

# **LAKE KILLARNEY PARTNERSHIP**

ECOLOGICAL PLANNING WITH ROOTS IN SCIENCE & POLICY

Kenna Patrick

A thesis submitted in partial fulfilment  
of the requirements for the degree of  
Master of Landscape Architecture

University of Washington  
2016

Committee:  
Ken Yocom  
Iain Robertson

Program authorized to offer degree:  
Landscape Architecture

© Copyright 2016  
Kenna Patrick

Univeristy of Washington

## **ABSTRACT**

### **Lake Killarney Partnership Ecological Planning with Roots in Science and Policy**

Kenna Patrick

Chair of the Supervisory Committee:

Associate Professor Ken Yocom

Landscape Architecture

For thousands of years philosophers have been asking questions about how people interact with the natural world, how our ethical and moral beliefs guide our treatment or mistreatment of the environment, and how we choose to use or conserve the resources of the land. In the United States a boom or bust mentality initially drove the expansion, growth, and strength of the nation, and also a widespread acceptance of the exploitation of the land. Political progression throughout the 1900s which brought with it the birth of environmentalism, as well as significant advancements in the field of the ecological sciences were two of the driving forces that began to shift this paradigm. An emerging understanding of ecosystem sciences and a more ethical perspective on the environment largely contributed to the establishment of ecological planning and design as its own field of research and practice.

Ecological planning is firmly grounded in the sciences as well as the ethical foundations of environmentalism. It promotes the idea that natural spaces have their own innate value beyond anthropocentric values, as well as providing ecosystem services that also benefit humans. By planning for human expansions in accordance with the flows of nature we can learn to develop in a more sustainable way.

To unfold these topics this thesis is comprised of two parts. The first is a research paper that explores the history of ecological planning- where it began, how it evolved, what challenges it addresses, and where conversations in the field are today. The second part is a more specific ecological health assessment and management plan for Lake Killarney, a small lake in south King County, which has provided the opportunity to explore the guiding principles of ecological planning in a current setting.

The conclusion is a discussion regarding the power of active community coalitions to bring positive change to the environment. Emotional connections to a place can bring people together and motivate them to engage both physically and mentally in projects in their community. Especially when there is a specific need for restoration, these groups can prompt ecological planning to take place and begin working toward an improved environment. Many successful restoration projects have been achieved in this way; and if community groups around the world followed suit we could see real improvement to the environment. Ecological planning helps to make this happen.



To Lake Killarney,  
& to my parents for raising me here.

# TABLE OF CONTENTS

## PART 1: ECOLOGICAL PLANNING

<b>Introduction</b>	<b>11</b>
Critical Stance	
<b>The History</b>	<b>15</b>
The Birth of a New Field	
Coevolving Fields	
Ethical Duty to the Environment	
Reaching the Tipping Point	
<b>The Challenges</b>	<b>27</b>
Language	
Environmental Policy	
<b>Evolving Landscapes: An Emerging Mindset</b>	<b>33</b>
<b>Conclusion: Citizen Partnership</b>	<b>36</b>
<b>References</b>	<b>39</b>

## PART 2: LAKE KILLARNEY

<b>Introduction</b>	<b>45</b>
A Personal Introduction	
Purpose	
Goals	
<b>Site Overview</b>	<b>49</b>
<b>Context</b>	<b>51</b>
White River Watershed	
Hylebos Creek Drainage Basin	
Weyerhaeuser	

<b>The Lake-Watershed Connection</b>	<b>59</b>
<b>Lake Killarney Site Analysis</b>	<b>63</b>
Lake Watershed	
Land Use Demographics & Regulatory Overview	
Climate & Precipitation	
Topography, Geology, Soils	
Hydrology & Wetlands	
Vegetation	
Fish and Wildlife	
Water Quality	
<b>Industrial Contamination</b>	<b>73</b>
<b>Creating Change</b>	<b>79</b>
Adaptive Management Strategy	
Participants are Partners	
<b>Concerns, Goals, Actions</b>	<b>81</b>
Green Stormwater Infrastructure	
Maintaining Biodiversity	
Focusing on East Hylebos Creek	
Concerns	
Goals	
Actions	
Monitoring and Evaluation	
<b>Conclusion</b>	<b>89</b>
<b>Appendix</b>	<b>91</b>
A: Influential Environmental Policy in Washington State	
<b>Reflection</b>	<b>97</b>
<b>References</b>	<b>99</b>

# LIST OF FIGURES

Figure 1- Ecological Planning Diagram	14	Figure 15- Industrial Contamination Across the Region Diagram	75
Figure 2- The Need for Ecological Planning Diagram	16	Figure 16- Arsenic Sediment Standards Graph	76
Figure 3- The Emergence of Ecological Planning Diagram	21	Figure 17- Comparing Arsenic in Several Lakes Graph	77
Figure 4- Ecosystem Services Table	26	Figure 18- Arsenic and Lead in Lake Killarney Sediment	78
Figure 5- Ecosystems Spanning County Lines Diagram	31	Figure 19- Arsenic Across Sediment and Water Column	78
Figure 6- Lake Killarney Basic Features Diagram	50	Figure 20- Adaptive Management Cycle Diagram	79
Figure 7- Watershed Context Maps	52	Figure 21- Lake Killarney Concerns Map	84
Figure 8- East Hylebos Creek Drainage Basin Map	54	Figure 22- Wetland Future Vision	86
Figure 9- East Hylebos Creek Development Map	55	Figure 23- Restoration Process Vision	88
Figure 10a,b,c- 0006 Stream Condition Over Time	56		
Figure 11- Lake Killarney Watershed Map	63		
Figure 12- Lake Killarney Location Diagram	65		
Figure 13- High Quality Ecological Communities and Priority Habitat Species at Lake Killarney	69		
Figure 14- Lake Killarney Food Chain Diagram	72		

# LIST OF IMAGES

Image 1- George Perkins Marsh .....	<b>16</b>	Image 18- Tributary 0006 .....	<b>67</b>
Image 2- Camping in Yosemite National Park, 1920s. ....	<b>17</b>	Image 19- English Ivy covers much of the shoreline in areas that could provide quality shoreline habitat. ....	<b>67</b>
Image 3- Odum’s Ecosystem Concept. ....	<b>18</b>	Image 20- Fallen Tree .....	<b>69</b>
Image 4- McHarg’s environmental factors map. ....	<b>19</b>	Image 21 a,b,c- High Quality Ecological Communities .....	<b>69</b>
Image 5- Aldo Leopold .....	<b>20</b>	Image 22 a,b,c,d,e- Priority Habitat Species .....	<b>69</b>
Image 6- First Earth Day April 22, 1970. ....	<b>21</b>	Image 23- Stormwater Discharge .....	<b>70</b>
Image 7- Rachel Carson .....	<b>22</b>	Image 24- Riparian Forest .....	<b>72</b>
Image 8- A creek in The Woodlands, TX. ....	<b>28</b>	Image 25- The ASARCO smelter plant in Ruston, Washington .....	<b>73</b>
Image 9- Freshkills Park, James Corner Field Operations. ....	<b>35</b>	Image 26- Tacoma Smelter Plume. ....	<b>75</b>
Image 10- Lake Killarney .....	<b>44</b>	Image 27- Lake Horizon .....	<b>75</b>
Image 11- Swimmers enjoying the lake in summer .....	<b>45</b>	Image 28- Lake Water .....	<b>76</b>
Image 12- A bald eagle above the lake. ....	<b>48</b>	Image 29 a,b,c- Three Non-native Plants .....	<b>84</b>
Image 13 a,b,c- Stream 0006 at three different points. ....	<b>54</b>	Image 30 a,b- Current Wetland Conditions .....	<b>87</b>
Image 14 a,b,c,d- Development in East Hylebos Creek at Four Points. ....	<b>55</b>	Image 31- Bald Eagle at Lake Killarney .....	<b>90</b>
Image 15- Weyerhaeuser .....	<b>58</b>	Image 32- James Gawel and his team conducting research. ....	<b>98</b>
Image 16- Tributary 0006 .....	<b>62</b>		
Image 17- Lake output point. ....	<b>64</b>		



1

# INTRODUCTION

## CRITICAL STANCE

The landscape is the spatial base of life for all organisms on earth; a complex network of biotic and abiotic systems that dictates the ability of living creatures to coexist. From the smallest scale to the largest, each component of the system is connected to the rest and contributes to the health of all living organisms. The landscape is the canvas on which human activities take place; a dynamic entity that bridges natural ecological process with human cultural processes, and where the built environment meets the soil from which every tree grows (Ndubisi 2014). The importance of the landscape cannot be understated, yet it continues to degrade even amidst technological advancements and progressive thinking in the fields of planning and design. “An urgent need, thus, exists to continue to search for ways to effectively balance human use with ecological concerns” (Ndubisi 2014, 24).

We are amidst a century of urbanization; of major population rise, technological advancements, demand for housing, and subsequently a great boom in development. Tall cranes overhead foretell the apartment buildings and office complexes to come; while byproducts of past industry are still present throughout the landscape. These toxic products can be harmful to people, plants, and animals and it is not always obvious that they exist. There are so many different ways that people can affect the natural environment from the smallest to the largest scales; and changes at any scale accumulate, altering the global environment over time. In today’s world, fast-paced and aggressive development is one of the most significant examples of this alteration. John Lyle (1994, 16) explains that “when

we reshape a landscape, we radically alter a system of forms and relationships that are the current manifestation of some 4.6 billion years of evolution. The results are unimaginably complex, interrupting countless interactions, destroying millions of creatures, most of which are unseen and hardly known.” Compared to an evolutionary scale our short lifespans make us nearsighted to the effects we are having on earth in the long run; and our practices of landscape development reflect this nearsightedness.

While human action responds to the pressures of our own species, the communities of plants and animals suffer from disjointed habitats and degradation of the natural systems they rely on. Each piece of land contains life in a delicate balance, and when we clear the land for development we disrupt not only the life there, but we alter the entire flow of the greater ecosystem. Ecological damage compounds and our attempts to mitigate these issues- driven by environmental policy- are costly and time consuming, and can cause even more disruption to the normal cycle. While environmental policy may tout great ecological ideas, more often than not these written protections are weak when tested in the real world.

Most advocates for the environment believe that it is our ethical duty to do the best we can to conserve land and to remediate sites on behalf of the entire ecosystem, people included. Since no single person can be tasked with environmental protection and since the political protections in place regularly fall short, it is up to each of us to find unique ways in our own lives to promote change in the right direction; and certain professions such as landscape architecture have the opportunity to do even more. By embracing the theory and techniques of

ecological planning landscape architects have the opportunity to be role models for partnering with the land and advocates for a just treatment of the environment.

Ecological planning projects attempt to seek design solutions that prioritize keeping ecosystems intact, remediating already degraded sites, protecting healthy ones, and pushing the boundaries to seek new, resilient design alternatives for the future. Ecological planning places human needs in line with the needs of other ecological systems rather than above them (Forman 2002). It is a process of shaping space “by integrating human structures with protection of natural resources” (Forman 2002, 91). By grasping the vast body of scientific knowledge available to us and engaging in the political process, landscape architecture and its allied fields can create more sustainable land-use changes that prioritize ecosystem function.

As designers of the landscape we are stewards, educators, and often the person that acts as mediator between human needs and the needs of ecological systems. This person has an important duty to understand the greater ecological story of a place. Ecological theory provides frameworks for understanding ecosystems, and by studying ecological science a designer can better understand the complexities of a place, what it means to be sustainable, and how to design for a resilient future. In this way landscape architects have a great opportunity to turn studied and tested knowledge into something tangible, with the potential to improve both natural environments and peoples’ lives. If the science of ecology were to be central to the field of landscape architecture this would strengthen the field immensely making it, “the only discipline with a palette of expertise effectively embracing both natural systems and hu-

man culture.” (Forman 2002, 86)

Yet the field faces many obstacles. In his article, “The Missing Catalyst: Design and Planning with Ecology Roots”, Richard T.T. Forman expresses his feeling that today’s designers and planners do not have the tools necessary to make a harmonious union between science and design. The greats such as Frederick Law Olmsted he praises for rigorously studying and understanding the other disciplines such as biology and socioeconomics that affected their work. He expresses the feeling that today designers place primary attention on aesthetic dimensions of design, and give scientific knowledge secondary status. We come up against perhaps even greater challenges in the world of politics. The environmental policies in place today often fall short of protecting the environment; bureaucracy, red-tape, and a lack of funding muddy the water. While positive environmental goals may exist on paper, many have no legal backing. The environment it seems is always fighting against economic pressures. Thus the system requires engagement from a concerned and educated public willing to stand up for the environment and demand its better protection. It often still comes down to grass roots movements to make real change happen in the realm of ecological planning. With community engagement and a collective voice of concern we can promote positive action in the political realm which can translate to positive environmental change around the world **(Figure 1)**.

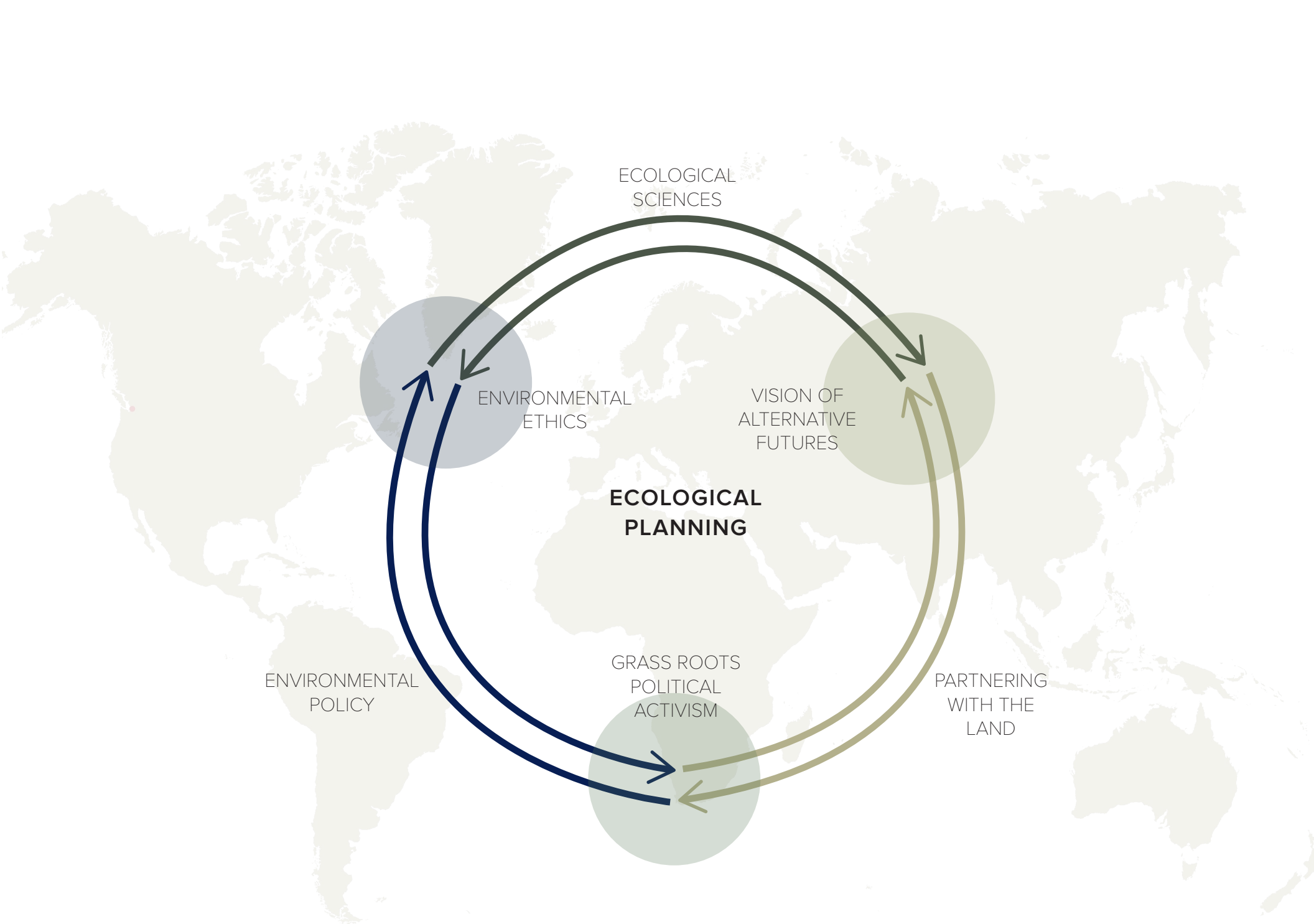


Figure 1. Ecological Planning Diagram

## THE HISTORY

### THE BIRTH OF A NEW FIELD

In the mid-nineteenth century, landscape planning evolved as a subset of the profession of landscape architecture (Ndubisi 2014). The field grew from the minds of early landscape architects and other great thinkers struggling to understand the relationship between people and the landscape. Living in the 1800's, George Marsh was one such person (**Image 1**). He was an American diplomat and philologist and would become known as the grandfather of environmentalism in America, the first environment conservationist as we know them today. His seminal book, *Man and Nature* (1864), was published just five years after Darwin wrote, *On The Origin of Species* (1859) which catalyzed a revolution in the world of biology and subsequently, ecology.

It was a time of massive economic growth of the nation, of taking and using the resources of the land; and also the birth of an idea- that humans could have major negative impacts on all systems of the earth, and that in the wave of development something needed to be done to protect those systems (**Figure 2**). In his book Marsh wrote to describe the character of human action and the changes man was having on the landscape; as well as the extent of those changes thus far. He expressed concern regarding the physical condition of the globe and pointed out the danger of “imprudence”, and especially, the necessity for caution in all actions that would interfere with the natural ways of the organic and inorganic world (Marsh 1864). He suggested that restoration was needed in areas where the degradation of natural systems had already occurred, and stressed the conservation of existing natural spaces (Marsh

## THE NEED FOR ECOLOGICAL PLANNING



**Image 1.** George Perkins Marsh (National Humanities Center).

**Figure 2.** The Need for Ecological Planning Diagram

1864). Ultimately, *Man and Nature* refuted myths of limitless plenty and spelled out the need for conservation.

Over the coming decades Marsh and his contemporaries such as Frederick Law Olmsted continued to explore the negative impacts human action was having on the environment. They wrote about “hostile human forces” tainting the natural landscape, seeing nature as a wholesome, closed system, and humans as a foreign invader (Ndubisi 2014, 49). One prevailing idea expressed by Marsh was that left untouched nature would function in a steady, calm manner, only changing when an extreme geomorphic event occurred. Today we see nature a little differently. We know ecological systems are not simple or predictable; and we know that natural events can cause changes that are in fact key to the health and resilience of those systems.

Discussing the perspectives of Marsh in the early twenty-first century David Lowenthal, an American historian and geographer who is known for his understanding of spatial concepts wrote, “anyone who wields an ax knows its likely impact, but no one before George Perkins Marsh had gauged the cumulative effects of all axes- let alone chainsaws” (2000, 56). Marsh was truly ahead of his time; and after his 1864 book was released the conclusion was clear- mankind depends upon a healthy and functioning landscape, and our exploitation of the land “deranges and may devastate the whole supporting fabric of nature” (Lowenthal 2000, 56). Lowenthal believes that by linking culture with nature and science with history, Marsh’s *Man and Nature* was the most influential text of its time next to Darwin’s *On the Origin of Species* (1859).

Following this era landscape architects took the ideas



**Image 2.** Camping in Yosemite National Park, 1920s (PBS).

proposed by Marsh and his contemporaries and began applying them in practice. In 1891 the U.S. Forest Reserve Act was passed accelerating the development of parks nationwide and providing landscape architects with one of their first opportunities to demonstrate how an understanding of the natural features of the land could be utilized for better planning and design at a large scale. Landscape architects participated in the design of Yosemite National Park (**Image 2**) in 1891, and Grand Canyon National Park in 1908- both major wins for environmental conservationists. A new belief system for guiding the use of the landscape was beginning to emerge, the foundation of ecological planning in practice. It was a loose conglomeration of ideas proposed by many different people with unique visions; but the unifying concept was that understanding the intrinsic character of the land was the key to sustainable landscape use

(Ndubisi 2014).

## COEVOLVING FIELDS

Advancements in the theory and practice of planning and policy, as well as parallel discoveries in the sciences during the mid 1900s contributed to the formation of ecological planning. Because ecology deals with the reciprocal relationship of all living things to each other and to their environments, both physical and biological, this science provides perhaps the most significant way of understanding the landscape (Thompson and Steiner 1997). The roots of ecology emerged in the early twentieth century from the work of several different scientific thinkers including Frederick Clements and Henry Gleason, American botanists studying the interactions between plant communities; and especially Sir Arthur Tansley, a British botanist and zoologist whose research, which focused on interactions between different communities of species, led him to coin the term 'ecosystem' in 1935 (Lister and Reed 2014). Across disciplines the research done by these men prompted new models of how ecosystems function, forming the basis for a new integrated science of plants, animals and environment- what we know today as ecosystem ecology (Lister and Reed 2014).

The ecosystem concept was transformative for the field of ecology in that it represented a unifying core for ecologists who at the time were operating with many disparate approaches of study. Eugene Odum was perhaps the most active American proponent of ecosystem ecology (Bocking 2016). He wrote a book entitled *The Fundamentals of Ecology* (1953) which was intended to serve as both textbook and handbook to help

educate the general public of the principles of ecology. The book explored how ecological principles could be examined in diverse habitats and applied to various practical problems including land use issues. Odum decreed that the ecosystem concept was critical to applying ecology to practical issues (Bocking 2016). He thought that since ecosystems could be understood in terms of cycles, so too could their management. He believed that maintaining cycles would ensure a balance between harvesting resources and the renewal of resources- an important step in achieving sustainability in human activities (Image 3) (Bocking 2016).

