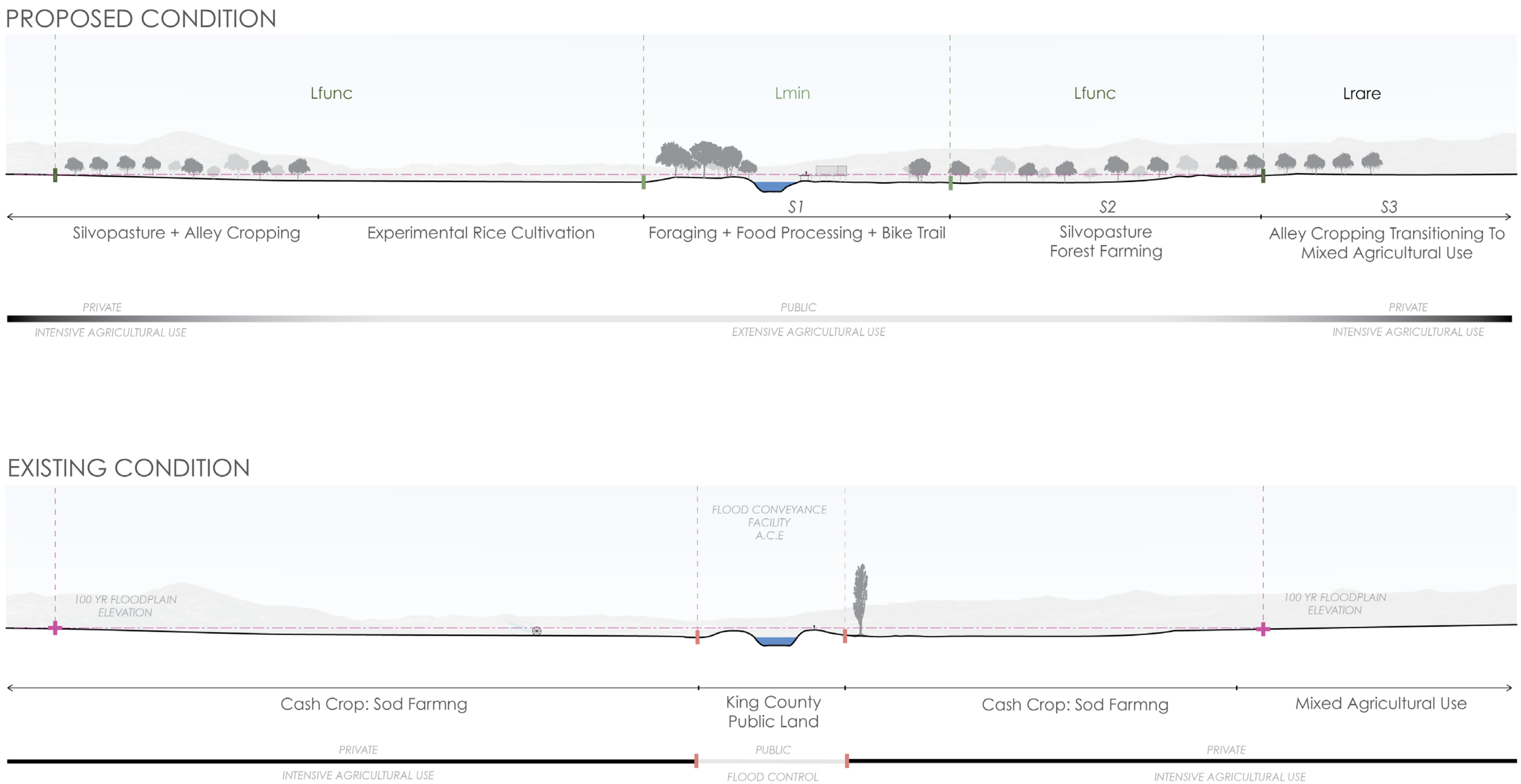
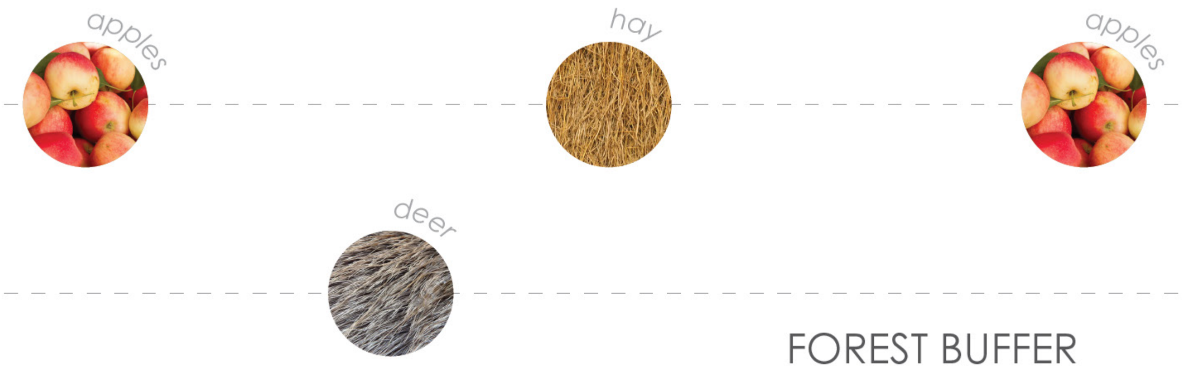
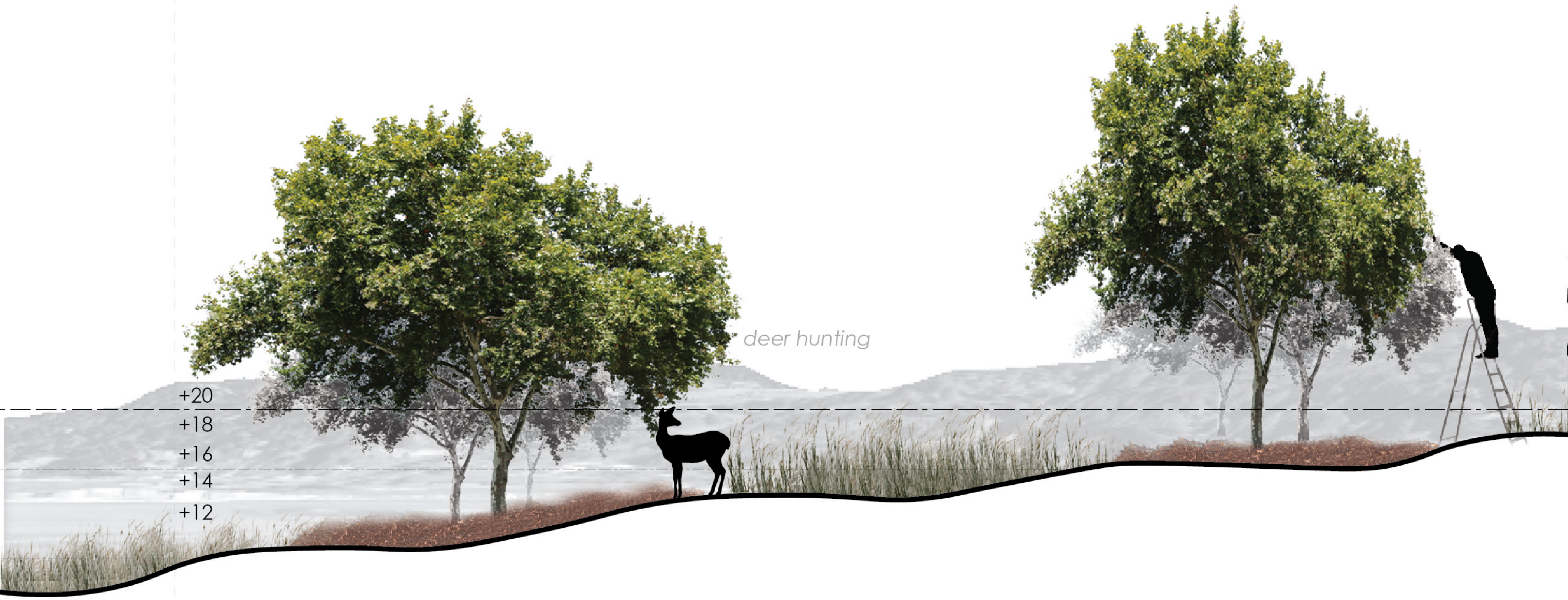