It wasn't until the 1960s however that the concept of ecology was accepted mainstream. This shift coincided with a rise in modern environmentalism- a movement brought on by growing public awareness and concerns regarding air and

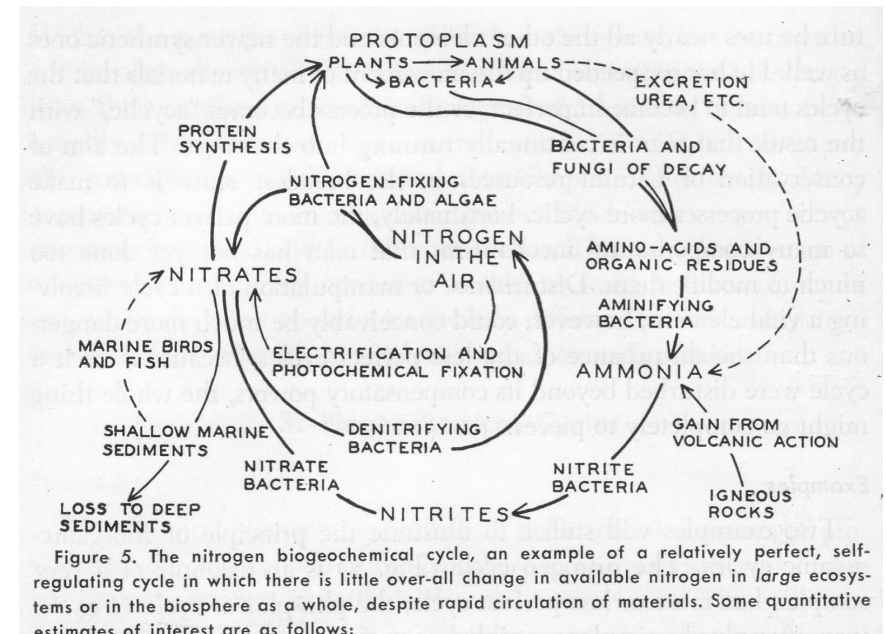


Image 3. Odum's ecosystem concept (Trent University).

water pollution, population rise, resource depletion and health risks associated with chemicals and industry. Rachel Carson contributed to this growing awareness in her book *Silent Spring* (1962), but she wasn't the only one. Throughout the '60s and '70s the volume of published research and work relating to the environment increased significantly, enabled by dedicated governmental funding for the study of the environment and resource management problems. As Nina Marie Lister and Chris Reed (2014, para. 6) write, "given that ecological research advanced during this era of growing environmental awareness, ecology has been closely linked to environmentalism — in the media as well as by scientists themselves — and perceived as a normative science akin to medicine, in that the work is goal-oriented toward some improvement in health or well-being". Many environmental regulations were passed during the late 1960s and early 1970s by the federal government that reflected this new understanding of ecology and ecosystems so that by the end of the 1970s the idea of environmental protection was mainstream in America.

Ecology was also used as a metaphorical tool to understand human organisms and our environment. Benton MacKaye wrote about this link extensively in his article "Regional Planning and Ecology" (1940) and he believed that human welfare as well as our environmental impact was better understood at the scale of the region rather than the site or city. He believed that by managing human actions at the regional scale we could better address our environmental impact and promote planning for human expansion that did less harm to the environment, as well as utilized the land's resources more effectively (MacKaye 1940). MacKaye's work opened the door for a wave of new

research and thinking. Two new leaders were Ian McHarg and Phil Lewis who produced pioneering theories regarding ecological planning at the regional scale- building on the theoretical foundation that had been developed in the decades preceding. McHarg believed that by approaching the landscape from a regional scale ecological systems could be better understood and importantly their interplay with human cultural landscapes could be revealed.

In *Design with Nature* (1969) McHarg described how an environmentally responsible approach to planning at the regional scale could help to address many of the challenges of development facing the industrialized world (Wenk 2002). He also argued firmly and persuasively for a scientific approach to examining and mapping the landscape, and for ecology as the foundation by which decisions regarding human advancement ought to be made. This ecological view was characterized by an interdependence between man and nature. By studying a region's ecological attributes- including the spatial patterns of waterways, wetlands, wildlife habitat, and important landforms- as well as patterns of human use of the landscape, he argued



**Image 4.** McHarg's environmental factors map.

that a planner could identify places to build that would do the least harm to these resources (Wenk 2002). This method would become known as a suitability analysis (**Image 4**). Contemporary criticisms of this method include that it is overly-simplified, and objectifies landscape components as things that can be easily mapped or quantified which is not always the case; but even so “McHarg’s practice opened up planning to the idea of the interconnectedness between cities, suburbs and the natural world: design with nature” (Lister and Reed 2014, para. 20).

## ETHICAL DUTY TO THE ENVIRONMENT

As has already been introduced, the environmentalism movement played a major role in the development of the foundations of ecological planning. Perhaps the key reason was that environmentalism infused an ethical argument into planning, suggesting that people have a moral responsibility to the environment beyond their anthropocentric views of land value. The foundations of this “new” ethic was expressed in a series of essays written by Aldo Leopold (**Image 5**), a wildlife biologist and forester. One theme of his writing is the need to distinguish right and wrong action to the land. He argues for an ethic that extends the boundaries of single biotic communities to include collectively all life in, on or of the land- of which people are an integral part. The notion was that people are members of a larger biological community rather than a separate entity (Ndubisi 2002). This inclusive view highlights the interdependent relationship between people and other lifeforms and calls for people to be responsible and caring members of the biotic community (Ndubisi 2002).

“That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics.” Aldo Leopold



**Image 5.** Aldo Leopold.

## FACTORS INFLUENCING THE EMERGENCE OF ECOLOGICAL PLANNING



**Image 6.** First Earth Day on April 22, 1970.

**Figure 3.** The Emergence of Ecological Planning Diagram

The resurgence of an ethical argument regarding the environment coincided with political and social upheavals taking place in the U.S. during the 1960s (**Figure 3**). Rachel Carson was an American biologist at this time who is commended for contributing greatly to the conversation about environmentalism (**Image 7**). In her article, “Obligation to Endure,” (1962) she presents a case study supporting the argument for why people ought to adopt an ecological perspective in planning, policy and in life. In the article she describes the detrimental effects of pesticide use on ecosystems- one form of mankind’s mistreatments of the landscape; and she explains that current practices are unsustainable. In a broader sense Carson is speaking about ethical issues regarding the way people approached nature at that time- attitudes which largely persist today. We are the first species that has the brain power to alter the natural world around us in a significantly positive or negative way, and with that power comes an egotistical entitlement to do so if we please. We also have a strong biological drive to protect ourselves and to better our individual condition. We often choose to put ourselves before all else including the environment. Carson argues that given our power, along with the scientific knowledge we possess of our impact on environmental systems, we are morally obligated to make better, more ethical decisions regarding the environment (Carson 1962).

In her article she describes how pesticides find their way into people via the food we eat and the air we breath, collecting in our tissues. Here they are capable of causing gene mutations and health problems. Carson points out that despite this knowledge we continue to choose to produce and use these chemicals- to spread them throughout the natural world, poi-

soning the earth and ourselves (Carson 1962). In our minds the economic benefits outweigh the negatives. She writes, “this is an era of specialists, each of whom sees his own problem and is unaware of or intolerant of the larger frame into which it fits. It is also an era dominated by industry, in which the right to makes a dollar at whatever cost is seldom challenged” (1962, para. 42). Here is the heart of the issue, and the same reason why in many aspects of life mankind is doing so much damage. We are driven by economics and our own self want, and we often ignore the ethical and health implications of our actions.



*Rachel Carson conducting marine biology with Bob Hines off the Atlantic Coast in 1952. Carson was an American marine biologist and conservationist.*

**Image 7.** Rachel Carson (U.S. Fish and Wildlife Service)

In her article, “Exquisite Communion: The Body, Landscape, and Toxic Exposures,” (2002) cancer survivor Sandra Steingraber expresses her take on the connection between people, the land, and the overall health of the environment. She explains that the connection between the body and the landscape is intimate and strong. That the health of the land is reflected in people, and likewise the degradation of the land is also reflected in the degradation of the body. Her focus is on chemical contaminants and how from the landscape these toxins find their way into people. She describes how toxicity is present even in the most mundane landscapes of America. She writes, “all of us suffer from toxic exposure to some degree, regardless of our attempts to limit these exposures by choosing where and how we live. This knowledge should be sufficient to bring us into a new era of chemical regulation, and urban design and landscape planning. It isn’t the same old story we heard in the 1970s; its a new story, and one that requires our attention in new ways... Yet despite all we know, in many ways we are just beginning to understand the ramifications of this communion between our bodies and the earth, air, and water” (Steingraber 2002, 192).

Steingraber goes on to describe the different ways that she, years earlier as a newly pregnant woman, began to understand how chemicals, toxins, and other pollutants threaten our health on a daily basis. She describes a small rural college town in central Illinois where she was teaching- a town that drew its water from a reservoir filled by various creeks and streams, all traversing through pesticide-intensive agricultural fields. One day when she stepped away from the gas station where her husband was filling up their car to avoid breathing in benzene

she finds herself standing amidst more chemicals. In front of her was a sweeping lawn of green grass, plastic signs warning that it had just been sprayed with pesticides (Steingraber 2002). “As it had recently rained,” she writes, “rivulets of rainwater ran from it and streamed toward the storm sewer, which eventually drains into one of the tributaries of the nearby Mackinaw River, which itself drains into the Illinois River and then the Mississippi, providing drinking water for tens of thousands of men, children and women (some of them pregnant) who live downstream” (Steingraber 2002, 193).

Steingraber’s realization of the imminent threat of toxins and pollutants is a realization that not everyone has. We are a country that has grown from its industrial era and widespread use of chemicals for an array of purposes. Historically people have accepted this and the majority of Americans seem unaware and unconcerned of the direct connection of human health and the environment. In middle-America the green lawn and incinerator stack are so common they are hardly noticed. Yet both are symbols of everyday toxicity. Human health is environmental health; and the health of people relies on the healthy and fair treatment of the land (Steingraber 2002).

Along with writing and practicing biology, Steingraber has also been a vocal environmental activist throughout her career. She fights for ethical treatment of the environment and protection of its valuable resources. In 2013 Steingraber was arrested for protesting as part of an anti-fracking movement (O’Conner 2013). Steingraber was hoping to call attention to the injustice of such extreme fossil fuel extraction techniques and the other health, economic and environmental concerns regarding the project. Steingraber recalls that it was her first time

acting in civil disobedience. She said she went to the protest with only two things in her pocket- her license and a picture of herself nine-months pregnant, standing in front of Seneca Lake (O’Conner 2013).

Planner Timothy Beatley explores another take on our ethical duties to the environment and how those interact with planning and policy in his article “Ethical Duties to the Environment” (1994). He states that as population growth and land consumption continues to rise, over time there are fewer and fewer natural areas- areas untouched by human hands (Beatley 1994). Urbanization, which replaces natural vegetation with pavement and other impervious surfaces, also creates and exacerbates serious air and water pollution problems. This results in decreased ecosystem function and fewer opportunities to connect habitat fragments with greenways or corridors- thus further limiting their ability to function in a beneficial way. Beatley believes that contemporary land-use practices threaten the ecological integrity of our planet; and that globally our planet is in the midst of an unprecedented era of resource exploitation and loss of biodiversity, the chief cause of which is habitat loss (Beatley 1994).

Part of the challenge is that throughout time people have judged a piece of land’s worth on its utility to people- how much it is worth economically. The environment was not given value based on the hydrologic, biologic and geologic systems that it supports or its other ecosystem services (**Figure 4**). Beatley’s main idea opposes this anthropocentric paradigm. He believes that people have an ethical obligation to protect remaining natural areas because of their inherent value, regardless of what human value has been given to that land. While

conservationists and supporters of the concept of stewardship accept this argument, the idea is generally hard to sell.

## REACHING THE TIPPING POINT

In the 1973 book *Land Use and Landscape Planning*, Derek Lovejoy introduces the idea that the world is at a crisis point. He writes that for the first time the existence of human civilization is primarily threatened not by war but by our own impact on nature (Lovejoy 1973, 3). He cites ignorance, selfishness and the greed of man as the primary sources of this impact. These human characteristics, which at one time allowed us to evolve and advance as a species, are now destroying ourselves and the planet. Worldwide statistics show tremendous degradation across the map, and amidst such turmoil it seems that no landscape, no matter how apparently pristine or remote, is beyond the reach of mankind (Franklin 1997).

Forty-three years after Lovejoy wrote his book the planet is even more out of balance. Today we are at the point where cascading calamities on earth have prompted a body of collapse scholarship. Writers are focusing less on isolated problems such as a polluted river or a threatened species, and focusing more on an entire global decline. Travis Beck writes, “as more than seven billion people dominate the planet... our ever-expanding megalopolises creep out into the landscapes cut over for timber, mined for fuel, bisected for roads, grazed by livestock, drained and plowed for farming, put back to cover, abandoned and regrown, parceled for houses, or opened for recreation” (Beck 2013, 1).

Beck believes that the planet is so far gone that from

now on the only way to maintain the limited ecological function we have left will be from a “network of preserved, restored, managed, and constructed landscapes. To maintain the function of this network, and the quality of life that it offers, we will have to change the way we think about landscape design” (Beck 2013, 1). Nina Marie Lister & Chris Reed make a similar point in their article “Ecology and Design: Parallel Genealogies” (2014) explaining that it is necessary for us to change the way we design and manage interventions to ecosystems if we hope to maintain any of their function in the future. They say that while founding design and planning on an ethic that accepts the importance of the natural patterns of a place may not solve all of our problems, it can go a long way toward changing current trends and making our civilizations more adaptable to the sudden change that is inevitable in today’s climate (Lister and Reed 2014).

The general global decline and metaphorical breaking point that has been described here may be at least partly responsible for the resurgence of ecological thinking not only in design and planning but also in regard to urbanism, society, and culture over the past two decades. Furthermore the field of ecology has moved away from a place of classical determinism- with certainty and order- to a place in favor of a more contemporary understanding of dynamic systems (Lister and Reed 2014). Change, adaptability, resilience, and flexibility are all themes that dominate today’s scientific research. All represent a more organic model that shifts between scales and locations. “In effect, change is built into living systems; they are characterized in part by uncertainty and dynamism... This places landscape architecture in a unique disciplinary and practical space

— informed by ecological knowledge as an applied science, as a construct for managing change, and as a model of cultural production or design” (Lister and Reed 2014, para. 7).

Throughout much of the twentieth century students were taught the early models of linear ecological succession where ecosystems gradually succeeded from a place of disturbance to a more stable state. Today research has shown that change is often built into these systems and that in many cases the ecosystem is dependent on change for growth and renewal (Lister and Reed 2014). It has come to be understood that people are not outsiders to this pattern of shifting stability and change, but rather we are participants. “This perspective also fundamentally challenges the Western Judeo-Christian ideology that humans are the dominant species and therefore have a responsibility (even a moral obligation) to manage or control other species and resources” (Lister and Reed 2014, para. 9). One way to think about this new understanding of our relationship with the land is to think of ourselves as partners. We are one party, interacting with and simultaneously a part of the processes of ecosystems as they unfold. We cannot truly manage or design whole landscapes or ecosystems, but we can attempt to manage our own actions, and to align our needs with the ebb and flow of the other systems of earth (Lister and Reed 2014).

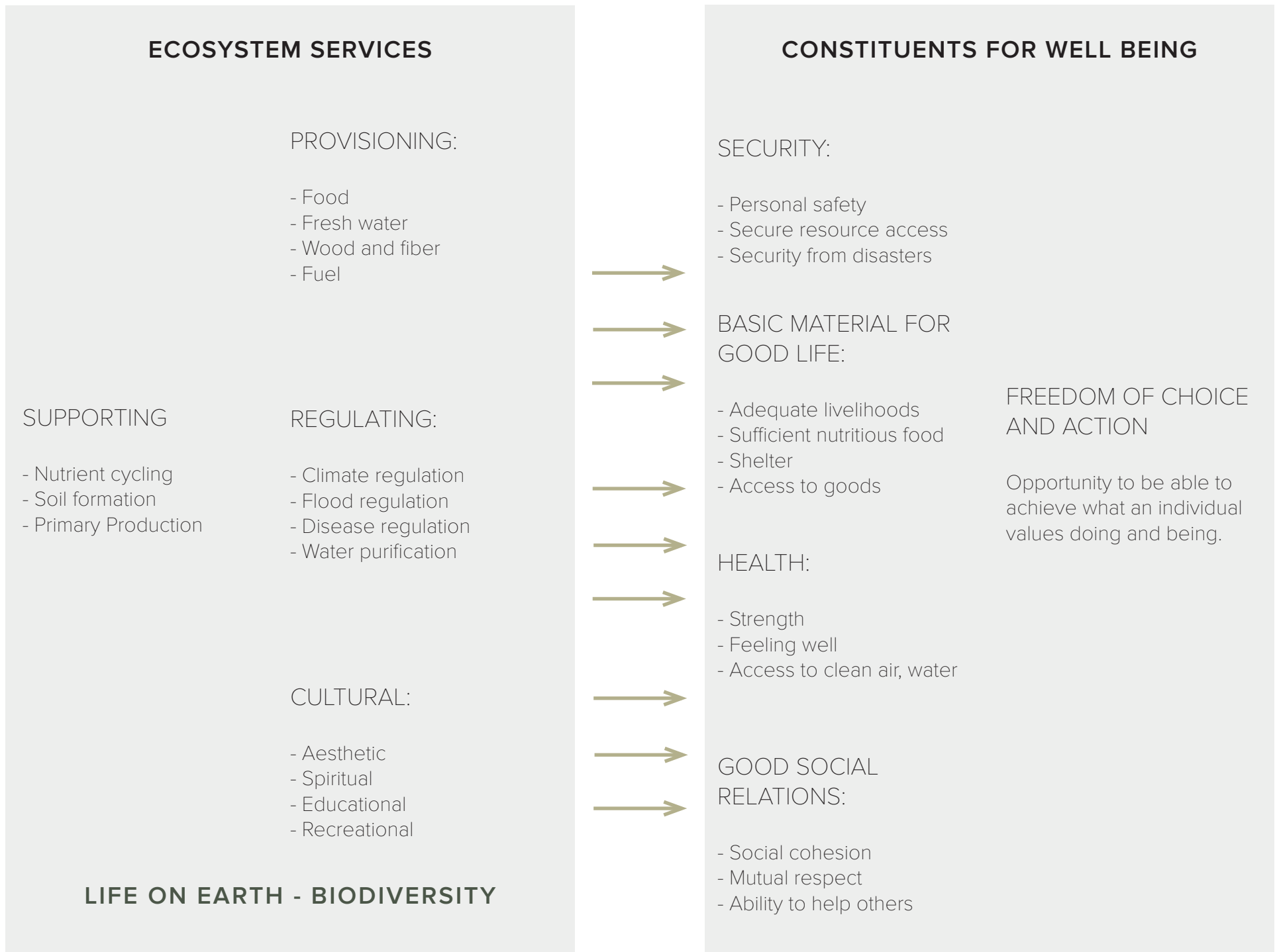


Figure 4. Ecosystem Services Table (Millennium Ecosystem Assessment).

## THE CHALLENGES

Ecological planning presents many good ideas, but it is difficult to execute in the real world. The field faces many challenges, perhaps one of the most significant being the persistence of the boom-bust mentality that has dominated the U.S. since Anglo-European settlement. Since that time we have mined our forests and land for its resources as though there is no tomorrow. Clair Reiniger writes in her article “Bioregional Planning and Ecosystem Protection” (1997), that “when a forest is viewed as a stockpile of timber and not as part of an ecosystem, there is little incentive to reforest. Just clear-cut and move on to the next stockpile” (Reiniger 1997, 187). The take and receive mentality that contributed to the growth and strength of America as a nation is just one of the many challenges that has historically faced the environment. William Wenk writing about early ideas in ecological planning in his article “Toward and Inclusive Concept of Infrastructure” (2002), suggests that although the concepts of ecological planning are sound they usually fail to address major issues such as fragmented land use and ownership, the limited scale and scope of most planning and design projects, and other realities of our political system (Wenk 2002, 176).

*The Woodlands*, a master planned community located twenty eight miles north of Houston, Texas, designed by Iain McHarg and following his ecological planning approach, is often presented as a prime example of ecological planning. The project has won many awards for environmental preservation and masterplanning, and represented an alternative to the urban sprawl that was rampant in the 1960s when it was built. Financial support from founder George Mitchell made the project possible here, where such a project would be too costly else-

where. The seventeen-thousand acre project gave McHarg a canvas on which to apply his theory of ecological determinism—allowing the ecology of the land to determine what development should take place there (Swann 2007). Within this project McHarg attempted to address issues of stormwater runoff, using natural systems to deal with as much runoff as possible. He also prioritized preserving the woodlands, thus protecting species diversity and richness. He hoped that by doing so soil erosion would also be diminished, and wildlife would be minimally impacted by the development (Swann 2007).

Projects such as The Woodlands, which are ecologically ambitious, are more or less anomalies that have not been widely replicated (Wenk 2002). Planners and designers alone do not have the power to make such projects come to life; they depend on cooperative policy and the financial support of other parties. This project was possible because the land was available at a large scale and the owner had the money and mindset to implement the project. It is hard to find this set of variables today. Such projects are costly and they require invested stakeholders that also believe in the importance and



**Image 8.** A creek in The Woodlands, TX (Grzelewski).

power of ecological planning. In order for this set of factors to align in the everyday, our partners in policy, engineering, development and the like must first be educated about the importance of ecological principles and committed to making those principles a reality in their projects.

Clair Reiniger discusses these and other challenges facing ecological planning. She states that most of our everyday practices in modern life impede the implementation of the ecological or bioregional approach to planning (Reiniger 1997). There is a distorted relationship between our economics and the ecosystems of which we are a part. These two forces are often pitted against one another, with the resources of the government rarely designated for the betterment and protection of the landscape. Furthermore a lack of coordination among resource planning agencies and the lack of an informed citizenry to engage in the public process limit progress (Reiniger 1997).

Landscape architects who do wish to promote these ideals may therefore need to take on a design activism role. They must work in tandem with many individuals from other fields who have different values, objectives, motivations, expertise and authority in realms that affect design decisions. They must engage in the process and act as mediator to navigate conflicting interests, limited monetary resources, and sensitive political climates, to propose implementable solutions that address a range of engineering, community and environmental needs (Wenk 2002). Richard Forman adds that when it comes to ecological planning objectives each of the allied fields are key to success and contribute in major ways, yet each has too few of the tools necessary to create a synthesis of nature and culture in the ways that planning and design can (Forman

2002). The objectives of engineering, ecology, and economics are narrow- they each offer a specific set of information or products which require synthesis by some other professional (Forman 85). One additional challenge in this effort is the issue of language. Each of these fields speak their own unique language and finding a way to communicate meaning to one another can take significant time and energy. The importance of a common language between scientists, planners, local stakeholders, engineers, policymakers and other involved parties cannot be stressed enough; and turning toward a more scientific language may be one way to address this issue.

## LANGUAGE

Yet another significant challenge in terms of language comes from within the field. How can we act as cross disciplinary mediators if planners and designers as a group lack clarity in the language we use to describe our projects? While as a field we begin to use scientific knowledge as a tool we continue to diversify the meaning of the language we use and are now to a point of confusion (Corner 1997). Rather than embracing a more precise way of speaking, we continue to extrapolate terms, applying our own concepts of their meaning. The term 'ecology' for instance, has been co-opted by the field to refer to a whole host of generalized ideas ranging from scientific to metaphorical. At this point the term is so overused and misused that it is essentially meaningless. The word is used as much in marketing by corporate and media industries as it is by politicians, land artists and somewhere down the list, by scientists (Corner 1997). Although the term is generally understood to

give some account relating to scientific natural processes and relationships, the fact that it also now represents and is used to describe an ideological stance in regard to nature highlights its importance and also its great challenge. The term 'ecology' conjures up certain images and projects certain values and ideas- and the word can be used as a tool to influence the way people think. In order for ecological planning and design to truly be understood and appreciated for what it is and does, designers must be careful with their use of language including words such as "ecology" and "nature".

For instance, Nina Marie Lister in her paper "Insurgent Ecologies: (Re)Claiming Ground in Landscape and Urbanism" (2016) uses the term more broadly. Here she uses "ecology" in a metaphorical context for the relationship between people and their various constructed environments. She writes, "all of our ecologies — multiple, layered, complex, and insurgent — collectively inform the design of our urban and urbanizing landscapes" (Lister 2016, 524). But in a strict sense ecology is a branch of the biological sciences, the study of complex relationships between organisms and their environments. Metaphorical usages of the concept of ecology can be powerful but confusing. James Corner writes, "this idea can be explored by looking at people's different perceptions of nature. There are at least two types of 'nature' that allow for people's confused understanding of ecology. "The first 'nature', refers to the concept of nature, the cultural construction that enables a people to speak of and understand the natural world, and that is so bound into ecological language; the second, 'nature' refers to the amorphous and unmediated flux that is the 'actual' cosmos, that which always escapes or exceeds human understanding"

(Corner 1997, 84).

The dual use of the word "nature", and the overlapping understanding of its meaning has allowed for some projects that misrepresent nature and/or ecology. In today's setting, where degradation of the natural environment is so common, and so widespread, design professionals must be careful and deliberate with their use of the terms, and their representations of ecology and nature. While the creative greening of urban spaces or the design of beautiful gardens can make a site pleasant and restorative, this does not make it natural and it should not be sold as such.

Another major challenge facing ecological planning is the issue of scale. While McHarg and Lewis set forth inspiring theory for ecological planning at a larger, regional scale, they provided little practical advice as to how to achieve this lofty vision. William E. Wenk discusses how ecological theory is studied at a regional landscape scale, but in reality design projects rarely manifest at that scale. Wenk points out that the scale at which most planners and designers work today is much smaller, a site specific scale; rarely do design professionals have the opportunity to tackle issues at such a large regional scale (Wenk 2002). As such it can be quite tricky for a designer to translate the ecological principles developed for the regional scale to his or her projects. Yet Wenk believes that the small site is the scale at which change occurs today in a dominantly urban or developing setting, where edges are set by property lines and political boundaries. These small sites build mass incrementally over time contributing to the larger pattern of development; therefore we must find a way to translate ecological principles to that scale. "This is the scale at which most

landscape architects, engineers, and other designers practice -- and it is also the scale that must respond to and implement new environmental policies” (Wenk 2002, 177).

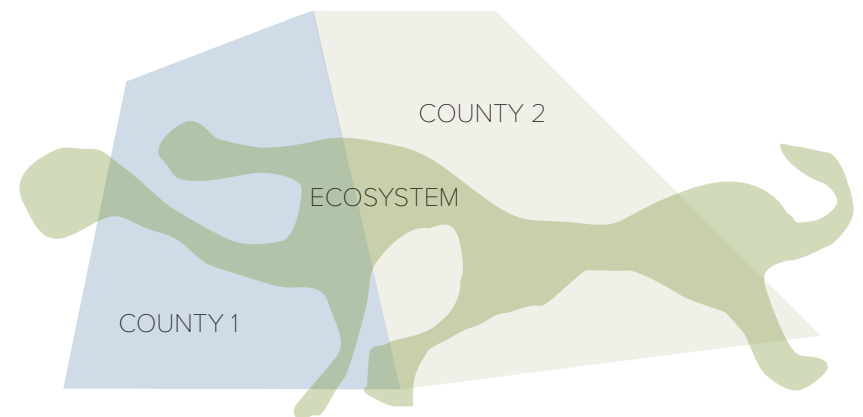
## ENVIRONMENTAL POLICY

One of the greatest challenges of ecological planning is that it must operate within the frame of policy and economy. Policy establishes large scale and long term developmental trends. Planning and design must happen in concert with such trends, and in compliance with the law and with local rules and regulations. Yet the ecological systems that would be used as a guide in ecological planning exist beyond political boundaries for “the earth is composed of ecosystems, the borders of which are not represented by political demarcations but follow nature’s contours” (Reiniger 1997, 185). They act according to the physical structure of the land and the unique environmental factors there. The natural forms of such ecological systems create shapes and outlines that juxtapose the city grid (**Figure 5**).

Policy has the power to make ecological planning succeed or fail; and many proponents of ecological planning feel that environmental policy today does not do enough to protect the environment. In her book *Nature’s Trust: Environmental Law for a New Ecological Age*, Mary Christina Wood presents a framework aimed at fundamentally redirecting current environmental policy in America from its present practice of what she calls the legalization of “colossal damage” to the environment, to a place of “epic restoration” (Wood 2013). She explains that law creates a membrane through which individuals act in relation to nature; and that the efficacy of this law should be of

the utmost concern to citizens. Today she believes the membrane is weak. Evidence of this includes the fact that despite environmental law the U.S. has wiped out more than half (53%) of its wetlands and nearly all (90%) of its old-growth forests (Wood 2013). At least nine-thousand species face extinction in the United States and industry annually releases more than four billion pounds of toxic chemicals into the waters, air, and soil. Under the Clean Air Act alone nearly fifteen-thousand permits have allowed the degradation of American air sheds (Wood 2013).

The United State boasts elaborate environmental law but the system of how the law gets carried out is complicated and inefficient. Much environmental policy trickles down from the federal level to the state level and then to local jurisdictions; but not all of it. Some of it, as William Wenk (2006) points out, grows from the ground up, and these policies often come about because of successful citizen movements. At each level the system relies on agencies, which have been charged with writing rules and regulations, to carry out the mandates of the



**Figure 5.** Ecosystems Spanning County Lines Diagram

law. A snapshot of environmental policy in the U.S. shows us that state environmental agencies generally handle air and water pollution, federal forests are the responsibility of the U.S. Forest Service, endangered species fall to U.S. Fish and Wildlife and the National Marine Fisheries Service, while land use matters go to local agencies. The EPA regulates toxins and pesticides, while the U.S. Army Corps of Engineers oversees wetland regulations. Each agency has its own process and all have vastly different reaches and regulatory stands causing them to overlap and often conflict. With so much overlap one might think that the environment would be better protected, but that is not always the case. Furthermore with little interdepartmental communication it is difficult to make ecological planning possible (Wenk 2002). Responsibilities are split among many different departments who are so busy with their own daily tasks that they rarely communicate with one another (Wenk 2002). These departments along with other public works agencies and parks departments are often competing for attention and dollars; all of which limits their ability to collaborate- something that is surely key to multifunctional, environmentally sound projects.

The one thing that agencies seem to have in common is the power to alter the environment (Wood 2013). “Such discretion rests on a presumption that agencies remain expert bodies that unfailingly exercise their judgment objectively, for the good of the public, and in accordance with protective statutory goals. That presumption now collides with reality” (Wood 2013, 7). Agency employees are given the power to influence nature based on their supposed expertise in an area; they write rules and regulations and hand out permits, but they are not elected officials. Wood states, “agency discretion drives the demise of

nature” (Wood 2013, 7).

There are many reasons why rules and regulations do not do more. Economic values, political agendas, a disorganized system, and a system that allows government agencies to hide behind bureaucratic confusion are all part of the problem. In the land of bureaucracy and politics, permits, exemptions, statutes to the law, and economic pressures, proponents such as Mary Wood argue that the environment gets forgotten. It is not one person’s fault, no single agency’s fault, it is the product of an evolving system that still has a long way to go before it achieves success.

**SEE APPENDIX A:** Summary of influential environmental policy in Washington State and King County.

## **EVOLVING LANDSCAPES: AN EMERGING MINDSET**

In his book *Principles of Ecological Landscape Design* (2013), Travis Beck describes his take on the ecological planning mindset and our role as partners to the land and environment. He writes that where intact natural spaces do exist we ought to protect them. Where a landscape has been degraded it is in our best interest to restore it. Finally, where such an ecosystem has been destroyed we should endeavor to replace this space not simply with the usual elements of the built environment—such as lawns and plazas— but rather we should replace it with dynamic communities that can begin to build back the ecosystems lost (Beck 2013). We should take these steps not only for our own benefit, he argues, but because the landscape has its own value. Beck and other contemporaries are beginning to see that environmental health and our own health relies not only on reactive, but rather on proactive action.

It is progressive thinking such as this that is carrying the field forward today. Advancements and research dedicated to alternative approaches to landscape design and planning allow the field to respond more effectively to ever-increasing design challenges; and to promote better planning for the future. Richard Forman states, “society will increasingly turn to planners and designers, not just to counteract the degradation of landscapes, but to provide the inspired solutions to problems” (Forman 2002, 105). Due to the constraints of the fragmented landscape we see today, ecological planning depends on small scale changes that happen locally at the level of the individual, the piecemeal conglomeration of small parts, that amount to a greater change. This is what we can control; and the vision we create as planners and designers can set a precedent for behavior that inspires people to rethink their individual actions

toward those pieces of the landscape they can influence (Perlman 2005).

In her article, “Insurgent Ecologies: (Re)Claiming Ground in Landscape and Urbanism” (2016), Nina Marie Lister describes how an evolved understanding of our place in the global ecosystem has opened the door to a new breed of urbanism- “one that is characterized by multiplicity, plurality, diversity, and complexity” (Lister 2016, 525). Lister embraces the idea of adaptive design. Adaptive design is a term she uses to describe an “integrated, whole-system, learning-based approach to the management of human-ecological interactions, with explicit implications for planning interventions and resulting design forms” (Lister 2016, 527). Change is normal she writes, but unpredictable and beyond our control. By expecting the unexpected adaptive landscapes prepare for evolution.

For whether we like it or not sites are always evolving in unique ways, moving away from static images into new aesthetics. In the future landscape architecture and ecological planning projects will utilize programs that embrace complexity, allowing plenty of room for growth and change. Martin Prominski author of “Designing Landscapes as Evolutionary Systems” (2005) wrote, “nothing stable can be built”. Prominski embraces a program of complexity in his design theory and pushes for the acceptance of change over time. Likewise James Corner explains that a truly ecological landscape architecture is likely to be less about a finished project, and more about designing for processes. By building strategies and scaffoldings for growth, we may be able to enable new and diverse relationships to emerge. The aim of designs like this, he writes, would not primarily be about aesthetic forms but rather they would be about enabling

relationships to grow freely while providing the structural foundation and quality of material necessary for such processes to occur (Corner 1997). James Corner’s *Freshkills Park* is one example of this type of ecologically minded work that promotes evolution and change in a landscape, allowing ecosystems to function while also promoting human co-existence (**Image 9**).



Image 9. Freshkills Park (James Corner Field Operations).

## **CONCLUSION: CITIZEN PARTNERSHIP**

Ecological planning provides a platform that seeks to address ecological values and project a better future- to build partnerships that are ongoing between the living landscape and mankind (Schauman 1997). This will help not only to reverse current trends of degradation of the environment but also to bring about changes to societal values of the landscape. A growing realization of the interconnectedness of development and environmental processes worldwide pushes sustainable design forward. In the twenty-first century landscape architects and ecological planners will be charged with finding ways to peel back the layers of human impact at many different scales, and to set up landscapes for a healthy evolution into the future. The field will be at the forefront of intervening on behalf of the landscape in a therapeutic way, of reconnecting people with natural spaces, and restoring ecological function so that the land can heal itself naturally from past abuse by people.

This can seem like a daunting task; and while widespread policy change can help to bring about large-scale change, this process can be difficult and slow. One way to contribute to the process while larger shifts in policy develop is to advocate for ecological planning projects at the community level that build change from the ground up. While the idea of grassroots activism may have been around for decades, many of today's members of Generation Y (born 1975 to 1995) and Generation Z (born 1995 to 2015) do not have the same understanding of the concept as their parents might. While these generations might possess more progressive attitudes about the environment, they do not always have a good idea about how they can act to bring about change, or believe that in a world of seven billion there single-self can make a difference.

These generations are more accustomed to waiting for a powerful, progressive thinker to make change from the top down. The challenge is to inspire them into realizing that environmental change is created when individuals with a connection to a place come together. It starts with a single person who steps up from a place of passive observation and is willing to engage both mentally and physically in a partnership with the landscape that they care about.

By tapping into the emotional connection that people share with the landscape we can begin to engage the community in improvement and planning processes. In her article “Importance of Place Attachment” (2006), Lynne Manzo discusses how attachment to place can positively influence community improvements and planning efforts. She writes, “it is noteworthy that emotional connection is at the core of a sense of community. While this connection is focused on bonds among people, place attachment (as an emotional connection to place) can complement a sense of community, since both can motivate community members to participate in neighborhood improvement and planning efforts” (Manzo 2006, 339). Finding and tapping into place attachment can be the starting point in channeling the power of younger generations to engage with the political process.

Ecological planning can promote this type of participatory process by assisting people to make changes themselves rather than bestowing perfected final plans upon them, which can make people feel less qualified to take action (Giliomee 1977). “By sharing the management responsibilities among public and private actors, local actors become engaged with the cause and the plan transforms from an ecological to a

socioecological one” (Briers 2014, 3). This process also relies on active citizens for the implementation of the plan and for further management of their local environments (United Nations Environment Program 2004). “Steps taken in this process will include the collective selection of desired (ecosystem or landscape) functions and finding a consensus on how the physical landscape structure will be changed to obtain the desired functions” (Briers 2014, 3).

By educating community members about the ecological systems, health concerns and opportunities of a place, planners and designers can help to empower people to understand how their actions can have real impacts on the landscape around them- good or bad. Peggy Gaynor, a practicing landscape architect in Seattle, Washington follows a design principle similar to the ideals of ecological planning. Her philosophy is to allow the landscape to renew itself, and to create opportunities for that to happen whenever possible; to design for health of the landscape and to seek unique design solutions outside of the traditional applications of management. She believes in the basic notion of giving the landscape the opportunity to heal and be healthy- she aims to uncover lost systems (Schauman 1997). “Gaynor’s projects reflect the ethical relationship to the landscape as described by Leopold, a concern for ecological integrity and beauty, and importantly, a relationship of respect for a partner” (Schauman 1997, 260).

Gaynor is a good example in this case because of her ability to engage with the community. She has long since realized that enabling an informed citizen group, catalyzed by tapping into people’s emotional connection to a place, can make a much larger impact than design alone. If citizen groups all over

the world worked hard to preserve the places that they care about in their neighborhoods- the places they have formed attachments to- we could not only see major global changes to the environment, but importantly, changes to the way society views and treats the environment. The reality is that the retrofitting and recycling of small neglected spaces, and engaging with the younger generations, is the key to change in today's global environment.

Many case studies exist where this type of process has been successful. In Seattle, Washington restoration projects such as Ravenna Creek, the Duwamish Estuary, and the Meadowbrook Wetland came to be because of citizens who care about their community spaces. Civic efforts such as these projects are evidence that people are willing to be active in their own neighborhoods; that they value ecological health over picturesque or modern landscapes, and that they want natural spaces to thrive even in urban settings (Schauman 1997). Furthermore, currently successful citizen activity is ongoing even without a mediator such as a designer or planner, without funding from environmental lobbies, and without government support (Schauman 1997). These groups have found real power in a coalition of people with one common goal, and they have not relied on external authorities to get the work done. Lynne Manzo (2006, 6) writes, "the political aspects of place and place attachments are illustrated in communities that have been empowered or disempowered (often the same community experiences both simultaneously or in succession) in response to environmental problems (Edelstein 2003). In such cases, place attachments can be used to foster a partnership approach as different parties find common interest in their health and their

neighborhood. When residents are able to take control of the situation themselves and identify common interests and targets, they are more likely to be mobilized toward action and be empowered".

For this type of effort to be a success concerned citizens must first be educated about the issues facing them and possess a willingness to engage in the political process if necessary. While ecological issues are not the main concern of the government, active citizens in large quantities are the main concern of the government, and that is where citizen groups have power (Wildermuth 2016). Equally important, planners and designers need to let go of the idea that we as people bestow the gift of our support to the land when we act as stewards; and move toward the idea that the landscape deserves our respect as an equal partner joined in a movement toward the goal of better human and environmental health.

"By nurturing the landscape's potential to self-renew, human beings are once again connecting with an essential and eternal process. This citizen based partnering of our abused built landscapes goes beyond stewardship because it does not depend on human control, on people improving by imposing on nature. Rather it recognizes that natural processes are powerful and more desirable ecologically, it demonstrates a sharing of the earth, and it recognizes that small gains in landscape's wellness are tied to our own human health" (Schauman 1997, 256).

# REFERENCES BY SECTION

## INTRODUCTION

Forman, Richard T.T. (2002). The Missing Catalyst: Design and Planning with Ecology Roots. In Bart R. Johnson and Kristina Hill, *Ecology and Design: Frameworks for Learning*. Washington, DC: Island Press.

Lyle, J. T. (1994). Chapter 2, Science, Design and Regeneration. In *Regenerative Design for Sustainable Development*. New York: John Wiley.

Ndubisi, Forster O. (2014). *The Ecological Design and Planning Reader*. Washington, DC: Island Press.

## THE HISTORY

Beatley, Timothy. (1994). Ethical Duties to the Environment. In *Ethical Land Use: Principles of Policy and Planning*. Baltimore: Johns Hopkins UP.

Beck, T. (2013). *Principles of Ecological Landscape Design*. Washington, DC: Island Press.

Bocking, S. (7 January 2013). Happy Sixtieth Birthday, Ecosystem Ecology. *Environment, History, Science*. Trent University. Web. 5 Apr. 2016.

Carson, Rachel. (1997). The Obligation to Endure. In Thompson, G. F., & Steiner, F. R. (Eds.) *Ecological Design and Planning*.

New York: John Wiley.

Franklin, C. (1997). Fostering Living Landscapes. in Thompson, G. F., & Steiner, F. R., (Eds.) *Ecological Design and Planning*. Chichester: Wiley.

Lovejoy, D. (1973) *Land Use and Landscape Planning*. New York: Barnes & Noble.

Lowenthal, D. (2000). Nature and Morality from George Perkins Marsh to the Millennium. *Journal of Historical Geography* 26.1: 3-23.

Mackaye, B. (1940), Regional Planning and Ecology. *Ecological Monographs*, 10: 349–353. doi:10.2307/1948509

Marsh, G. P. (1967). *Man and Nature*. Cambridge: Harvard U.

Ndubisi, F. O. (2002). *Ecological Planning: A Historical and Comparative Synthesis*. Baltimore: Johns Hopkins UP.

Ndubisi, F. O. (2014). *The Ecological Design and Planning Reader*. Washington, DC: Island.

O'Connor, K. (21 March 2013) Locals Protest Gas Storage Facility. *The Ithican*. Web. 5 Apr. 2016.

Reed, C., & Lister, N. M. (2016). Ecology and Design: Parallel Genealogies. *Places*. 24 Apr. 2016.

Steingraber, S. (2002) Exquisite Communion: The Body, Landscape, and Toxic Exposures. In Johnson, B. R., & Hill, K. *Ecology*

and Design: Frameworks for Learning. Washington, DC: Island Press.

Thompson, G. F., and Steiner, F. R. (Eds.) (1997) *Ecological Design and Planning*. Chichester: Wiley.

Wenk, W. E. (2002). Toward an Inclusive Concept of Infrastructure. In Johnson, B. R. and Hill, K. *Ecology and Design: Frameworks for Learning*. Washington, DC: Island Press.

## THE CHALLENGES

Corner, J. (1997). Ecology and Landscape as Agents of Creativity. In Thompson G. F., & Steiner F. R., (Eds.) *Ecological Design and Planning* (81 - 107). New York: John Wiley and Sons.

Forman, R. T. (2002). The Missing Catalyst: Design and Planning with Ecology Roots. in Johnson, B. R. & Hill, K. *Ecology and Design: Frameworks for Learning*. Washington, DC: Island Press.

Lister, N. M. Insurgent Ecologies: (Re) Claiming Ground in Landscape and Urbanism. Academia.

Reiniger, C. (1997) Bioregional Planning and Ecosystem Protection. In Thompson, G. F., & Steiner, F. R. (Eds.). *Ecological Design and Planning*. New York: John Wiley and Sons.

Swann, K. (2007). The Dream of Designing with Nature: The Woodlands, Texas, USA. *Green Urbanism and Ecological Infrastructure*. Web. Accessed 24 April 2016.

Wenk, W. E. (2002). Toward an Inclusive Concept of Infrastruc-

ture. In Johnson, B. R., & Hill, K. *Ecology and Design: Frameworks for Learning*. Washington, DC: Island Press.

Wood, M. C. (2013). *Nature's Trust: Environmental Law for a New Ecological Age*.

## EVOLVING LANDSCAPES

Beck, T. (2013). *Principles of Ecological Landscape Design*. Washington, DC: Island Press.

Corner, J. (1997). Ecology and Landscape as Agents of Creativity. In Thompson, G. F. & Steiner, F. R. (Eds.), *Ecological Design and Planning* (81 - 107). New York: John Wiley and Sons.

Forman, R. T. (2002). The Missing Catalyst: Design and Planning with Ecology Roots. in Johnson, B. R. & Hill, K. *Ecology and Design: Frameworks for Learning*. Washington, DC: Island Press.

Perlman, D. L., & Milder, J. C. (2005). *Practical Ecology for Planners, Developers, and Citizens*. Washington, DC: Island.

Prominski, M. (2005) Designing Landscapes as Evolutionary Systems. *The Design Journal* 8.3: 25-34.

Reed, C., & Lister, N. M. (2014). Ecology and Design: Parallel Genealogies. *Places*. 24 Apr. 2016.

## CONCLUSION: CITIZEN ENGAGEMENT

Briers, C. (2014). Towards Sustainable Landscape and Ecological Planning: Reciprocal Effects of Incorporating the Social

Dimension. Web. Accessed 10 May 2016.

Edelstein, M. R. (2003). *Contaminated communities: Coping with residential toxic exposure*. Boulder, CO: Westview Press.

Giliomee, J. H. (1977). Ecological planning: method and evaluation. *Landscape Planning*, vol.4 pp.185-191.

Manzo, L.C., & Perkins, D. (2006). Finding common ground: The Importance of Place Attachment to Community Participation and Planning. *Journal of Planning Literature*, vol. 20 pp.335-350.

Schauman, S. Beyond Stewardship Toward Partnership. (1997). In Thompson, G. F., & Steiner, F. R. (Eds.). *Ecological Design and Planning*. New York: John Wiley and Sons.