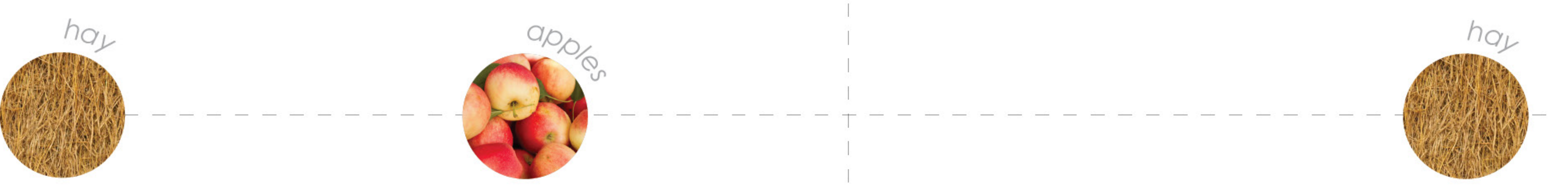
Figure 5.5

This hypothetical valley section shows how arranging agricultural use according to the Freedom Space approach enables a gradient of agricultural use and habitat. This gradient starts with conventional agriculture at the edges of the valley (L_{rare}), which is buffered by Alley Cropping. Silvopasture and rice farming make up the seasonally flooded prairie (L_{func}), and Forest Farming, Short Rotation Biomass and Wetland Foraging form the areas closest to the river and its tributaries (L_{min}). This gradient of agricultural uses contrasts the existing condition where river, agriculture, and the public are spatially separated.