United Nations Environment Program. (2004). Environmental management and Community participation: Enhancing local programs. Urban Environment Series, International Environment Technology Centre (IETC).

Wildermuth, T. (15 January 2016). Personal interview.

## FIGURES

Figure 4- "Ecosystem Services Table". Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being: Synthesis*. Washington, DC: Island Press.

## IMAGES

Image 1- George Perkins Marsh [Photograph]. Retrieved from National Humanities Center <http://nationalhumanitiescenter.org/tserve/nattrans/ntuseland/essays/amcward.htm>

Image 2- Camping in Yosemite Valley, Yosemite National Park, 1920s [Photograph]. Retrieved from PBS [http://www.pbs.org/nationalparks/media\\_detail/309/](http://www.pbs.org/nationalparks/media_detail/309/)

Image 3- Odium's Ecosystem Concept [Photograph]. Retrieved from <http://environmental-history-science.blogspot.com/2013/01/happy-sixtieth-birthday-ecosystem.html>.

Image 4- McHarg, Environmental Factors Maps [Photograph]. Retrieved from <https://www.gislounge.com/geodesign-to-create-smarter-cities-and-adaptable-landscapes/>

Image 5- Aldo Leopold [Photograph]. Retrieved from NPR <http://www.npr.org/2013/03/10/173949498/remembering-aldo-leopold-visionary-conservationist-and-writer>

Image 6- Earth Day 1970 [Photograph]. Retrieved from <http://gisetc.com/the-history-of-earth-day/>

Image 7- Rachel Carson and Bob Hines [Photograph]. Retrieved from the U.S. Fish and Wildlife Service <http://www.britannica.com/biography/Rachel-Carson/images-videos/Bob-Hines-and-Rachel-Carson-conducting-research-in-Florida-1952/99786>

Image 8- Grzelewski, Brian [Photographer]. (2012). Creek in The Woodlands [Photograph]. Retrieved from <http://adventureswith->

[andrea.com/category/the-woodlands/page/2/](http://andrea.com/category/the-woodlands/page/2/)

Image 9- Freshkills Park [Graphic]. Retrieved from James Corner  
Field Operations [http://www.fieldoperations.net/project-details/  
project/freshkills-park.html](http://www.fieldoperations.net/project-details/project/freshkills-park.html)

2



LAKE KILLARNEY PARTNERSHIP  
ECOLOGICAL HEALTH OVERVIEW AND  
MANAGEMENT PLAN

Image 10. Lake Killarney

# INTRODUCTION

## A PERSONAL INTRODUCTION

In my world there is a place of special significance. It is the place where I grew up, the place where I explored and learned to love nature. It is a place of beauty set within the suburban sprawl of south Seattle. When you think of Federal Way, you do not think of this place. It is an oasis in the drab suburbs- filled with cookie-cutter homes and strip-malls.

Lake Killarney is a small, rain-fed lake. It is so small that motorboats of any kind are prohibited; canoes and kayaks rule the water. Surrounding the lake is a canopy of tall Douglas Fir trees with private residences dotted beneath. When you look out all you see is the sky reflected in the water. In recent years intense development of nearby land has felled acres of forest. Where in my childhood there used to be thirty healthy acres, there is today a new development with over one hundred-fifty homes. The greater ecosystem of the lake has been slowly degraded, and much more development is planned for the near



**Image 11.** Swimmers enjoying the lake in the summer.

future. There seems to be almost nothing stopping developers from clearcutting acres of valuable forest set above this system of sensitive wetlands and lakes.

Each year more stormwater run-off enters the lake carrying with it pollutants that threaten the fragile ecosystem. For beneath the water is a secret, a relic of the industrial past of nearby cities- arsenic and lead. These contaminants are by-products of the ASARCO smelting plant that dates back to 1917 in nearby Tacoma, Washington, and was in operation for almost one-hundred years. Arsenic and lead pose significant health threats to the public, and while the EPA has been involved in cleanup efforts replacing contaminated soils throughout Tacoma, little attention has been given to other affected ecosystems.

As I walk around the southern edge of the lake I wonder how the system can withstand so much. Here I come to a stream, the output of the lake. It used to flow across miles of vegetated land, cleansing the water of pollutants as it wound downhill heading to the Fife Valley and then its ultimate destination, Commencement Bay of Puget Sound. Today, a few hundred yards from the lake the stream is culverted. The natural landscape and wetland system is disjointed and constrained. Overflow fills up along roadsides walled off with feet of concrete. The water stands here causing an accumulation of sediment, arsenic, lead, and other pollutants.

Crammed next to the road and the new cookie-cutter homes are multiple retention ponds for the new developments. Signs read "this pond is in our care", yet fences keep everyone away from the oddly murky, standing water. The ponds cover what was once marsh, now filled in and fenced off, creating a

strange new landscape. They are flanked in concrete and a few shrubs. Trash from neighbors and a nearby bus stop float by in the water; and the fence on one side is slouching down. A combination of lake water from Killarney and excess stormwater are trapped in the walled system slowly moving a few feet before entering the culvert. Here it crosses the road beneath feet of concrete and asphalt and flows, now piped, through the next neighborhood accumulating more pollutants from storm-drains along the way. About three miles downstream the water emerges into a protected area.

Here I meet it, running alongside the newly day-lit stream on a paved running path. I can watch the water flowing next to me as it meets natural obstructions- fallen trees, large rocks and rapidly growing ferns. This land is protected because on either side steep slopes make it too difficult and dangerous for developers to build here. The water flows, the stream turns, and I follow its progress down hill. One and a half miles later we both meet flat land. Here as I keep turning my legs the water stops. In an agricultural field in the Fife lowlands, with farms on one side and I-5 on the other, the water from Lake Killarney is no longer running. Here it enters a large pool, flooding the crop land and inviting ducks to come and play. I imagine that most of the pollutants are here now not having had a proper chance to filter out of the water; they seep into the earth where crops will soon grow.

As I turn to run back home I think about what the path of that water would have looked like years ago- back before settlers tamed the land. I wonder what will happen in a few more years when the last remnants of forest are gone and industrial waste continues to seep into the landscape. Will there still be

woodpeckers, great blue heron and bald eagles for me to admire from my backyard? How can it be that people do not feel a greater sense of connection to these natural systems? How can it be that we so thoughtlessly carry out our plans, ignoring the damage we are causing? For I know that this place and other open spaces like it- that bring many people joy, provide critical habitat for species, and provide important ecosystem services- are worth conserving for generations to come.

## PURPOSE

As has been discussed, ecological planning is a challenging theory to apply in the real world (Wenk 2002). Yet despite these challenges it provides many opportunities for building sustainable landscapes that are capable of adapting to change and evolving gracefully over time (Lister 2016). These healthy landscapes are made up of functioning ecosystems and represent places where humans can coexist with the natural processes of the land and the other forms of life that occupy that space (Corner 1997).

Lake Killarney is a unique and beautiful asset to our community; but lakes are sensitive ecosystems and those located in urbanized settings are less stable compared to those in a natural setting. As a small eutrophic lake, Lake Killarney is one such lake whose sustained health rests on continued monitoring and proactive strategies. The purpose of this plan is to lay out the significant areas of concern, set goals, and propose solutions for improving the condition of this ecosystem. As a community we must take steps to promote its resilience to future changes and disturbance; and a system of adaptive man-

agement can help us to partner with this complex landscape. In this way we can do our best to ensure that Lake Killarney does not degrade further as many of the other small lakes throughout the region have.

## GOALS

- A) **IMPROVEMENT:** To improve the lake's ecological function by examining the larger ecosystem and identifying concerns, goals and actions regarding the condition of that ecosystem (sometime referred to as ecological health).
- B) **EDUCATION:** To educate residents & concerned citizens about the issues and opportunities regarding the condition of the lake.
- C) **PARTNERSHIP:** To promote the idea of community activism and partnering with the landscape to form a reciprocal, beneficial relationship.
- D) **CONSERVATION:** To prepare for & protect the lake's ecosystem from future threats by conserving healthy land.



**Image 12.** A bald eagle above the lake.

## SITE OVERVIEW

Lake Killarney is located in unincorporated south King County. Its northwestern edge meets the boundary of the City of Federal Way and residents either have Federal Way or Auburn addresses. It is located within the Urban Growth Area of King County, an area that has developed intensely in the last twenty years. The rate of development here is projected to increase in the coming years as the area is located in Federal Way's east potential annexation area (PAA) and will soon be incorporated into the city. Development has already encroached upon natural areas and degraded native habitats; the hydrological system of the watershed has been severely altered. Filling, channeling, and piping of water prohibits the natural hydrological processes of filtering pollutants and toxins from water running off of the surface before it enters lakes and streams.

Lake Killarney is approximately 3 miles in circumference, and 31 acres in surface area with a maximum depth of 15 feet and an average depth of 9 feet (**Figure 6**). It is mostly rain and run-off fed with no stream or spring inlet. Groundwater and a wetland to the north of the lake contribute to its constant level while it fluctuates seasonally about 12 to 18 inches. The lake is slowly undergoing the process of oligotrophication and is currently classified as eutrophic. There is a small boat launch at the north end of the lake operated by the Washington State Department of Fish and Wildlife; and an approximately 11 acre public park owned by the City of Federal Way. The lake is popular for recreational hook-and-line fishing, and during the hot summer months as a local swimming hole.

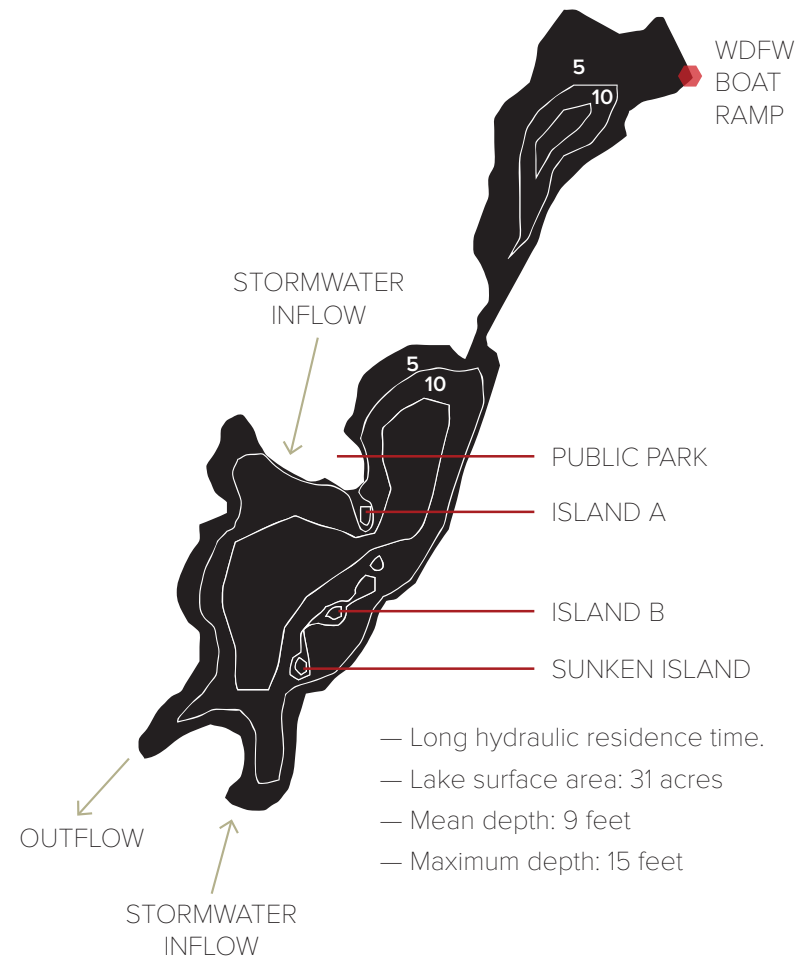
There are at least two major stormwater overflow basins that discharge into the lake frequently during heavy storm events and a surface outflow drains from the lake at its south-

western edge sending water into tributary 0006 of the east branch of Hylebos Creek. Algal blooms are common in the lake and treated semi-annually with money collected from residents by the Lake Killarney Improvement Association (LKIA). In 2015 the LKIA collected \$7310 from 58% of homeowners, of which \$5400 was used for aquatic-weed control. Treatment is mostly effective although certain years the algal blooms are much more virulent. Recent issues with other lakes in Federal Way that are being negatively impacted by urban development have made the condition of the lake's ecosystem a concern.

About one quarter of the shoreline maintains natural vegetation and provides riparian habitat critical for fish and wildlife. There have been several noxious weeds documented at the shoreline of the lake including Tansy Ragwort (*Jacobaea vulgaris*) and Purple Loosestrife (*Lythrum salicaria*) recently. The lake supports a healthy fish community that is supplemented by King County with stocked fish annually. It is also home to an impressive array of wildlife particularly avian species including: bald eagle, osprey, hawks, great blue heron, king fishers, pileated woodpeckers, owls, grouse, and cormorants along with the usual ducks and geese.

The water quality of the lake has been monitored by the King County Lake Stewardship Program since 1989. Trend reports from this organization show that Lake Killarney is more variable in its water quality than other similar lakes. This may be in part due to other toxins that are present within the lake's watershed including arsenic and lead which were byproducts of the ASARCO smelter plant that was in operation in nearby Tacoma, Washington throughout the 1900s. University of Washington researchers have recently obtained a Superfund Re-

search Grant for continued work at lake Killarney through 2017 to study arsenic and lead in the sediment and water column.



**Figure 6.** Lake Killarney Basic Features Diagram

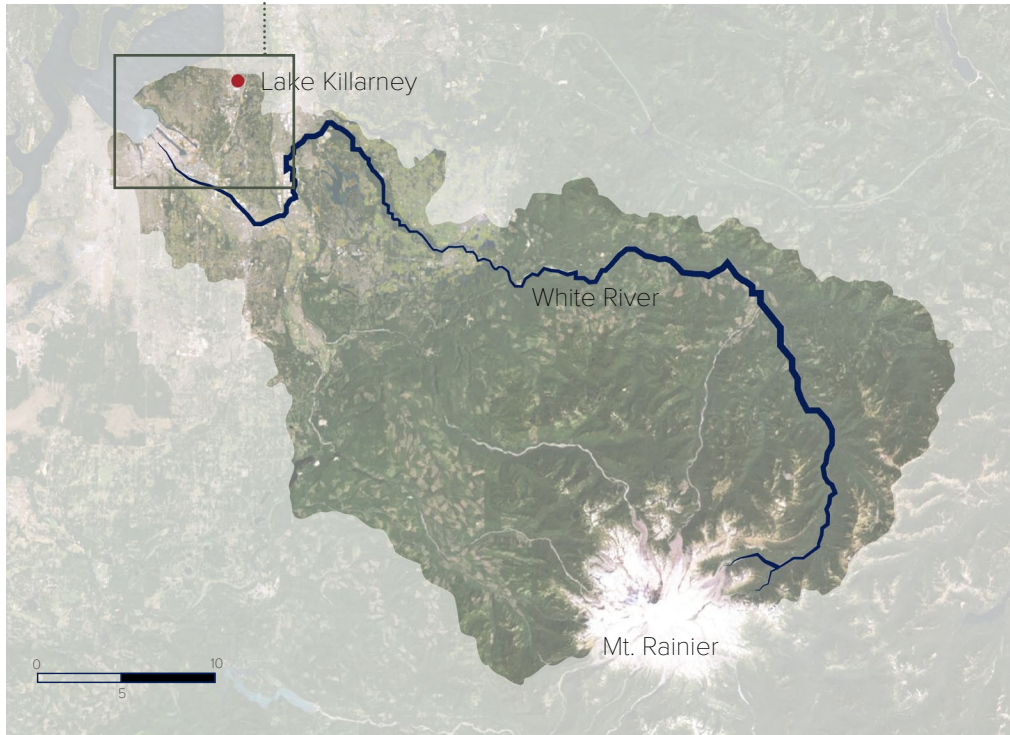
## CONTEXT

### WHITE RIVER WATERSHED

Lake Killarney is located in the White River Watershed at the watershed's northern boundary (**Figure 7**). The Green River Watershed is located just to the lake's north, with neighboring Lake Geneva included in that watershed. The White River watershed has been significantly altered since the early 1900s when a debris jam blocked the channel of the white river diverting its floodwaters away from King County, down the Stuck River and into the Puyallup River (King County 2015). A permanent diversion replaced the jam and is located today at the Game Farm Park in Auburn, Washington.

The headwaters of the White River emerge where the Emmons and Fryingpan glaciers meet on Mt. Rainier (King County 2015). The river flows 68 miles and drains 494 square miles before draining into the Puyallup River near Sumner, Washington. Mud Mountain Dam has provided flood control for the area since the U.S. Army Corps of Engineers began operating it in 1948 (King County 2015); and the dam has affected salmon runs in the area since it was built by altering flows and inhibiting migration. Downstream another dam is operated by Puget Sound Energy and redirects <2,000 cubic feet of water per second into Lake Tapps, a man-made reservoir. The water flows back into the White River about 20 miles downstream of the diversion dam. Examining the greater watershed begins to reveal the large-scale affects that human impact has had on the region. The flow of water from Mt. Rainier to Puget Sound is very different today compared to what it looked like before modern human settlement. Many areas within this watershed are now polluted and contribute to the decline of ecosystems in

## WHITE RIVER WATERSHED



## HYLEBOS CREEK DRAINAGE BASIN

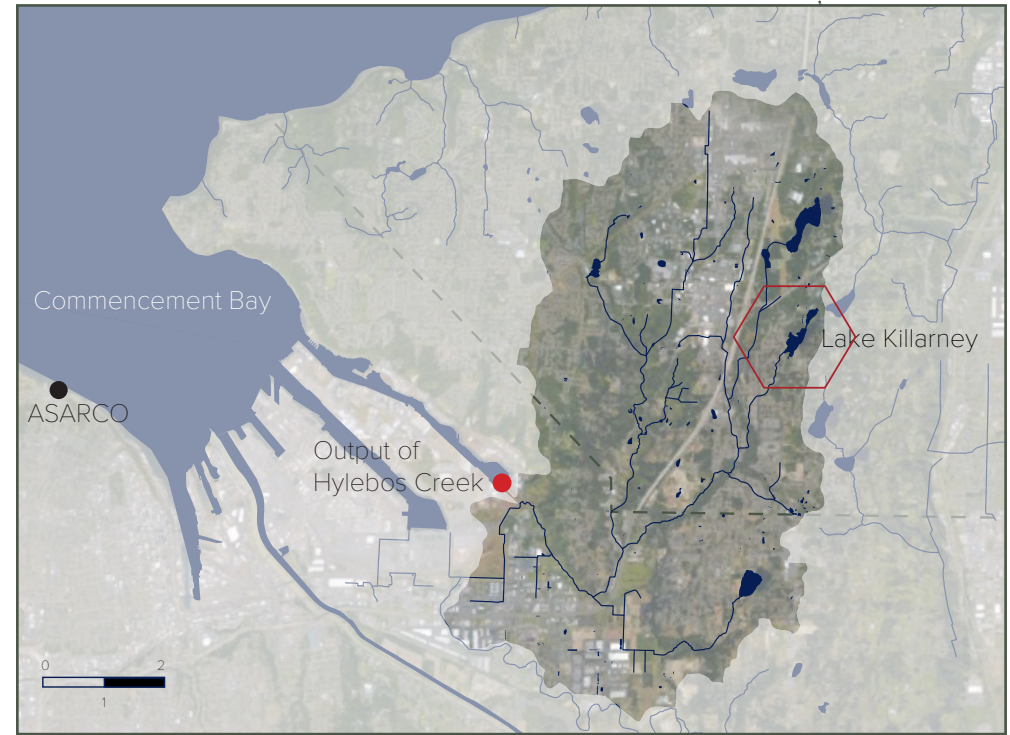


Figure 7. Watershed Context Maps

the Puget Sound. Salmon runs have been affected not only by physical barriers but also by a decline in overall water quality.

## HYLEBOS CREEK DRAINAGE BASIN

The Hylebos Creek drainage basin is located partially within the White River watershed in the northwest corner of its area near Puget Sound (**Figure 7**). The Hylebos Creek system is an independent tributary to Commencement Bay. The headwaters of Hylebos Creek originate in the City of Federal Way and the creek flows via two primary branches through the cities of Milton and Fife before discharging in the bay. The drainage basin for this creek is further divided into sub-basins and Lake Killarney is located within the East Hylebos Creek Sub-Basin (**Figure 8**). The main tributaries of East Hylebos Creek flow from Lake Killarney and neighboring North Lake (Pierce County 1993). These Creeks meet the west branch of Hylebos Creek near the King-Pierce County line where they converge to form a single mainstream. This portion of the creek is protected under the Shoreline Management Act of Washington State (1972) and it has poor water quality (Pierce County 1993).

The entire watershed of Hylebos Creek comprises some 18,000 acres. Originally it was home to more than 25 miles of streams, 11 named lakes and several other smaller, unnamed lakes and ponds. The same area today now contains seventy-five percent less water due to filling, channeling and piping (Pierce County 1993). Major development over the past twenty years has almost entirely altered the hydrologic systems of Hylebos Creek. Today the creek is regulated by a complex system of retention ponds, underground piping, and ditches. It

has been channeled and rerouted in many areas throughout Federal Way and man-made features now control its flow (University of Washington).

Due to an increase in impervious surfaces throughout the area flooding causes channel-scouring in the remaining small streams (**Figure 10c**) (University of Washington). The area of Federal Way that is located within the Hylebos watershed is dominated by commercial, industrial, and residential land uses. The everyday activities associated with these land-uses contribute to the amount of water and pollution that enters the creek system as runoff. Furthermore within the Hylebos waterway are 5 superfund sites; and the outflow point at Commencement Bay is where the highest concentrations of pollutants accumulate creating health concerns for ecosystems of the Puget Sound. Contaminants include arsenic, zinc, copper and hydrocarbons (University of Washington).

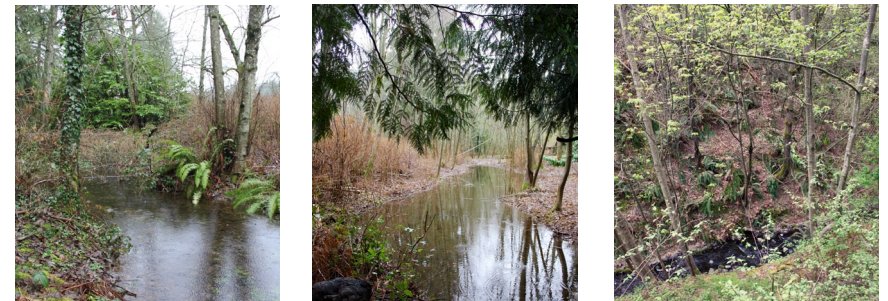
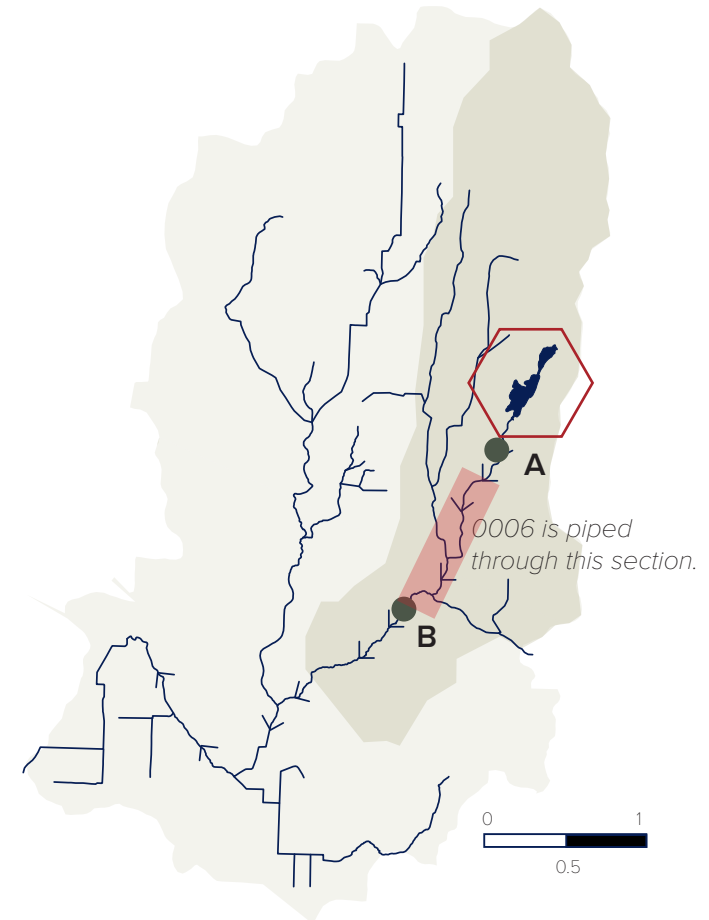
Just one major portion of the system is now protected thanks to community activism. The Hylebos Creek Preserve in Federal Way consists of some 120 acres of land, and is home to 4 different types of wetlands at the headwaters of the Hylebos Creek system. Many animal communities rely on this area for foraging and habitat within the greater urban area. Avian species that utilize Lake Killarney likely also inhabit land at the Hylebos Creek Preserve. The preserve is also home to ancient Sitka spruce trees and a lowland bog, one of the last remaining in south King County (University of Washington). The bog contains peat that reaches up to 30 feet thick- it absorbs massive amounts of water and helps to prevent flooding. The Friends of the Hylebos organization actively work to preserve the site.

Another important feature of the Hylebos Creek system

is Tributary 0006 which originates at the outflow point of Lake Killarney (**Figure 8**). Throughout the 1900s and 2000s several studies were conducted on this stream aimed to assess the water quality of the east branch. All of the reports are evidence of the significant changes that have been seen in the environmental and water quality of the Easy-Hylebos Basin in the past several decades. Parameters that were evaluated multiple times include total suspended solids (TSS), turbidity, total phosphorus (TP), total and dissolved copper, total and dissolved zinc, hardness, fecal coliform, total petroleum hydrocarbons (TPH), conductivity, dissolved oxygen, pH and temperature. Of these parameters fecal coliform, total phosphorus, copper, zinc, and total suspended solids were found to be parameters of concern in the East Hylebos Basin (University of Washington). This indicates that stormwater from roadways which carries pollutants and organic matter into the stream, as well as potential sources of point-source contamination are of concern.

Even greater rates of development have been seen since these studies were conducted. Today there are several large new single-family residential neighborhoods directly adjacent to the headwaters of tributary 0006 (**Image 14a**), and at least five other similar developments are currently planned which will put continued and future pressure on the creek system (**Figure 9**). Water quality can be expected to continue to degrade as more naturally vegetated land is lost to suburban development (**Figures 9 & 10**).

## EAST HYLEBOS CREEK DRAINAGE BASIN



**A** Lake output.

Tributary 0006.

**B** 0006 daylight.

**Image 13 a,b,c.** Stream 0006 at three different points.

**Figure 8.** East Hylebos Creek Drainage Basin Map

# EXISTING & PROJECTED DEVELOPMENT WITHIN EAST HYLEBOS CREEK



**A** *New neighborhood cuts into wetland buffers.*



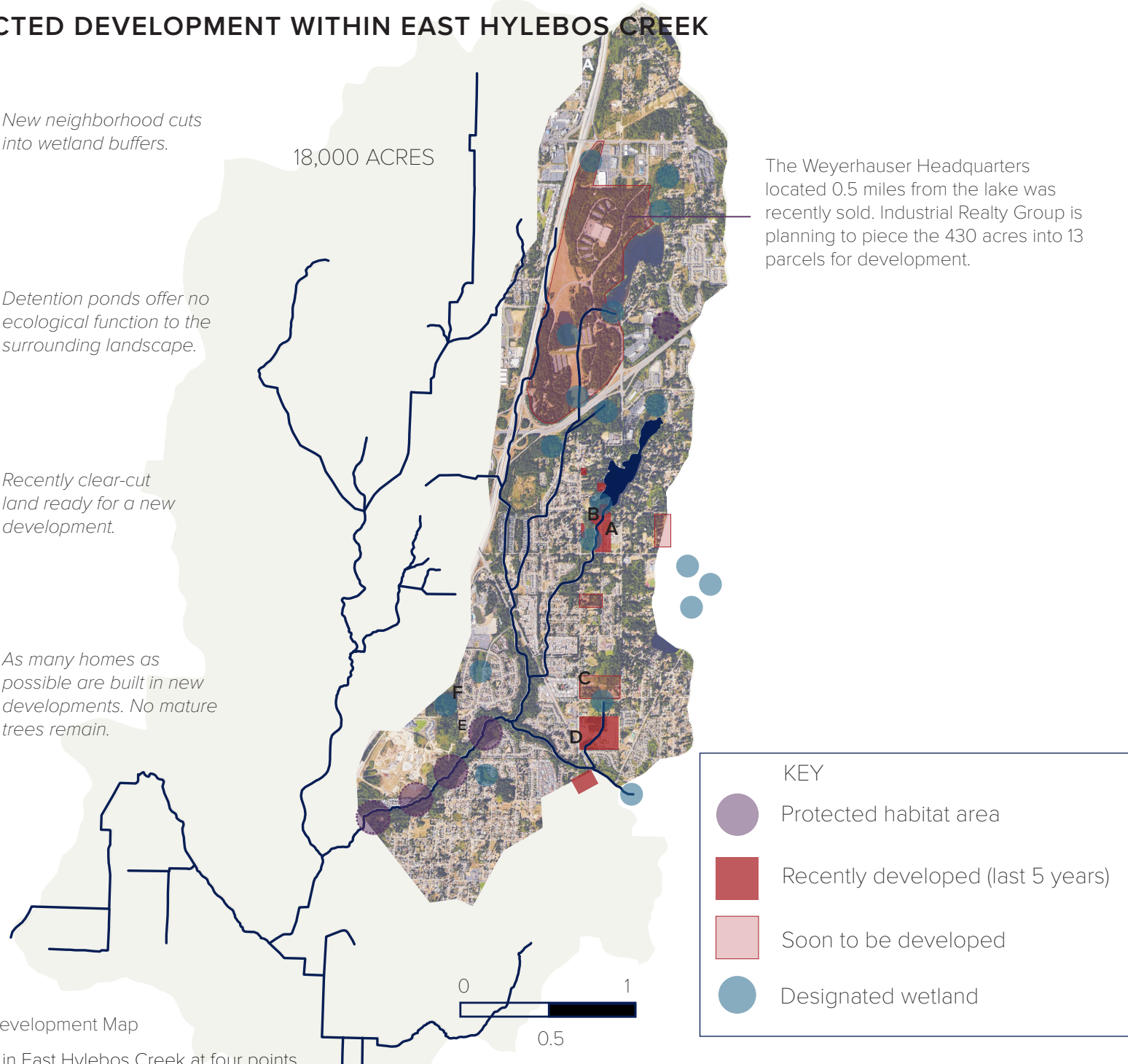
**B** *Detention ponds offer no ecological function to the surrounding landscape.*



**C** *Recently clear-cut land ready for a new development.*



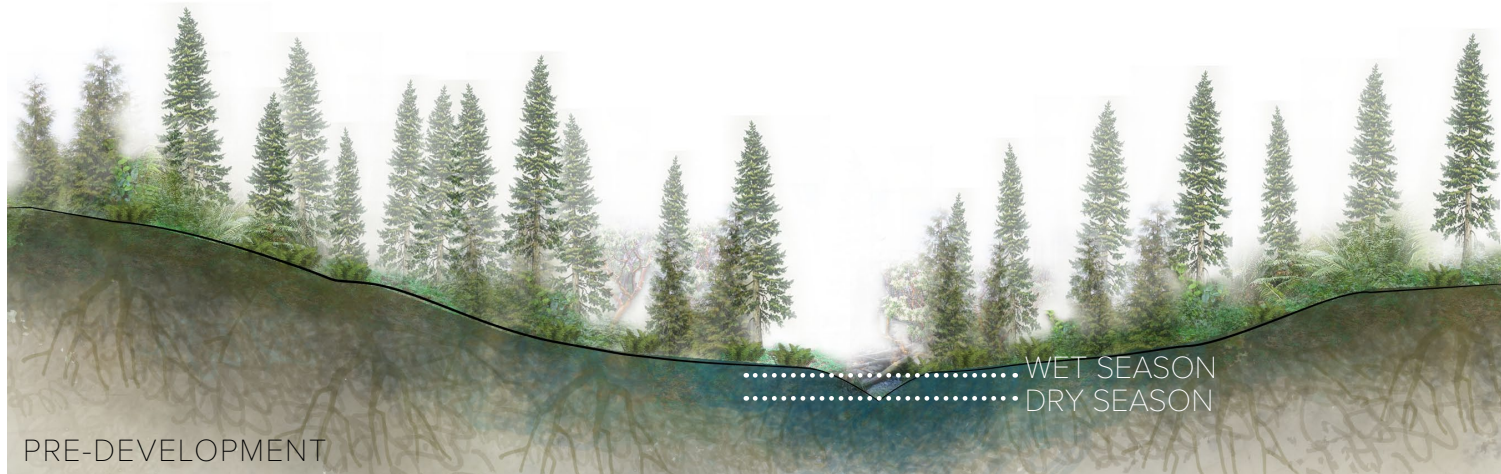
**D** *As many homes as possible are built in new developments. No mature trees remain.*



**Figure 9.** East Hylebos Creek Development Map

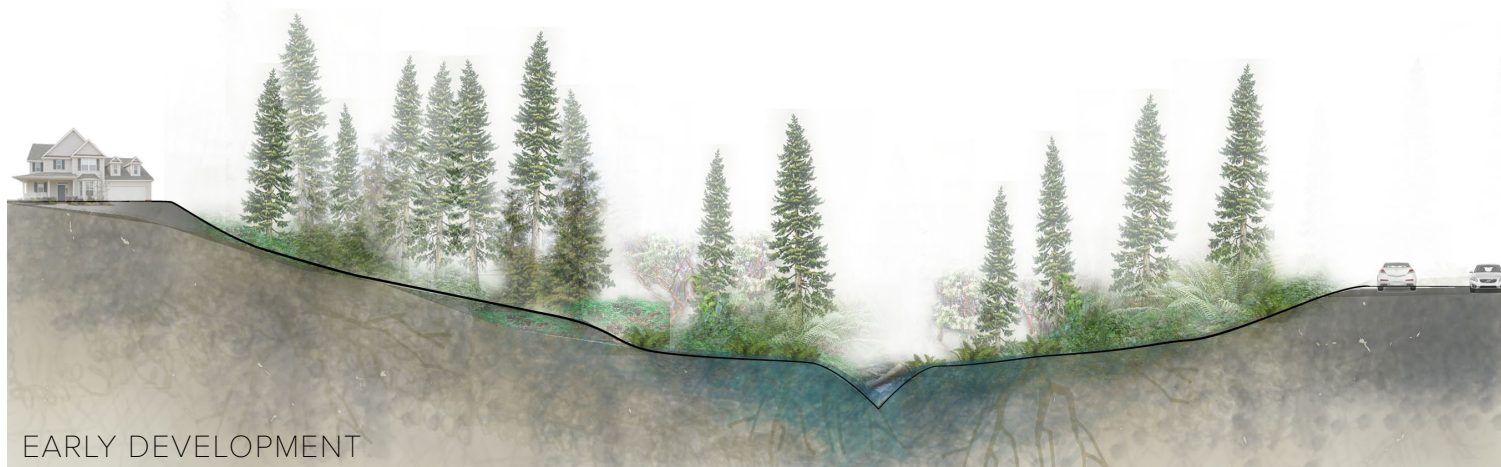
**Image 14 a,b,c,d.** Development in East Hylebos Creek at four points.

## 0006 STREAM CONDITION



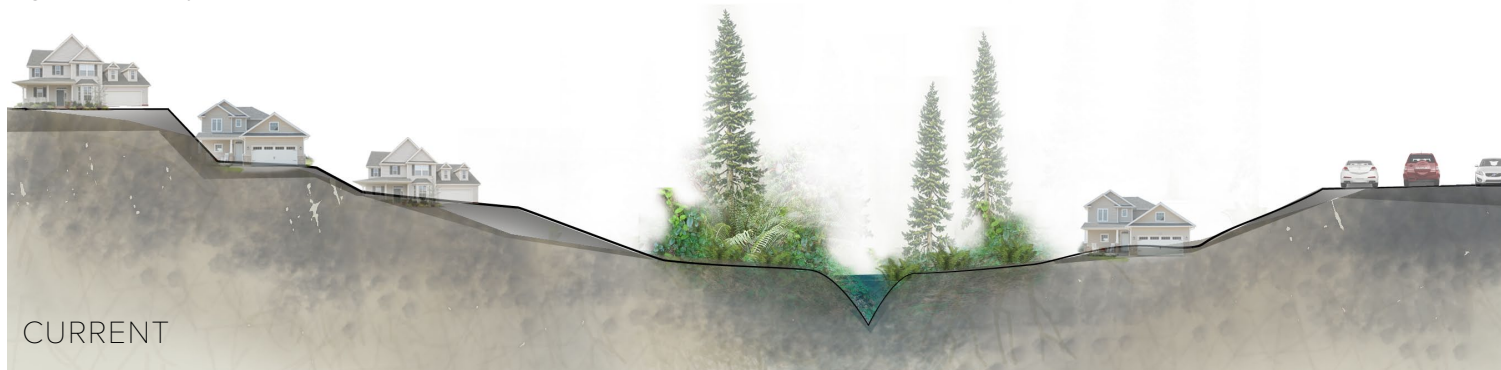
*Seasonal flooding leads to the development of diverse plant communities. Riparian environments such as this represent rich, unique habitat and functional hydrologies that cleanse water and return it to the ground-water table.*

**Figure 10a.** Pre-Development Section



*Upland development effects the natural environments downhill. Entire ecosystems are altered via land development. Permeable surfaces change to impermeable surfaces; streams are culverted and piped; forested land is lost.*

**Figure 10b.** Early Development Section



*Impervious surfaces increase the amount of water flowing to the stream. This in turn increases the velocity of flow and causes scouring of the stream-bed; deepening and narrowing the stream. Water has less opportunity to slow, spread and seep in conditions like this; cleansing of pollutants is inhibited.*

**Figure 10c.** Current Conditions Section

## WEYERHAEUSER

Lake Killarney is located approximately 1/4 mile from the 430 acre Weyerhaeuser campus located within the Federal Way city limits (**Figure 9**). The campus is complete with large tracts of mature forest, well kept with healthy native understory and trails for passive recreation (**Image 15**). The campus also contains a large prairie where people take their dogs to play, a large pond which provides habitat for waterfowl, and many wetlands. The campus provides a significant amount of quality habitat for animals in the area, and a retreat for people. It is well loved by city residents, runners and outdoor enthusiasts; and the project exemplifies many of the ideals of ecological planning.

In 2014 Weyerhaeuser leadership decided that in order to attract the ideal type of employee they would need to move their headquarters to Seattle, WA. The move was kept quiet for a number of months while logistics took place for building the new Weyerhaeuser headquarters in Seattle, and while the sale of the land was carried out behind closed doors. In early 2016 a buyer was finally announced and the move was made official. Industrial Realty Group (IRG) purchased the Weyerhaeuser land for \$70.5 million on February 2, 2016 (Dawson 2016). IRG is known for purchasing and renovating industrial land, and for completely redeveloping large parcels of land for commercial and industrial use. An article in the Federal Way Mirror states: “Industrial Realty Group owns more than 120 properties in 28 states with more than 100 million square feet of space. The company is currently the master developer for the National Football League’s Hall of Fame Village, which includes the renovation of the Pro Football Hall of Fame Field” (Dawson 2016,

para. 7). Due to this sale a large scale preservation opportunity has been lost by Federal Way and King County and now the continued health of this land is uncertain. What is certain is that IRG will parcel the land into 13 plots for sale and development which will disjoint and disconnect the intact ecosystems. Ecosystem services and human environmental health benefits will be decreased and a general degradation of the land’s health is expected. This will be a major loss for Federal Way and specifically Lake Killarney.

### FOOTNOTE

Before the purchase became official it was my hope that the Federal Way community would voice their concerns with the move and encourage the city or King County to purchase the land for conservation. Protecting mature forested land within the urban area is written into both the City of Federal Way Master Plan as well as the King County Comprehensive Plan of 2016. After writing an open letter of concern to the Federal Way City Council I was able to speak with several of the council members and they informed me that the land was “too expensive” for the city to purchase. Four out of the five city councilmen responded directly to my letter. In order to protect the valuable open spaces that our community cares about we need to come together and present a unified citizen coalition. Without an informed and active citizen group, economic pressures will continue to drive decisions that have major impacts on the future health of the environment.



*Looking out over the Weyerhaeuser Campus in Federal Way, WA. The iconic building seen in the distance was built in 1971.*

**Image 15:** Weyerhaeuser

## THE LAKE-WATERSHED CONNECTION

The hydrologic cycle is the process by which water moves from the atmosphere to the ground and back again in a circular pattern (King County 2016). Clouds are made up of water vapor, which falls to the earth in the form of rain, snow or sleet. Approximately three quarters of that water then returns again directly into the air- either by evaporating off of the earth's surfaces, or through transpiration from the pores of plants (King County 2016). Much of the water that remains on earth's surface is temporarily held in streams, lakes, wetlands, in the ground or in oceans before it moves again through the hydrologic cycle (King County 2016).

Similarly, though lacustrine systems are understood as still bodies of water, the water within a lake is constantly changing. Precipitation, stormwater runoff, streams, springs and sub-surface flows of groundwater all represent sources of water for lakes. Water also leaves lakes by seeping into the ground, evaporating from the surface or outputting into a creek or stream (King County 2016). Seasons and precipitation have dramatic affects on a lake, especially a small lake like Lake Killarney, influencing its level on any given day. In temperate climates of the Puget Sound, at the end of summer lake levels are generally at their lowest. Some lakes stay relatively clean all year long while others seem more susceptible to pollution or algal blooms- both signs of increased nutrient loading in the lake (King County 2016). These differences often have to do with a lake's hydraulic residence time. That is, the time it takes for the lake to completely replace its volume of water through inflow and outflow. A relatively short hydraulic resident time is generally days or weeks, and these lakes tend to stay largely free of algae and organic matter, remaining clean and clear as

these organisms are flushed out before they can multiply. Lakes with a long hydraulic residence time- which tends to be months or years- favor the growth of algae and are more sensitive to additional inputs from pollution (King County 2016).

The hydraulic residence time, amount and rate of nutrient supply, climate, and the shape of the lake basin all determine the trophic state of a lake. The term “eutrophic” means well-nourished and these lakes have high nutrients and high plant growth. An “oligotrophic” lake has low nutrient concentrations and low plant growth. While finally “mesotrophic” refers to lakes somewhere in between (Lake Access). These terms are important because they can give clues as to a lake’s lifecycle and it’s overall condition. Oligotrophic lakes tend to be younger and cleaner, while eutrophic lakes tend to be older and more filled with nutrients including toxins and growing matter like algae (Lake Access). Lake Killarney is a eutrophic lake. It’s bottom maintains aquatic vegetation year round and the clarity of the lake is lower due to zooplankton and phytoplankton, larger organic material, sediment, and pollutants that enter in stormwater. Changes in climate and watershed vegetation can exacerbate productivity in a lake. Nutrients such as nitrogen and phosphorus are necessary for algae to grow; so when too many nutrients are present from human inputs, algae can grow much more rapidly and become a nuisance. Everyday human activities serve as nutrient sources including pollution from roadways, washing of cars, gardening, agriculture, forestry and land development (Lake Access).

Stormwater management is the key to keeping natural hydrologic systems healthy and becomes increasingly challenging as land use within the watershed changes from natural

to urban (Zhang et al 2015). Not only does this increase stormwater runoff but it also decreases the landscape’s physical connectivity and breaks the natural functioning of the hydrologic cycle. When any part of the cycle is unable to function normally, such as when excess stormwater inundates the system, then the entire cycle will begin to degrade. This is why it is important in successful planning to find ways to manage excess stormwater and design ways for the system to function as closely as possible to its natural state. Green stormwater infrastructure is one way to address the issue of functional connectivity in the hydrologic cycle as it introduces designed spaces that naturally filter and store excess stormwater (Zhang et al 2015).

A lake reflects its watershed so when the land within the watershed moves away from its natural conditions so too does the lake. Changes in land use patterns across the extended landscape as much as changes directly at the lake edge can alter the natural functioning of the lake. As developments are built the natural ecological systems around them become disjointed. Developmental patterns often disregard sensitive ecosystems, and are formed by zoning and economic pressures (City of Federal Way 2007). Fragmentation places tremendous pressure on priority species with fewer and fewer suitable places to reside, forage and reproduce, and no safe avenue of movement from habitat patch to habitat patch. Erosion is another result of development that stems from a loss of vegetative cover. When root systems are absent to hold soil in place it moves, potentially releasing large quantities of sediment into lakes and streams. Increased quantities of sediment can clog lacustrine systems inhibiting their natural cycles (King County 2016).