FOREST BUFFER

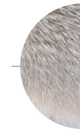




CONVENTIONAL AGRICULTURE

Figure 5.6: L_{rare}

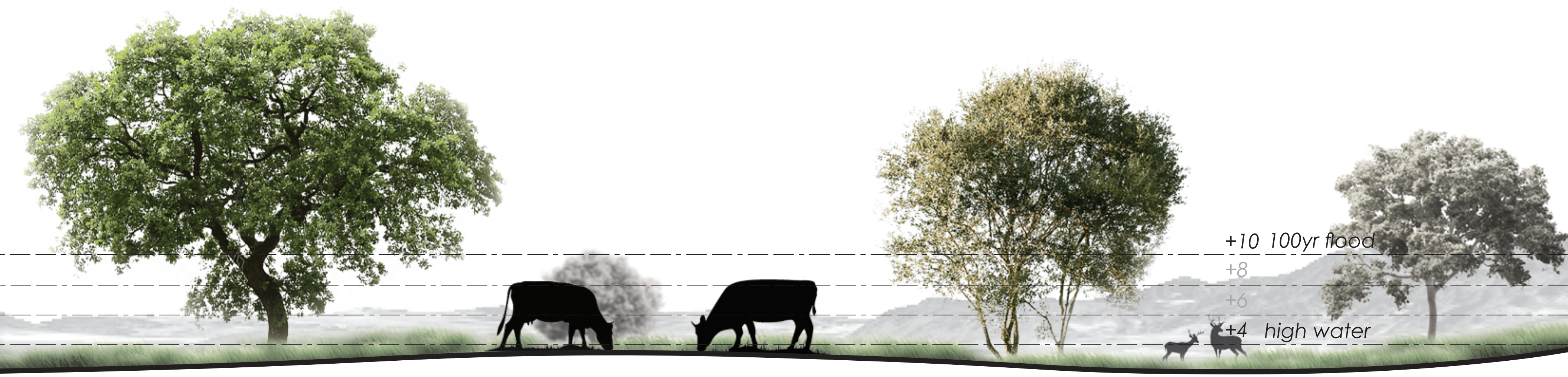
Alley cropping buffers existing agriculture. Hay is grown in-between cider apple trees enabling the farmer to enter two separate markets. The hay is sold to the nearby silvopasture so they can feed their cattle during winter. The apples are processed into cider at the food hubs along the river and sold to the public.