When development is taking place bulldozers compact soil making it difficult for water to infiltrate. This exacerbates issues of erosion as stormwater runs off of the hard surfaces with little or no foliage to slow and collect it. Increases in stormwater and a decreased ability of the natural landscape to infiltrate water back into the groundwater table causes flooding issues and pollution. “Protected” wetlands are also increasingly encroached upon by development. Often wetlands are not accounted for, not mapped, or provided a sufficient buffer. Developments fill them via permits erasing their ability to cleanse water as part of the natural system, and sequester carbon- being one of our best natural weapons against global warming. These moist areas are also a hot-spot for diverse plant and animal communities that enrich the natural environment tremendously and help to maintain biodiversity around the world (King County 2016).

Another general but substantial environmental loss due to development which puts added pressure on hydrologic systems, is the loss of trees. Trees, like wetlands, are incredible at dealing with excessive carbon emissions. In fact one acre of healthy Puget Sound area Douglas-Fir has been found to store about 500 metric tons of carbon dioxide in 60 years primarily in trunks and roots (King County 2013). Considering that the average King County resident emits about 13 MtCO<sub>2</sub>e (million metric tons of carbon dioxide equivalent) per year, this is quite a lot. It has been estimated that in recent years the new growth forest in Washington State has reabsorbed about 1/4 of the climate pollution emitted in the state (King County 2013). Trees are equally efficient at moving water through the system as they are at storing it. Approximately 2,380 gallons of rain is absorbed

and used annually by a single medium sized tree in a healthy forest (King County 2013). This means that healthy forests not only absorb pollution, but also help to reduce flooding in our wet, marine environment (King County 2013). Combine those benefits with the other benefits of healthy forest such as habitat, and you may begin to wonder why there aren't more stringent laws protecting our forests in urban areas.



*Tributary 0006, output of Lake Killarney running through cleared land with new developments encroaching upon buffer.*

Image 16. Tributary 0006

# LAKE KILLARNEY SITE ANALYSIS

## LAKE KILLARNEY WATERSHED

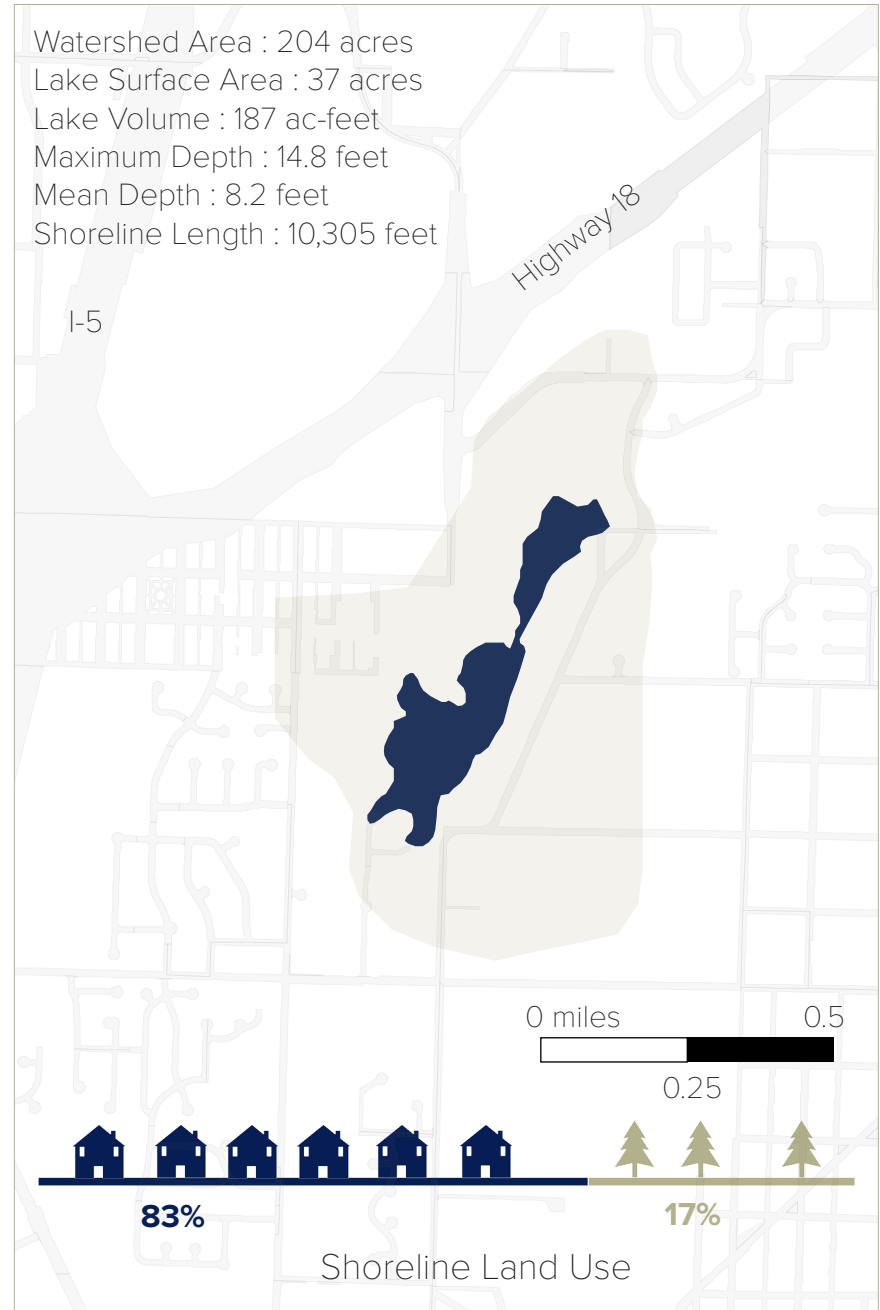


Figure 11. Lake Killarney Watershed Map

## LAKE WATERSHED

Lake Killarney has a 204 acre watershed (**Figure 11**) that drains into the lake from a gently sloping area. Roughly 59% of the land in the Lake Killarney watershed was still classified as forested in 1976 (Washington State Department of Ecology 2006), and according to King County in 2002 only 17% was still classified as forested- a decrease of 42% in 26 years (**Figure 11**). There are two major stormwater inflow points, one at the southeast corner of the lake and one near the public park. Here stormwater discharges into the lake during especially rainy events. There is one outflow point at the southwest corner of the lake where water exits the lake and enters tributary 0006. Outflow is regulated by a small manmade dam (**Image 17**). The



*The small man-made dam that regulates the height of the lake and represents the one outflow point of the lake. Stream 0006 emerges from this dam.*

**Image 17.** Lake output point.

eastern shoreline of the lake is moderately steep, however development is not tiered; thus many mature trees are still present (King County 2002).

## LAND USE DEMOGRAPHICS AND REGULATORY OVERVIEW

Land use at Lake Killarney in 2002 can be divided into the following categories: single family- 53.8%, office industrial- 21.6%, right-of way- 0.1%, open space park- 11.6%, vacant- 12.1% and other- 0.8% (King County 2002). Shoreline Management Code classifies Lake Killarney as an urban lake. With a surface area of thirty-one acres the lake falls under regulations by the Shoreline Management Act (SMA) which regulates all shorelines of the state belonging to water bodies with a total surface area of 20 acres or greater. While the lake is located in unincorporated King County, its northwest boundary borders with the city of Federal Way (**Figure 12**) meaning that the lake is partially regulated under the Federal Way Shoreline Management Program (SMP) and partially regulated under the King County SMP. The land located within Federal Way is designated for conservation and contains more natural habitat than the rest of the lake.

The location of the lake to the east of the I-5, Highway 18 interchange (**Figure 12**) is within the City of Federal Way's Potential Annexation Area (PAA) (King County 2008) and within the King County Designated Urban Growth Area (UGA)- one factor that has contributed to the increase in development in this area in recent years. Relatively large tracts of land are still intact and zoned for development. The city of Federal Way acknowledges that it will likely incorporate the area within the next five to ten

years which will drive further development (King County 2008).

Roughly two-thirds or more of the shoreline and inward land at Lake Killarney is designated R-4 residential with 4 Dwelling Units (DU) per acre. A section of nearby land through which tributary 0006 runs is zoned R-6 residential- 6 DU per acre (King County). This area is surrounded by fluctuating marshy land designated as wetland and classified as critical habitat. Clearing and grading on land within the designated sensitive areas is dangerous to the health of the lake and also requires a permit. “King County’s Zoning Code (Sensitive Areas Ordinance) prohibits any clearing of plants and any earth work along the edges of lakes or streams, within wetlands, or inside the buffer zones of these and other sensitive areas. Typically,

buffers extend 25 to 100 feet from the outer edge of a sensitive area. Only with an approved permit exemption, or variance, from King County can such activities take place” (King County 2015). The remaining shoreline of the lake is zoned CP-1, Office Park. Adjacent to this area is a parcel that is government owned and constitutes a public park with access to the Lake.

## CLIMATE & PRECIPITATION

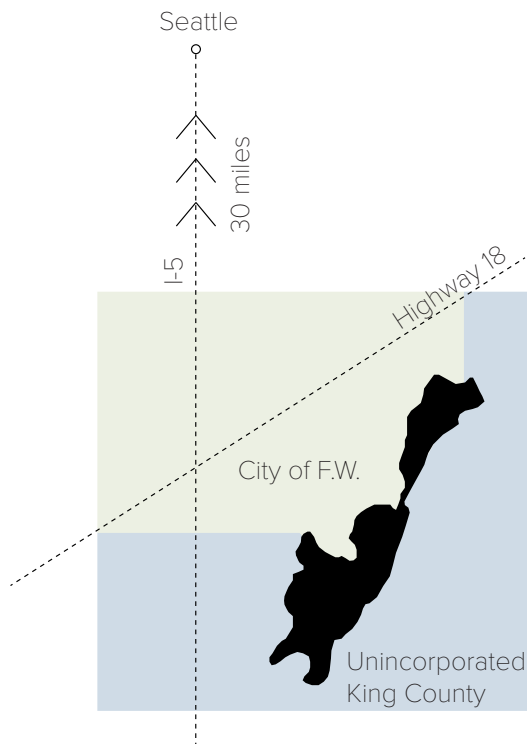
Federal Way is located in the greater Puget Lowlands of western Washington. Here a maritime climate keeps winters cool and summers dry with a distinct rainy season from fall to spring. The area receives about 35-40 inches of rain annually with the majority of that precipitation, about 75%, falling between October and March (Washington State Department of Ecology 2006).

## TOPOGRAPHY, GEOLOGY, SOILS

In the past two million years the area has been glaciated six or more times. The most recent glacial ice receded about 13,500 years ago and is responsible for most of the lakes existing

### FOOTNOTE

For those with questions about how this portion of the lake is regulated, the shoreline management goals and policies can be found in the land use element of the Federal Way Comprehensive Plan, FWCP Section 2.8.5. The Shoreline development regulations and permitting procedures are codified in Chapter 18, Article III of the Federal Way City Code (Washington State Department of Ecology 2006).



**Figure 12.** Lake Killarney Location Diagram

throughout the region today. This event is known as the Vashon Stade of the Fraser glaciation (Washington State Department of Ecology 2006). Lodgement till associated with the Alderwood soil series makes up the majority of surface soil in the area. This soil tends to be more compact due to the weight of the ice when the area was glaciated, which prevents much permeation of water into the ground. Recessional outwash (sand and gravel) and recessional lacustrine (silt and clay) overlays the till in many areas of the upland plain. The depths of the subsurface contain aquifers and aquitards which contribute to groundwater movement from the plateau to the shoreline or adjacent valleys (Washington State Department of Ecology 2006).

Because of the soil conditions, the upland area of Federal Way, which is essentially a wetland plateau (The Des Moines Plain located between the Duwamish Valley and Puget Sound), does not filter water vertically through much land; instead it generally runs off into the nearest stream or water body (Washington State Department of Ecology 2006). Development of the hydrologically sensitive areas, of which there are many, is destructive to the integrity and water quality of the freshwater ecosystems that depend on clean flowing water for survival (Washington State Department of Ecology 2006).

## HYDROLOGY & WETLANDS

The ecological systems that have formed and maintain Lake Killarney are focused on hydrology. Today precipitation falling on the upland plateau is conveyed directly into the small lakes and associated streams by surface runoff or is soaked into the ground. During heavy rainfall the ground quickly becomes

saturated and water unable to infiltrate travels downhill over the ground as stormwater runoff. This water erodes soil which is conveyed into streams and eventually outputs into Puget Sound. As has been previously explained impermeable surfaces including pavements, buildings or compacted soils increase stormwater runoff. Alternatively, vegetation intercepts rainwater and slows it allowing for more permeation into the ground. Vegetation helps to reduce erosion when water is flowing over the ground by holding soil in place with its roots and also by reducing splash erosion (Shoreline Inventory).

Many of the poorly draining areas near Lake Killarney are where wetlands formerly existed or still do currently. Wetland functions include storing water during flood events, stormwater detention, water quality improvement partly due to the phytoremediating qualities of wetland plants, shoreline structure protection, and habitat for fish and wildlife (Washington State Department of Ecology 2006). They also store large quantities of carbon dioxide, a function that makes them critical to the overall health of the global environment, and one of the reasons why they enjoy more protections than other natural systems. In 1999 a total of 232 wetlands were documented within Federal Way and its PAAs (Washington State Department of Ecology 2006). Development in the area has greatly decreased this number, and today we see higher volumes of stormwater and faster rates of flow moving through the system (Washington State Department of Ecology 2006).

Lake Killarney is considered a permanent lacustrine wetland by the City's Wetland Inventory except in areas where the depth exceeds 6.6 feet which is considered deepwater habitat (City of Federal Way 2007). The area to the north of



**Image 18.** Tributary 0006

the lake is classified as a palustrine emergent and scrub-shrub wetland. This wetland stores water and acts to recharge the lake throughout the year as well as provides critical habitat. The wetland at the south fills up in the rainier times of the year, between October and March, and forms tributary 0006 (**Image 18**) which runs throughout the wet season. This wetland area helps to filter water exiting the lake, allows the water to infiltrate into the ground and regulates its inflow into the Hylebos Creek system. The water quality of Lake Killarney greatly affects the water quality of the Hylebos Creek system downstream.

## VEGETATION

Before modern settlement this area was made up primarily of



**Image 19.** English Ivy covers much of the shoreline in areas that could provide quality shoreline habitat.

coniferous forest, deciduous riparian forest (**Image 24**), wetlands and other native habitat types (Washington State Department of Ecology 2006). Today native vegetation is restricted to undeveloped areas and the land lining the few protected wetlands. Native vegetation at the lake comprises trees such as Douglas fir, Western Red Cedar, Western Hemlock, Red Alder and Madrone Trees. Western Red Cedar, once dominant in wetter areas, is less common now. Today common upland understory plants within the watershed include salal, ferns, Indian plum, Oregon grape, elderberry, oceanspray, salmonberry, and snowberry.

The lake is also home to a less positive set of plants—non-native invasive plants. Himalayan blackberry is common at the lake although its presence has been somewhat reduced.

The aquatic plants Eurasian Watermilfoil (*Myriophyllum spicatum*) and White Water Lily (*Nymphaea odorata*) became a problem in the mid-1970s. Lake residents' concerns regarding these plants in particular resulted in the formation of the Lake Killarney Improvement Association (LKIA) which functions to make decisions regarding herbicide applications to the lake. Herbicides were first applied in 1979, but since 1987 the Lake Killarney Improvement Association has been applying chemicals consistently for weed control as well as copper sulfate to control algae once or twice a year (Department of Ecology 1997).

In 1993 the LKIA and King County Surface Water Management (KCSWM) joined together to apply for a grant to develop a more long-term, integrated plan for control of aquatic plants that did not rely entirely on chemical controls for treatment. Basic recommendations of the plan included stocking sterile Grass Carp to consume submerged plants. Herbicides were suggested on a time scale of one to three years to control floating-leaved plant beds. Hand cutting was also suggested to be done by residents to maintain nearshore areas. Today LKIA relies once again on chemical treatment of the lake.

In 2002 Eurasian Watermilfoil (*Myriophyllum spicatum*), Fragrant Water Lily (*Nymphaea odorata*), Yellow Flag Iris (*Iris pseudacorus*), and Purple Loosestrife (*Lythrum salicaria*) were identified as non-native invasive plants present at the lake (King County 2002). These plants can take over the small sections of intact riparian zones and vegetative buffers that do exist at portions of the lake which can lead to a loss in biological diversity. More common non-natives such as English Ivy (**Image 19**) are also present at the lake and have taken over what could be diverse nearshore habitat. The recommendation of this plan is

to revitalize volunteer efforts to manage invasive species.

## FISH & WILDLIFE

Several of the state's federally listed species are known to inhabit land within the shoreline areas of Lake Killarney. Species of significance include the bald eagle (*Haliaeetus leucocephalus*) listed as threatened in the state, and the pileated woodpecker (*Dryocopus pileatus*) which is a state candidate for endangered status. Each of these species require healthy, substantial habitat in order to survive. There are very few areas within the greater watershed that are capable of supporting these species. Species listed as priority habitat species and regularly seen at Lake Killarney include: bald eagle, great blue heron, pileated woodpecker, wood duck and hooded merganser. According to King County guiding policy E-434, "habitats for species that have been identified as endangered, threatened, or sensitive by the state or federal government shall not be reduced and should be conserved" (King County Comprehensive Plan 2016).

The lake also supports stocked and natural communities of trout and large-mouth bass as well as other fish species including yellow perch, pumpkinseed sunfish and brown bullhead catfish. "Salmonids inhabiting East Hylebos Creek, which is fed by both North Lake and Lake Killarney, include coho salmon, chum salmon, and cutthroat trout" (Washington State Department of Ecology 2006). Since the Creek exiting the lake ends up supporting salmon species, the water quality of the lake and its stream are important for their health. Furthermore, each of the species that live at the lake contribute to the balance of

## HIGH QUALITY ECOLOGICAL COMMUNITIES



**D** Riparian wetland



**F** Douglas-fir, Pacific Madrone / Salal



**G** Douglas-fir, Western Hemlock / Swordfern

**E** Large Woody Debris + Shoreline Vegetation

**Image 20.** Fallen Tree (background)

## PRIORITY HABITAT SPECIES

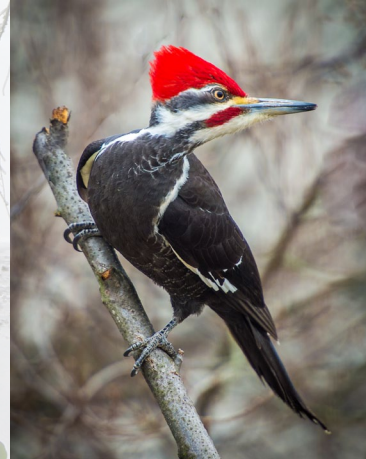
As listed in King County Comprehensive Plan **E-435**.



Bald Eagle



Great Blue Heron



Pileated Woodpecker



Wood Duck



Hooded Merganser

**Image 21 a,b,c.** High Quality Ecological Communities

**Image 22 a,b,c,d,e.** Priority Habitat Species

**Figure 13.** High Quality Ecological Communities & Priority Habitat Species at Lake Killarney

the ecosystem's food web which constitutes a flow of energy through the system (**Figure 14**).

## WATER QUALITY

Overall water quality trends have been monitored by the King County Volunteer Lake Monitor Program off and on since the late 1980s. These data trends provide a basic idea about the physical conditions and water quality of the lake, and a classification of its trophic state. The trophic state is determined by total phosphorous, chlorophyll-a, and transparency and indicates the biological activity of the lake (King County 2015). The data collected by the lake monitors show trends over time and can be examined in relation to development or other changes in a lake's watershed. Changes that are detected can help to inform restoration measures to improve conditions of the lake.

Data that has consistently been collected at Lake Killarney by lake monitors includes clarity, chlorophyll-a, temperature, phosphorus and nitrogen. At the lake, secchi depth, a measure of water clarity, has always hovered around 2 meters, and the data is fairly consistent from 1989 to 2015. Water temperature in Lake Killarney is usually around 20 degrees Celsius, plus or minus about 5 degrees. Chlorophyll-a has maintained levels between 2 and 10  $\mu\text{g/L}$  and there has been a slow increasing trend. Chlorophyll-a concentrations indicate the abundance of phytoplankton (algae) in the lake and so an increasing trend would suggest a decrease in water quality (King County 2015).

Phosphorus and nitrogen are both natural occurring elements necessary for growth of plants and animals. Since

phosphorus is usually low in healthy ecosystems this is often the limiting nutrient. When the amount of available phosphorous increases this can lead to more biological activity including larger and more frequent algal blooms in lakes which are usually seen as a nuisance by residents. Many human related activities such as residential development can increase these nutrients in lake levels beyond their natural amounts. Additionally, most of the older houses on the lake operate on their own private septic systems. Any of these systems that might be faulty are capable of leaking phosphorus into the water, as does runoff from fertilized lawns.

Throughout the 1990s phosphorus levels averaged



*Stormwater discharging into the lake from one of the main overflow points- this one at the southeastern shore of the lake.*

**Image 23.** Stormwater Discharge

around 40  $\mu\text{gP/L}$  in Lake Killarney, but by the year 2015 the average level was closer to 20  $\mu\text{gP/L}$ . This significant decrease in phosphorus might indicate an improvement in water quality. Nitrogen has fluctuated between 40 and 80  $\mu\text{gN/L}$  since the mid 1990s. Although phosphorous levels have decreased over time the overall water quality has not necessarily improved- it remains moderately good to fair. The use of herbicides to treat algae and aquatic plants are likely being reflected in the lower chlorophyll-a levels observed in the last decade relative to the amount of phosphorous. Nutrient loading control measures remain important to preserving existing water quality as new land continues to develop throughout the watershed (King County 2015).

Based on these water quality parameters Lake Killarney is categorized as a eutrophic lake with moderately-high productivity (King County 2015). Lake Killarney is unique among the lakes of King County in that it has exhibited both increases and decreases in water quality over the past decades, and has shifted between mesotrophic and eutrophic. Water clarity is quite low and the flushing rate of the lake is also low which may exacerbate water quality issues.

The chemistry of the lake is further complicated by additional toxins present which are not monitored by the King County Lake Stewards. Arsenic and lead are the two toxins of greatest concern which have recently been shown to exist in elevated levels within the lake's system. A separate team of researchers from the University of Washington have been studying the long term effects of the ASARCO smelter that existed in nearby Tacoma from the late 1800s to the late 1900s and which output lead and arsenic into the air. Results of the study show

greater than 200 mg/kg of arsenic in the top 2 cm of the sediment core at Lake Killarney; and a level of 30ppb dissolved arsenic throughout the water column (Gawel 2013). A peak level of nearly 80 ppb was recorded in August of 2015 (Gawel 2013). Studies have also found significantly elevated levels of arsenic within the phytoplankton (maximum concentration 1574.2  $\mu\text{g/g}$  dry wt) and zooplankton (maximum concentration 146.9  $\mu\text{g/g}$  dry wt) which indicates the ability of Arsenic to move up the food chain (Adrissono et al 2016).