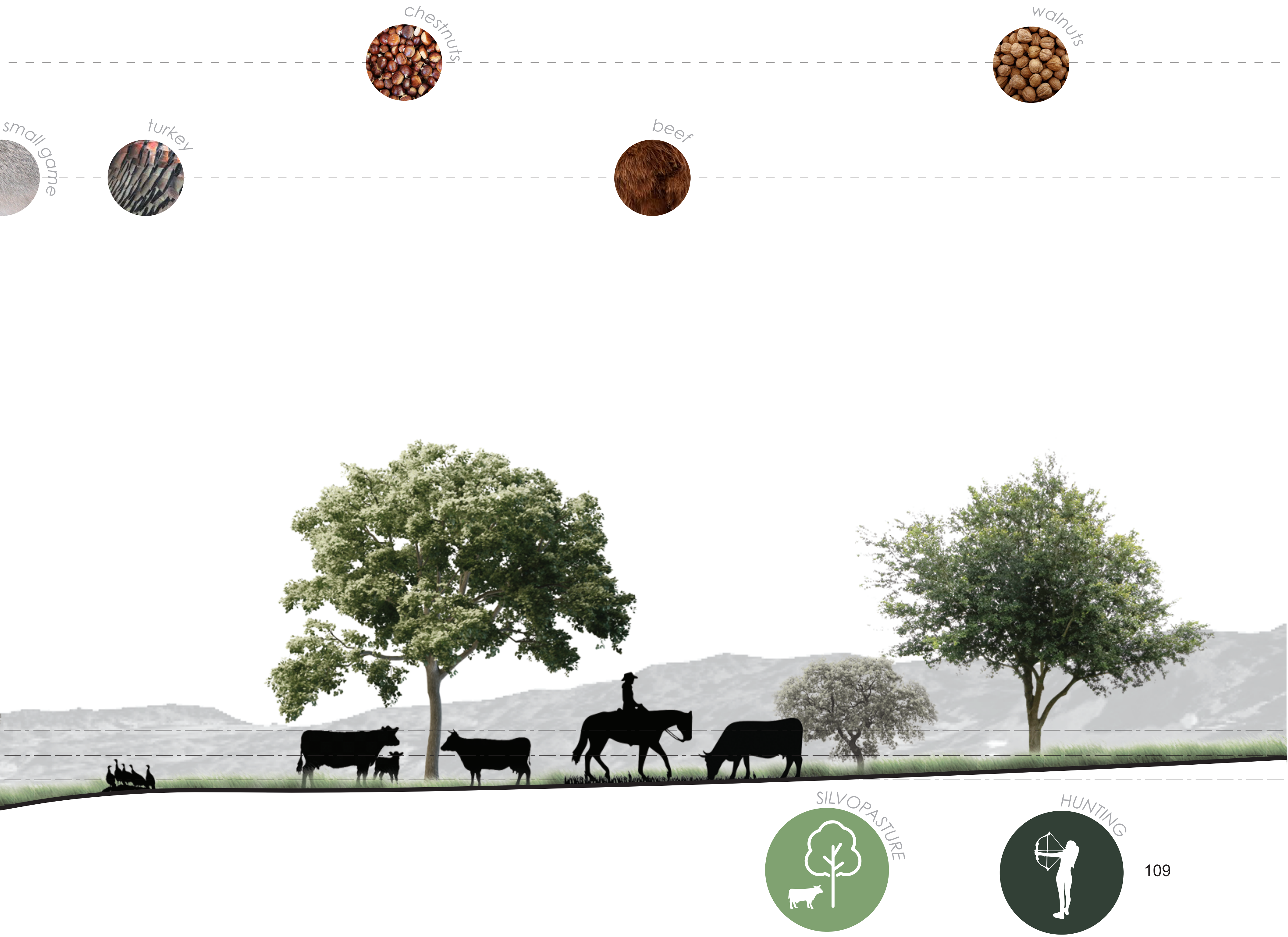


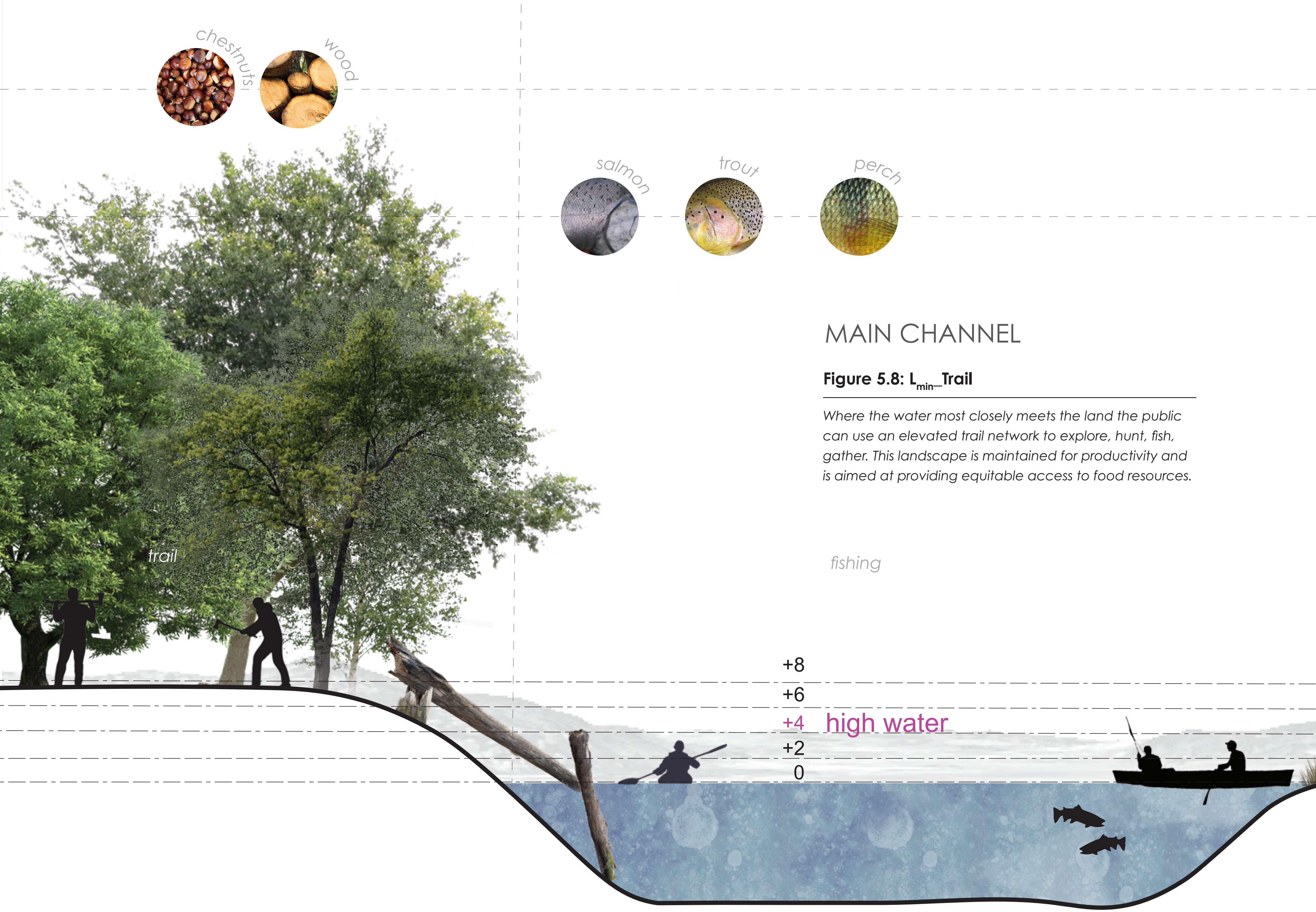
SEASONALLY FLOODED PRAIRE

Figure 5.7: L_{func}

The seasonally flooded prairie is used by the farmer to graze his cattle from late spring until fall. At the end of the summer they are able to harvest the various nuts from the trees, process them and sell them at the food hubs. As winter comes the prairie periodically floods, providing off channel habitat for juvenile salmon. If deer or other wildlife populations overreach their carrying capacity hunters can be given permission to harvest them, adding to the food offerings.