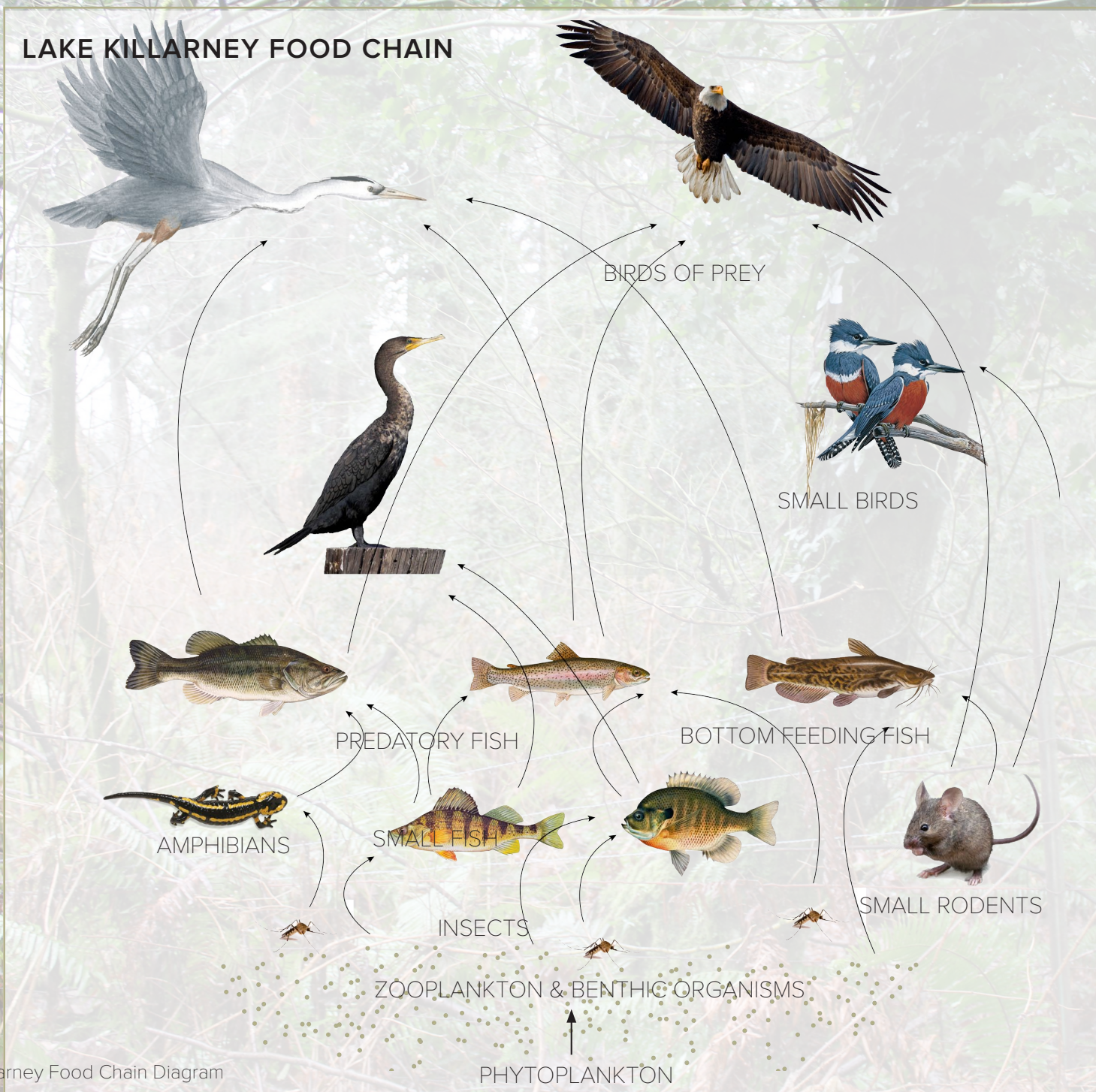


Figure 14. Lake Killarney Food Chain Diagram

Image 24. Riparian Forest (background)

## INDUSTRIAL CONTAMINATION

Arsenic occurs naturally in the soil and bedrock in many parts of the U.S. including the Pacific Northwest. While it is a natural metal, in large quantities arsenic can be toxic to people. Arsenic pollution occurs around the world and is often the result of smelting or other industrial processes (Glass 2003). The south-central Puget Sound region has been impacted by a century of metal emissions from the American Smelting and Refining Company (ASARCO) smelt in Tacoma, Washington (**Image 25**) (Glass 2003). The smelter was in operation between 1890 and 1986 and specialized in the smelting of lead and then copper ores containing high concentrations of arsenic- all of which were sold commercially. Thanks to this plant arsenic and lead contamination is now widespread throughout the region- these byproducts having been transported via the atmosphere especially during storm events. While soils have been studied for decades, lacustrine systems have had little devoted research to date (Gawel 2013).



**Image 25.** The ASARCO smelter plant in Ruston, Washington.

To study the effects of the ASARCO plant on the region's lakes, James Gawel and his team of researchers began modeling wind patterns that would have dispersed arsenic and lead throughout the region (predicted arsenic deposition zones). They also compiled data from soil studies that showed the greatest concentrations of arsenic and lead within a distance of 20 miles from the smelter stack (**Figure 16**). The result was what turned out to be a very accurate prediction of which lakes would have been affected by the plant (Gawel 2013).

Following the modeling phase, in 2004 initial sampling for arsenic and lead contaminants took place at Lake Killarney and 16 other freshwater lakes within a 20 mile radius of the ASARCO emissions stack. Surface grab samples and sediment cores were used for testing. A sample of the sediment core from Lake Killarney was dated in the Nittrouer lab at the University of Washington, Seattle using excess  $^{210}\text{Pb}$  activity to determine the age of the sediment (Nittrouer 1979). In 2004, 2005 and 2007 water column measurements were conducted at Lake Killarney including temperature, dissolved oxygen, specific conductivity and pH. Water samples were also used to determine total dissolved arsenic levels. Of the lakes sampled Lake Killarney was discovered to exhibit some of the highest concentrations of arsenic and lead in its water and sediment (**Figures 17 & 18**) (Gawel 2013).

Lake sediments act as reservoirs of metal contaminants providing overlying waters with a long-term source of the toxin (Gawel 2013). Arsenic is particularly susceptible to remobilization into the water column in lakes where organic matter and nutrient inputs to the lake feed bacterial respiration in sediments and water near the bottom of the lake (Couture 2010).

Normally when arsenic is present in the water column it will bind with other particles and sink to the bottom where it remains (Gawel 2013). Arsenic will normally only remain suspended in the lake water in anoxic conditions due to a lack of oxidized iron for it to bond with (Adrissono et al 2016). When lakes become anoxic, which is common near the bottom of the water column, Fe(III)-oxides in the surface sediments are reduced to dissolved  $\text{Fe}^{2+}$ : Fe(+II) which then binds to arsenic in the sediments and releases it to overlying waters (Aggett et al).

However, Lake Killarney is an exception to this normal mechanism. Although the lake exhibits oxic characteristics which would normally limit dissolved arsenic in the water column, arsenic levels remain surprisingly high throughout the water (Adrissono et al 2016). One theory that researchers have put forth is that Lake Killarney is slightly more humic- that is it contains more organic matter- than similar lakes; and researchers are currently exploring whether this might influence the chemistry of the water, somehow keeping arsenic suspended.

WAC 173-204-563 went into effect in September of 2013 and provides freshwater sediment chemical criteria for lakes throughout the state. The concentrations listed in the WAC establish "sediment cleanup objectives" and "sediment screening levels" for freshwater sediment (**Figure 16**). These levels estimate when contaminants may begin to have adverse effects on the benthic community, which might then have health implications for people if the contaminants were to move up the food chain (WAC 173). When levels exceed the sediment screening criteria then the site is classified as a potential cleanup site for benthic community toxicity. For arsenic the sediment cleanup objective is 14 mg/kg (dry weight); and the cleanup screening

# ARSENIC MEASURED IN SOIL OR SEDIMENT ACROSS THE REGION

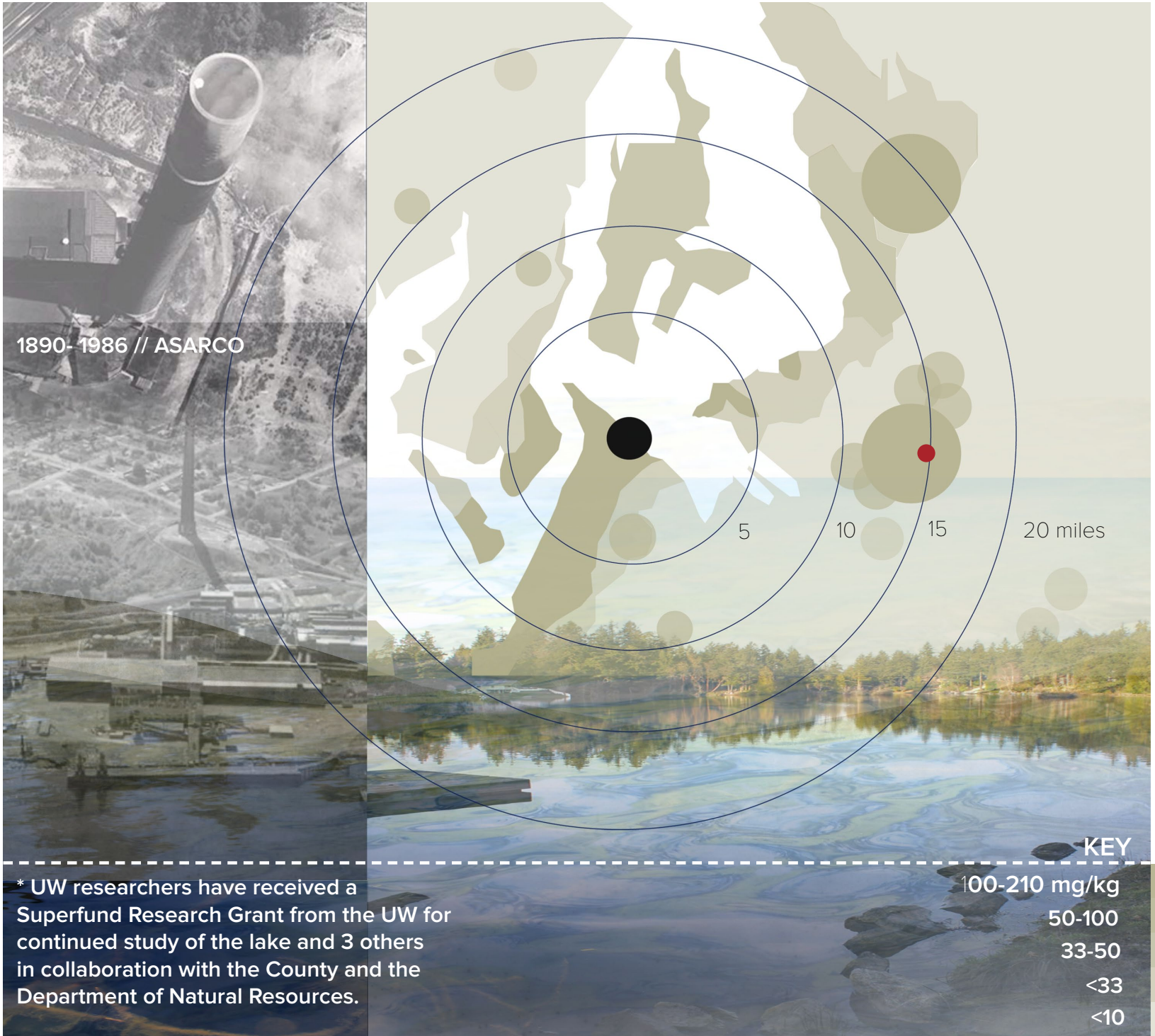
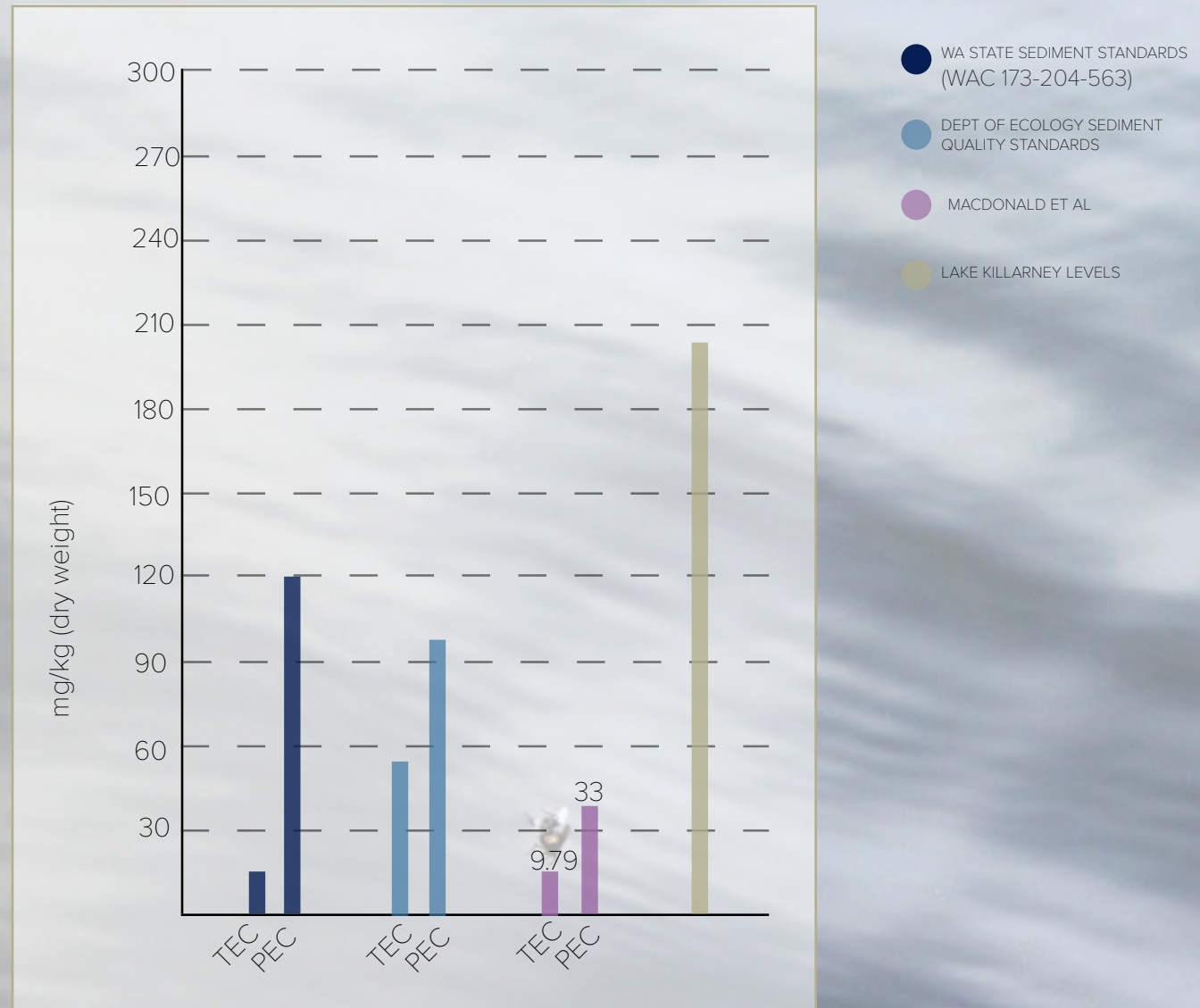


Figure 15. Industrial Contamination Across the Region Diagram

Image 26. Tacoma Smelter Plume.

Image 27. Lake Horizon (background)

## ARSENIC SEDIMENT STANDARDS



*TEC= threshold effects concentration (aka sediment cleanup objectives or sediment quality standard) : "below which harmful effects are unlikely to be observed" (MacDonald et al).*

*PEC= probable effects concentration (aka sediment screening levels or cleanup screening level) : "above which harmful effects are likely to be observed" (MacDonald et al).*

**Image 28.** Lake Water

**Figure 16.** Arsenic Sediment Standards Graph

level is 120 mg/kg (dry weight). Results of the study at Lake Killarney found greater than 200 mg/kg Arsenic in the top 2 cm of the sediment core (Figures 18 & 19), well exceeding this standard. Researchers have also found high concentrations of arsenic near the surface of the lake, up to 80 ppb. Highly elevated levels of arsenic were also measured within the phytoplankton (maximum concentration 1574.2 µg/g dry wt) and

zooplankton (maximum concentration 146.9 µg/g dry wt) (Figure 17) (Adrissono et al 2016) showing that Arsenic has the ability to move up the food chain. James Gawel and his team have obtained a Superfund Research Grant to continue studying the unique mechanism of arsenic mobility within Lake Killarney. The research will be conducted once-monthly throughout the year and twice-monthly in the summer months through 2017.

### COMPARING ARSENIC IN SEVERAL LAKES

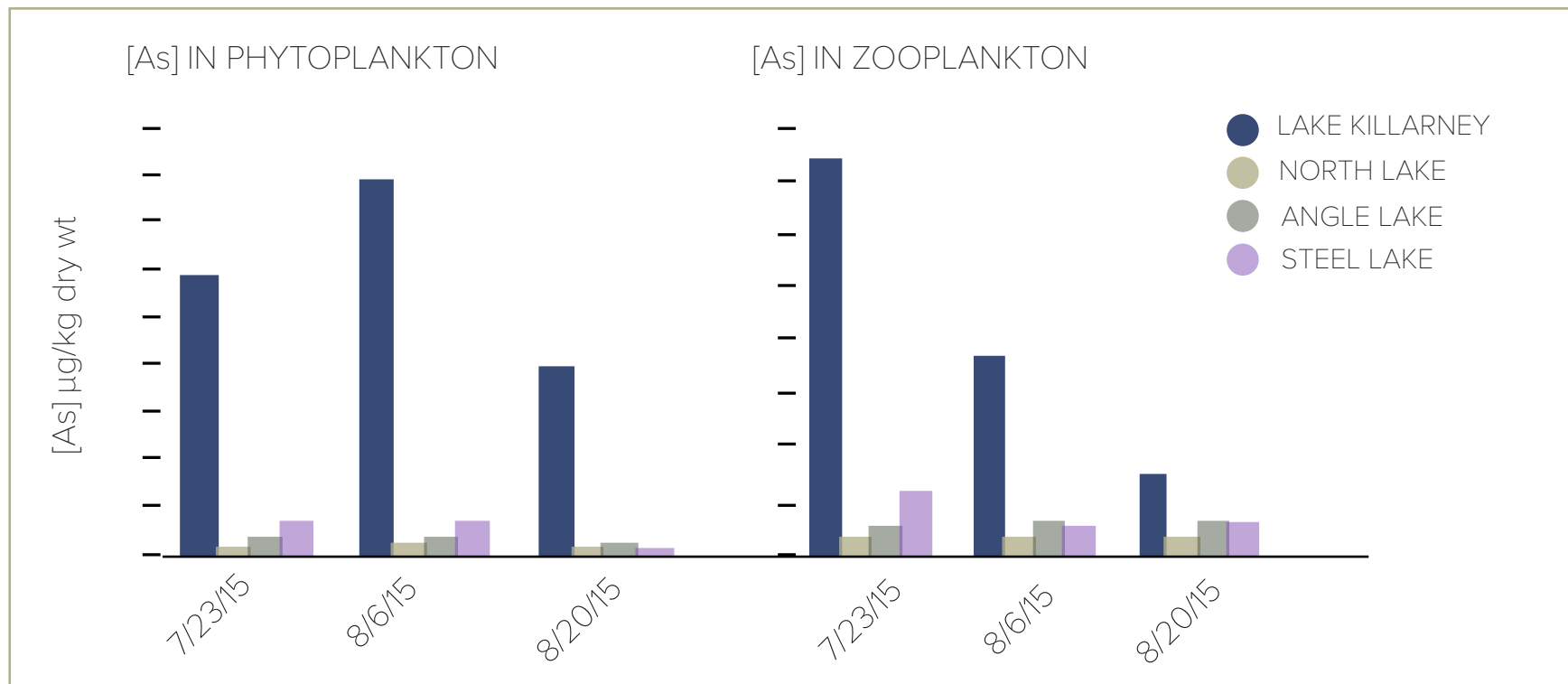
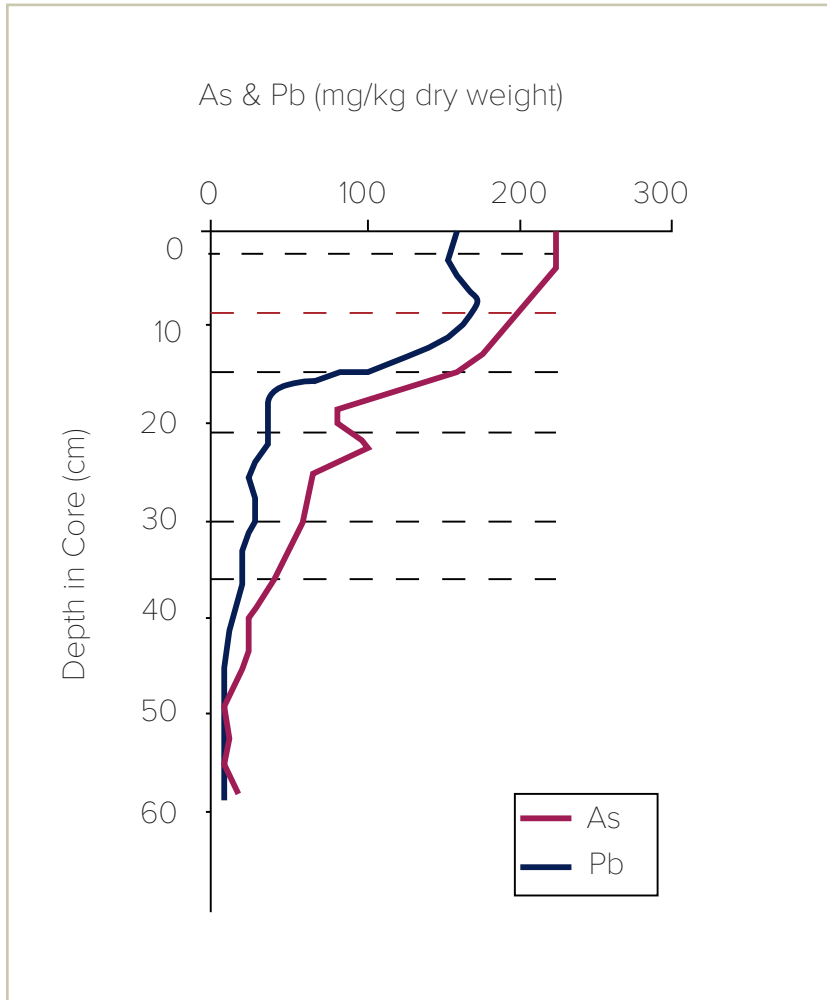