small game
turkey
chestnuts
beef
walnuts
SILVOPASTURE
HUNTING



MAIN CHANNEL

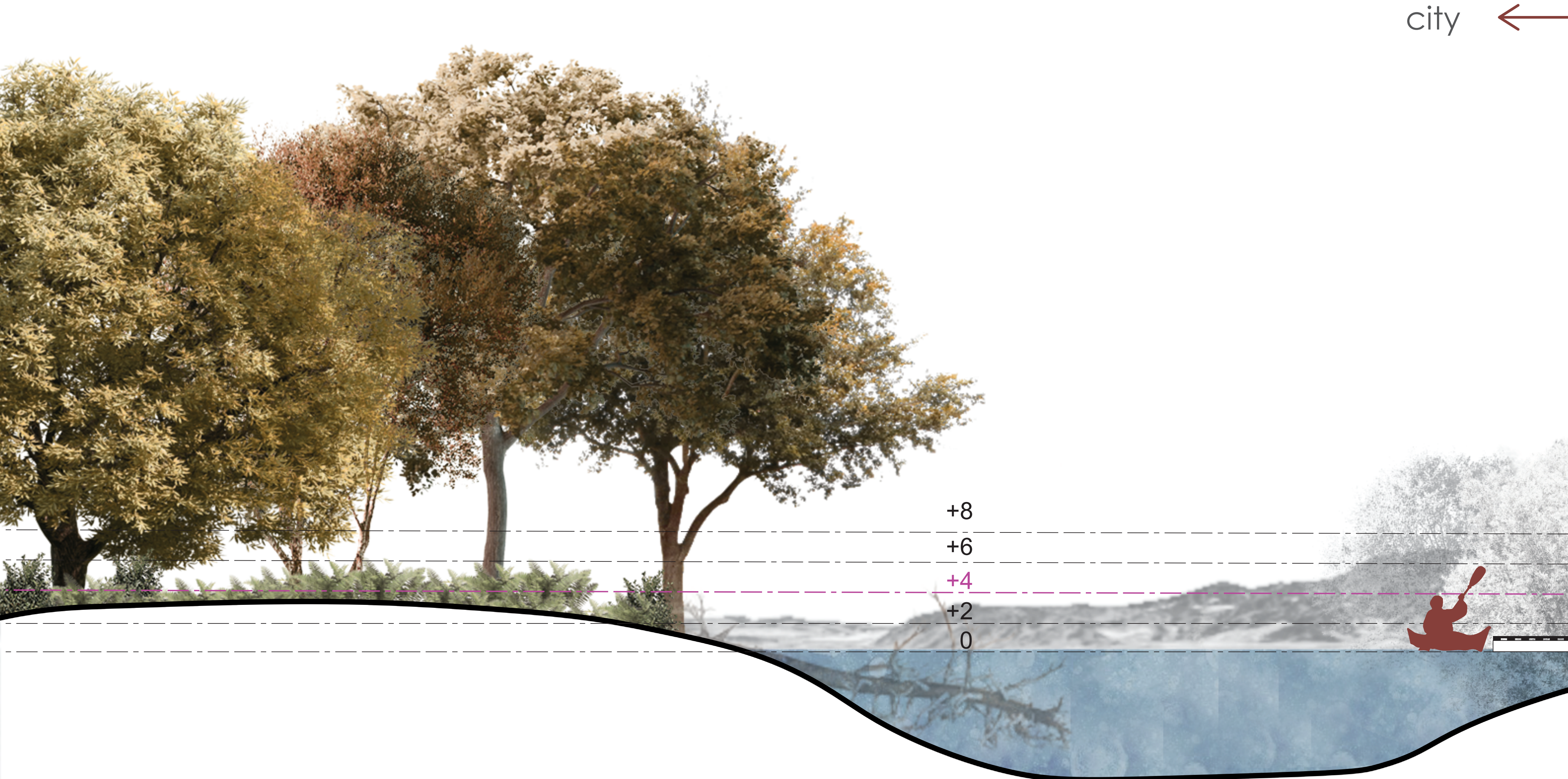
Figure 5.8: L_{min}_Trail

Where the water most closely meets the land the public can use an elevated trail network to explore, hunt, fish, gather. This landscape is maintained for productivity and is aimed at providing equitable access to food resources.

cattails
wild rice
knotweed
wapato
hazlenuts
walnuts
duck
WETLAND
RIPARIAN FOREST
duck hunting
bike trail
wetland foraging
fruit + nut foraging
SHORT ROTATION BIOMASS
WETLAND FORAGING
FOREST FARMING
HUNTING/FISHING

Figure 5.9: L_{min}_Food Hub

Arrayed throughout the trail several food are placed on stilts above the high water mark. These community spaces allow farmers and the public to process their goods, host chefs, markets and educational sessions. These are the spaces that allow the public to become engaged with farmers and the landscape. They also empower farmers to process and make more of a profit from their goods. These are the educational and economic backbone of the valley.



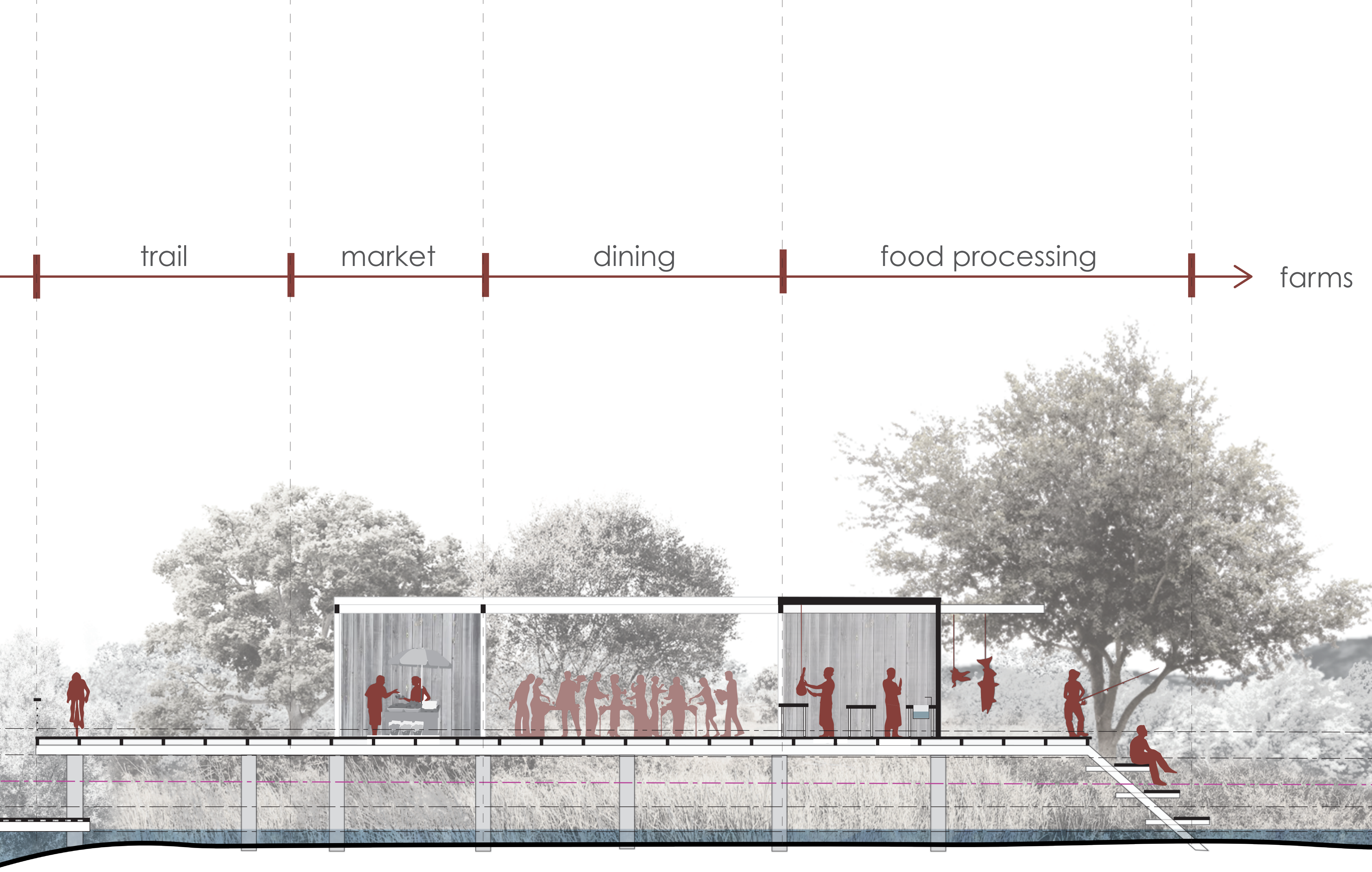
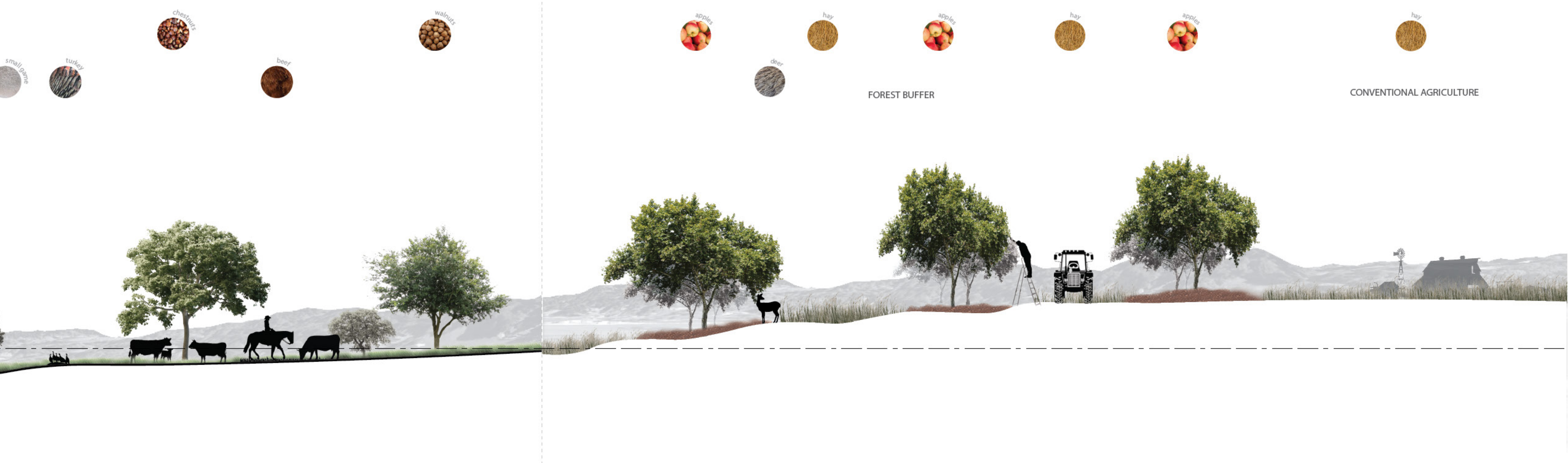
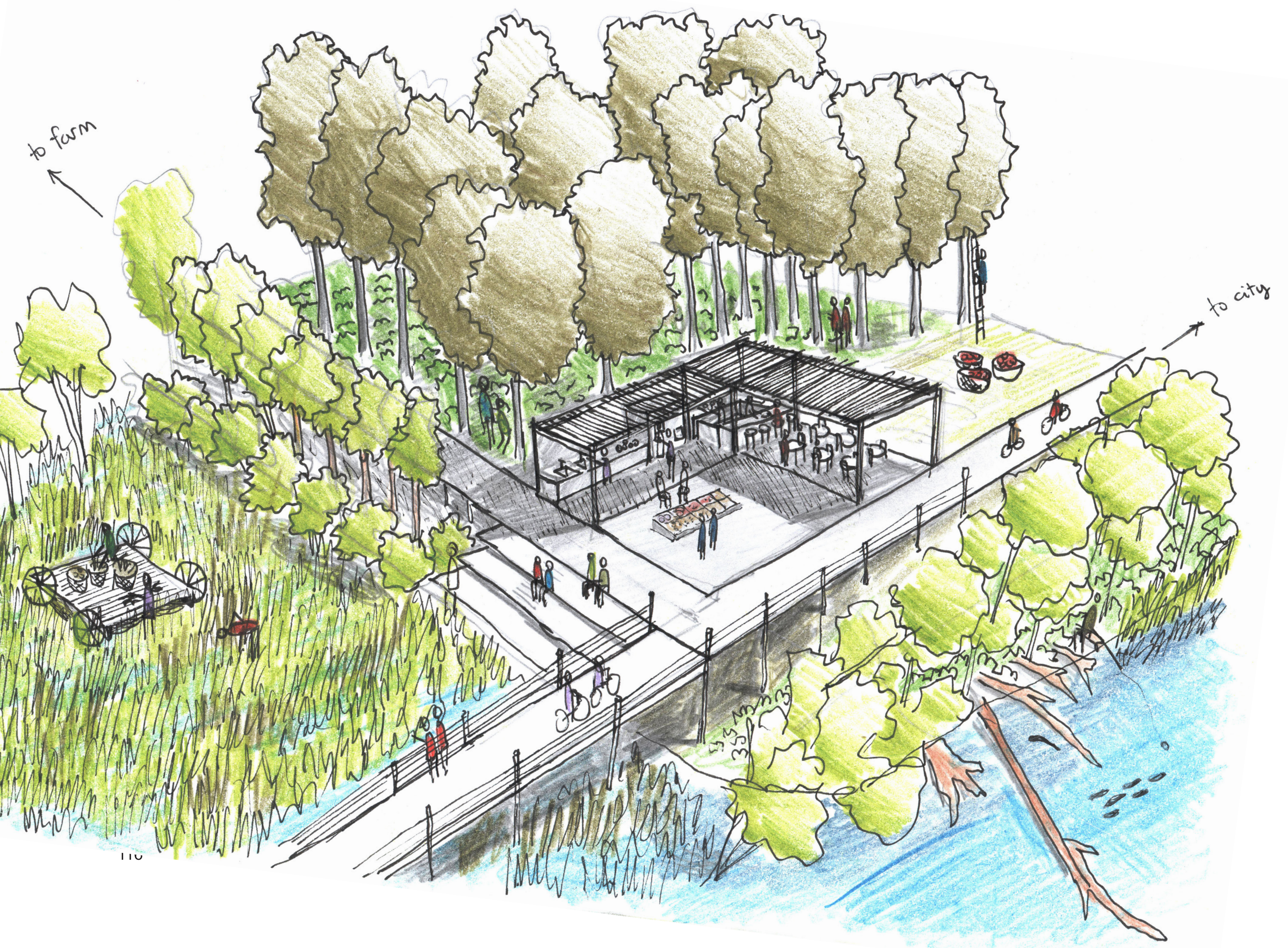

trail
market
dining
food processing
farms

Figure 5.10: L_{min}_Food Hub

Imagine a landscape where you have theseasonal opportunity to catch salmon, hunt ducks or harvest wild rice. As you do this, you understand that your actions are not only helping you exercise and feed yourself, but they are also supporting the health of the ecosystems you connect with. From this landscape you can explore seasonally flooded foraging trails and responsibly farmed land. You can come together with farmers, friends and the local community to process your gathered bounty and buy products from local farmers knowing that they support the landscape you just connected with. At the end of the day, you bike home back to your apartment in Seattle, tracing the path of the salmon that this landscape was designed to protect.


small game
turkey
chestnuts
beer
walnuts
apples
deer
hay
apples
hay
apples
hay
FOREST BUFFER
CONVENTIONAL AGRICULTURE



to farm
to city

Conclusion:

Given the successful implementation of massive infrastructural projects of the twentieth century, re-imagining the relationship between agriculture and floodplains in the Pacific Northwest is entirely possible, but it will require a coordinated effort backed by the general public. This effort needs to include policy makers, farmers, ecologists, restoration officials, engineers, designers and several other disciplines. These disciplines have often been at odds with each other, especially in the context of river management, but it is essential that they come together to develop a landscape that fits everyone's needs. The fundamental factor that will lead us to overcome these socioeconomic issues should be a vision for regional food sovereignty. Peri-Urban agricultural districts are the ideal typologies to test this interdisciplinary effort for river restoration, and the Sammamish River Agricultural district in the Seattle metropolitan area can provide equitable access to this emerging idea of resource management.

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