Figure 17. Comparing Arsenic in Several Lakes Graph

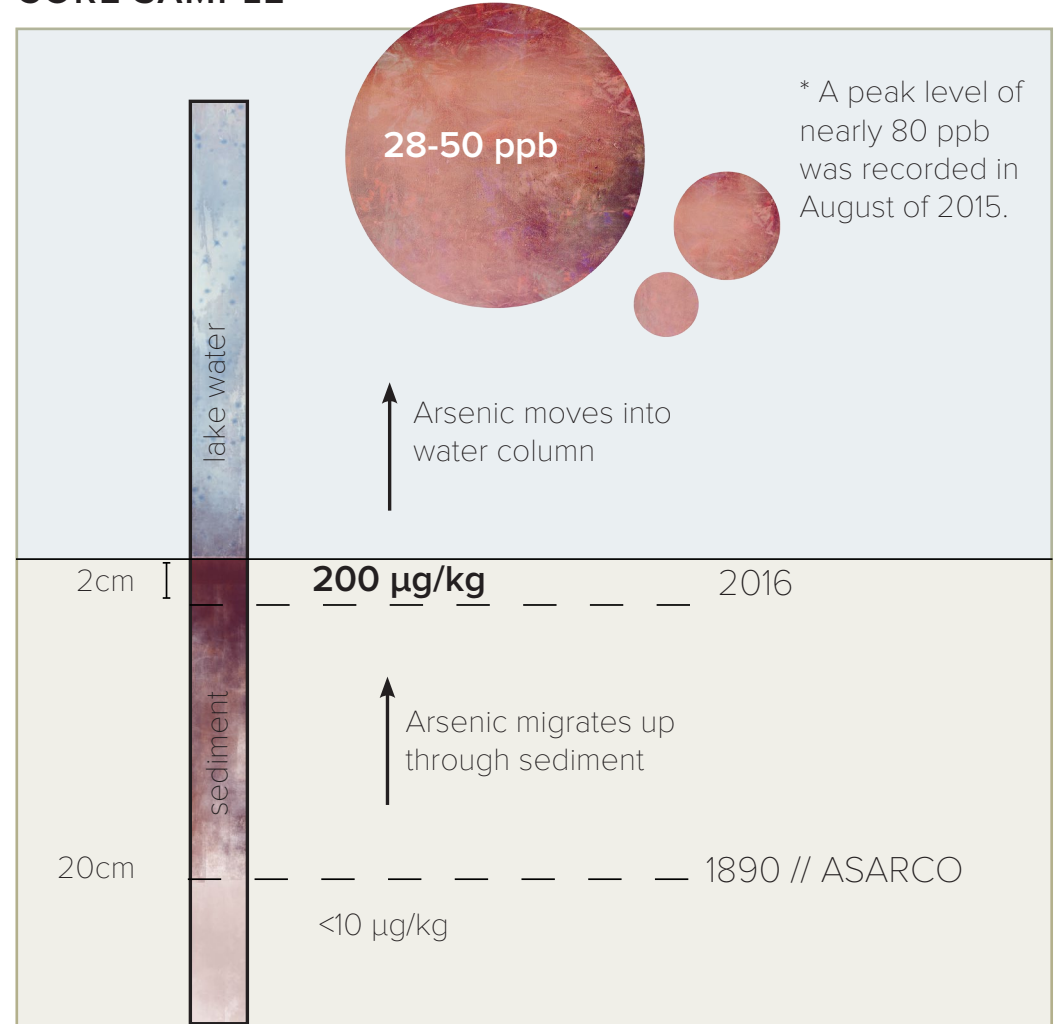
## ARSENIC & LEAD IN LAKE KILLARNEY



This graph shows concentrations of lead and arsenic at increasing depths of the sediment. Both are highly elevated.

Figure 18. Arsenic and Lead in Lake Killarney Sediment Graph

## CORE SAMPLE



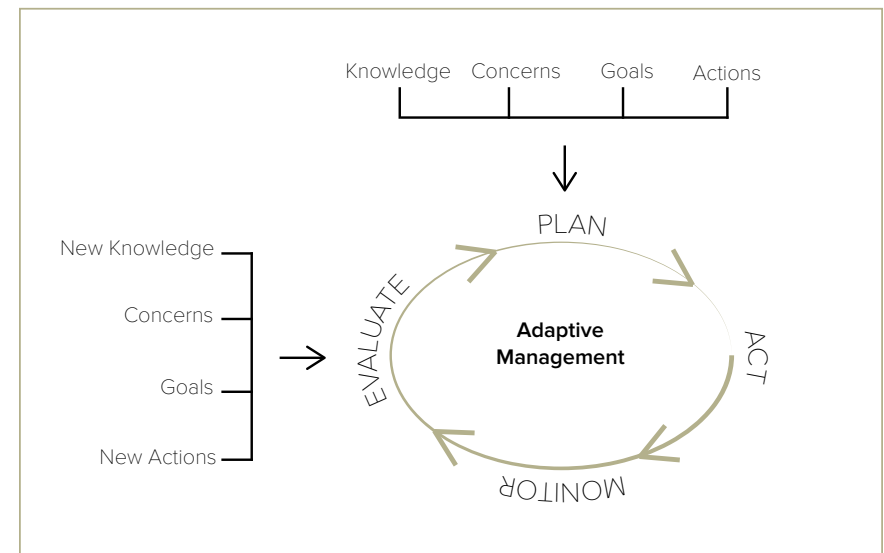
This graphic shows how arsenic levels increase at the top of the sediment core and then disperse throughout the water column.

Figure 19 Arsenic Across Sediment and Water Column Diagram

## CREATING CHANGE

### ADAPTIVE MANAGEMENT STRATEGY

To achieve improved water quality and ecosystem function at Lake Killarney, adaptive management is a promising approach and one that exemplifies the ideals of ecological planning. Adaptive management proposes a four step process that is cyclical in nature (**Figure 20**). As ecosystems too are cyclical in nature and change over time, this type of approach is better suited to manage existing complex systems (Beck 2013). This is also the key to the more general idea of sustainable design in which a systems based approach is adopted (Beck 2013). Adaptive management supports a more holistic view of working with the landscape. Nothing exists in isolation, and so to improve the health of Lake Killarney we must look beyond its borders to the greater watershed. The ecological health concerns discussed in this plan therefore move out into the greater



**Figure 20.** Adaptive Management Cycle Diagram (Adapted from Stanley, Clark, and Bormann 2005).

landscape. Each of the possible actions taken there would ultimately result in the betterment of Lake Killarney.

For each ecological health concern that is discussed in this plan there are many different options for actions that might address that concern and begin to bring about positive change. Rather than suggesting one concrete action for each concern there is instead a set of possible actions each of which focuses on gathering momentum in a certain direction. The Lake Killarney Improvement Association and lake community will be able to pick the action best suited to their capabilities at that time. Following the adaptive management model (**Figure 20**), this action would be carried out, monitored for some time, and then evaluated (Beck 2013). The evaluation of the action and the new knowledge gathered from the experience is then used to revise goals which can inform new strategies for future actions at the lake. In this way concerns, goals and actions all evolve as the lake ecosystem evolves. The cycle continues until the desired goal is reached in the evaluation phase. The earlier we can identify potential problems, the less invasive, more environmentally sensitive and cost-effective options we will have for controlling those problems.

## PARTICIPANTS ARE PARTNERS

---

With an adaptive management strategy it is up to the consensus of the community group to decide what action will be attempted at any given time. This ensures that the knowledge of community members is also given weight in the process. The community has their own set of knowledge and constraints to work with and so are best suited to decide which actions are

possible in order to keep momentum going with the project.

This type of design process is inclusive and more or less democratic in nature. “It is a relationship of consenting equals that builds consensus as a project proceeds” (Franklin 1997, 265). By breaking down traditional frameworks in which the planner or designer is subservient to the client while being more powerful than the community, and the community takes a subordinate role, we can empower new parties in partnership. This is critical to a sustainable design process. Here the community, planners, and all other invested parties are treated as partners in the project and interact equally in the process, encouraged to advocate for their needs and desires (Franklin 1997).

Another basic premise of sustainable design is that “product and process are one” (Franklin 1997, 264). In contrast to other more traditional design methods “the design process is rarely linear. Instead the work is characterized by a focus on the whole project and by feedback loops that create changes in the structure of the work process throughout the lifetime of the project” (Franklin 1997, 264)

## CONCERNS, GOALS, ACTIONS

Currently the Lake Killarney Improvement Association oversees the annual herbicidal treatment of the lake, and this system has done a good job to date of managing algal blooms and unwanted vegetative growth at Lake Killarney- keeping the water relatively clear. However, there are many more possible improvements that the LKIA could oversee for the betterment of the lake and the ecosystem services that it provides. The root of the problem that makes herbicidal treatment necessary at Lake Killarney is the influx of stormwater which carries pollutants and toxins into the water- and this is what ultimately needs to be addressed.

The concerns, goals and actions outlined in the following pages consist of the information I believe to be the most important for homeowners and residents within the greater watershed of Lake Killarney to know. These are the people with an emotional connection to this place, who will have the motivation to make change happen here (Manzo 2006). This information is meant to empower this group of people (Manzo 2006). The intricacies of how development can adversely affect lacustrine systems has been discussed at length in early sections of this plan, and I believe there are actions that can be taken individually and as a group to help mitigate some of these impacts.

### GREEN STORMWATER INFRASTRUCTURE

As the rate of development in the watershed is expected to rise over the next ten years due to the area's annexation into the city of Federal Way, the stormwater challenge will only increase. Recently in the field of planning and design a huge shift has been made in the profession's handling of stormwater is-

sues. Today the preferred option for dealing with stormwater is to implement green stormwater infrastructure (GSI) which relies on civil engineering as well as the landscape architecture profession. This newer approach emphasizes using living systems as key elements in stormwater management to help restore hydrologic functioning to its predevelopment state (Beck 2013). GSI options might include bioswales, rain gardens, or filtration strips, all of which can be used to cleanse stormwater runoff in a natural, cost-effective, and attractive way. These engineered systems not only function to improve water quality but they also provide a host of ecosystem services. Used at Lake Killarney (**Figure 21**) GSI could go a long way in improving the quality of stormwater discharging into the lake.

## MAINTAINING BIODIVERSITY

---

It is possible that boaters may have introduced at least one of the invasive aquatic species in the lake, Eurasian water milfoil (*Myriophyllum spicatum*), and possibly Purple loosestrife (*Lythrum salicaria*) (**Figure 21**) which are both common non-natives in lakes across the United States. Invasive species such as these can disrupt the functioning of the native ecosystem. Purple loosestrife for instance is able to displace native species that are present in the wetlands it invades. Its dense growth also reduces habitat for ducks, turtles or other lacustrine creatures. One of the main principles of ecological planning is to promote biodiversity which supports healthy ecosystem functioning. This is why it is important for us to monitor and control the spread of non-native species throughout the lake's watershed.

One prevention and control strategy is to post educational signs at the boat launch and in the public park to prompt visitors to clean their boats and other equipment before bringing them into the lake. Beyond the continued chemical treatment of the lake, physical removal of invasive species- which was once successful in controlling an outbreak in the 1990s- might again be used to manage these plants. While complete eradication may be impossible with physical removal, this process can help to keep plant populations below levels where they can affect the overall balance of the lake.

Another way we can work as a community to maintain biodiversity at Lake Killarney is to keep invasive species out of the existing riparian habitat at the shoreline. Residents can begin by removing invasive species on their own property so that they won't spread to more highly valuable land. In fact, "the State Noxious Weed Control Law (RCW 17.10) establishes all property owners' responsibility for preventing and controlling the spread of noxious weeds. Because plants grow without regard to property lines or political jurisdictions, everyone's cooperation is needed" (King County Comprehensive Plan 2016). Following, the LKIA might organize work parties to tackle non-native species in the two larger areas of shoreline habitat at the north and south ends of the lake respectively where continued loss of lake-shore vegetation and riparian structure due to non-native species as well as residential development has limited the habitat diversity, habitat quality, and reduced large woody debris at the lake already (Washington State Department of Ecology 2006). There are also areas where restoration efforts of removing English Ivy as well as planting back a native plant palette could help to strengthen existing habitat (**Figure 21**).

The next broader, and longer-term step in this process would be for the LKIA to form a community outreach group whose primary role would be to form relationships with policymakers, planners and other parties who have the power to influence policy change at the local and county level. By forming alliances with people in the political realm we can begin to promote better designations of critical habitat at Lake Killarney. While some designations do exist, there is certainly evidence for increased designations and buffers around the lake. The residents can help this process by documenting the sighting of threatened, endangered and sensitive species on the Washington Department of Fish and Wildlife website.

## FOCUSING ON EAST HYLEBOS CREEK

In a more conventional approach to this project we would focus solely on the lake itself. However, this plan places emphasis on a holistic, ecosystems approach to planning; and the issues at Lake Killarney stem from changes in the greater watershed. The East Hylebos Creek Sub-Basin has been an appropriate and helpful scale for examining the land-use changes of the landscape and for proposing actions in response to those changes.

Again it will be important for the Lake Killarney outreach group to form relationships with policymakers, and advocate for political change at the local and county level when it is necessary. This group can function as mediator between the lake community and the policymakers that affect land-use decisions within East Hylebos Creek. By presenting an educated coalition of concerned citizens we have greater power to influence poli-

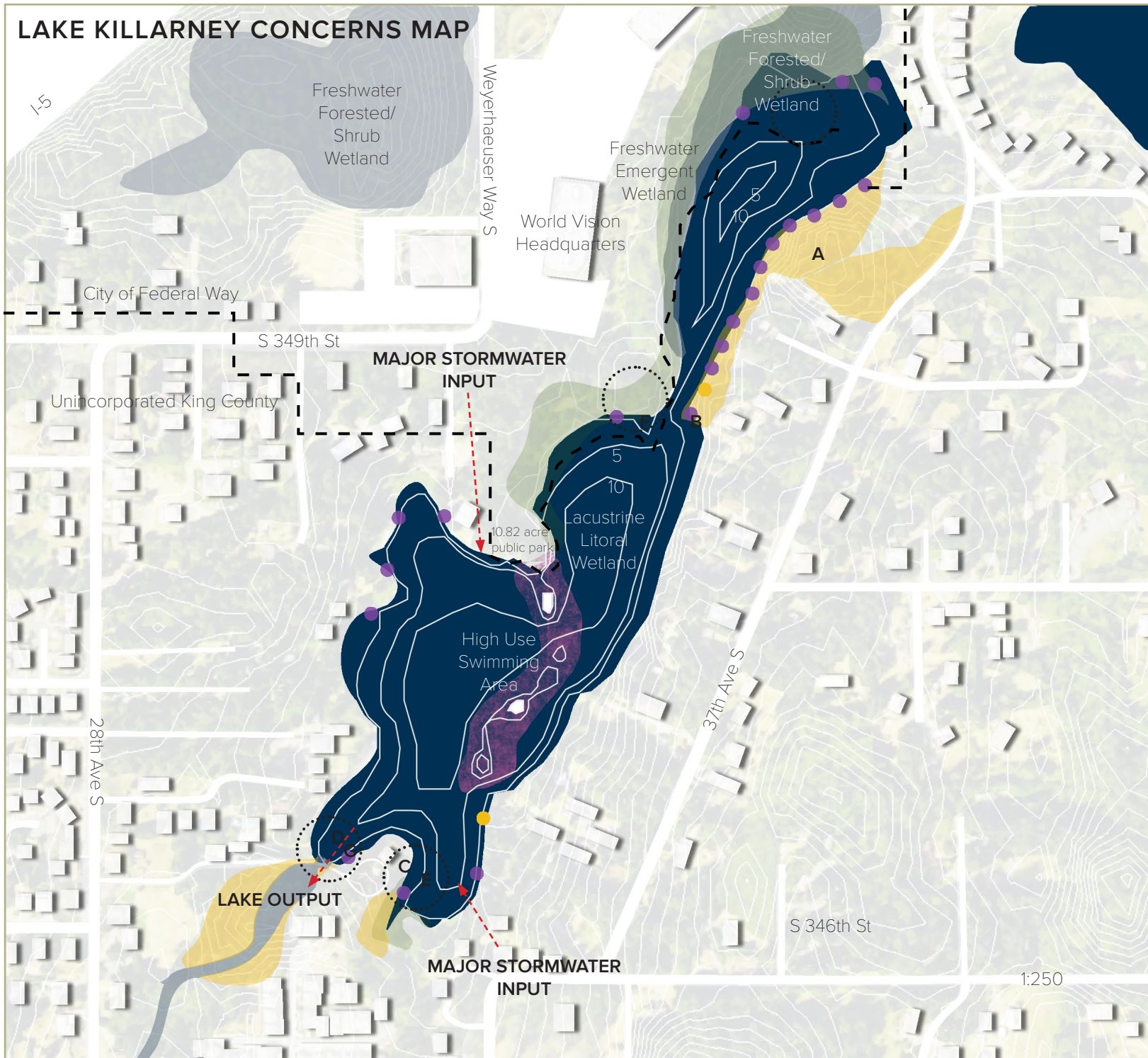
cymakers to do their part to help protect our valuable ecosystems here. Kelly Maloney of the Federal Way City Council is one such policymaker who has already established a relationship with some Lake Killarney residents and has voiced concern for the environment on past issues. A partnership and friendship with Kelly is a great jumping off point for these efforts.

Focusing on a vision for improving East Hylebos Creek will help to bring about change within the ecosystem as a whole. The daylighting of the creek in the stretch between its origin at Lake Killarney and the point where the creek currently daylight in the ravine is a great starting place. Along this 1.5 mile stretch pipes could be replaced with restored stream sections providing much needed green space for the community and forming a corridor along which wildlife can navigate. By having a safe passage between two larger habitat patches the wildlife in the area will benefit from more land to forage, hunt, reproduce and live. Water flowing from Lake Killarney will also be better filtered in these day-lit areas, removing some of the toxins present before the water reaches the agricultural fields in Fife- a benefit for people that eat food grown on that land, and downstream sections utilized by salmonids (Washington State Department of Ecology 2006).

## CONCERNS

- Loss of critical forested habitat in the East Hylebos Sub-Basin due to development.
- The disconnection of hydrologic systems.
- The continued loss of lake-shore vegetation and riparian structure.

# LAKE KILLARNEY CONCERNS MAP



- KEY**
- Wetland Area
  - Conservancy Area
  - Restoration Need
  - GSI Design Intervention
  - Missing Critical Habitat Designation

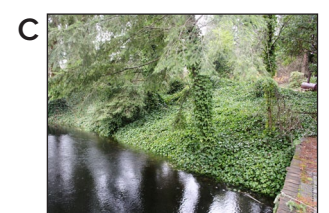
**INVASIVE SPECIES**



Purple Loosestrife (*Lythrum salicaria*)



Tansy Ragwort (*Senecio jacobaea*)



English Ivy (*Hedera helix*)

Figure 21. Lake Killarney Concerns Map

Image 29 a,b,c. Three Non-native Plants

- Arsenic and lead in the lake sediment and water.
- The degradation of water quality primarily due to additional pollutants entering the lake.
- Non-native species within the lake's watershed.
- Environmentally damaging development practices throughout East Hylebos Creek.
- Encroachment on the main tributary of East Hylebos Creek, 0006, which supports state listed endangered, threatened and sensitive species.

## GOALS

- Restore (improve) natural hydrologic function of the watershed.
- Support the promotion of stronger environmental policy at the county scale.
- Promote restoration efforts at key areas throughout the lake's watershed (**Figure 23**).
- Achieve proper designation of critical habitat.
- Support researchers studying arsenic and lead.
- Improve the water quality of the lake.
- Limit additional stormwater input to the lake.
- Promote low impact development throughout the watershed.
- Begin restoration efforts to daylight the east branch of Hylebos Creek where it has been piped.

## ACTIONS

- Provide residents with educational material regarding the ecological condition of the lake.

- Recruit young &/or new residents to the Lake Killarney Improvement Association.
- Form a community outreach group within the LKIA whose primary role would be to form relationships with policymakers, planners and other parties who have the power to influence policy change at the local and county level.
- Restore the near-shore land at the output of the lake (Tributary 0006).
- Monitor new projects throughout the East Hylebos Creek Watershed. Engage with the process as a concerned community group and as individuals; comment on the EIS.
- Work with King County planners to update critical habitat designations in the area & promote new designations of critical habitat.
- Work with planners to change zoning to conserve land that forms hydrologic corridors between lakes, streams, wetlands, etc.
- Organize and run restoration work parties with the community (**Figure 22**).
- Work with local planners to designate nearshore habitat for conservation where possible.
- Work with policy makers to prohibit additional stormwater discharge points into the lake.
- Work with a designer to envision options for green stormwater infrastructure at the two existing major stormwater discharge points to naturally treat stormwater before it enters the lake.
- Implement green stormwater infrastructure at the two major stormwater input sites.
- Work with designers and planners to envision other potential areas throughout the East Hylebos Creek Watershed for green

## RESTORATION WORK



*Since so little green space exists within the East Hylebos Creek Watershed, restoring and preserving the existing green space is critical to improve the health of Lake Killarney along with the entire system.*

**Figure 22.** Restoration Process Vision

stormwater infrastructure development.

- Educate property owners about which plants are non-native and how to remove them.
- Post interpretive signage at public access points.
- Organize community events for the physical removal of invasive species. Volunteer efforts can help ensure that non-natives are removed on the private property of homeowners physically unable to remove them themselves.
- Work with planners and policymakers to promote stricter low impact development standards.
- Begin un-piping sections of Tributary 0006 between Lake Killarney and the ravine.

## MONITORING AND EVALUATION

A healthy lake ecosystem is a goal that is not only challenging to achieve but challenging to measure. As the community steps through different actions, change will begin to happen slowly and possibly without anyone realizing it. As the process cycles, we learn by doing, observing and recording changes however small they may be. This type of monitoring and evaluation of actions keeps the adaptive management cycle rolling.

This process is not about coming to a day when suddenly the work ends. Rather it is about fostering a lifelong partnership in which people who care about the living landscape and are willing to take action to maintain and improve the ability of the ecosystem to function. By monitoring each action over time we can adapt to what works and what doesn't knowing that the culmination of our effort will be the better health of the lake and the greater landscape.

## CURRENT CONDITION OF WETLANDS



**Image 30 a,b.** Current Wetland Conditions

**Species Recommendations** (right page): Some examples of those species that would provide high quality ecological value in this area include Creek Dogwood, Willows (Arroyo Willow), Sweet Gale, Pacific Waterleaf, and Skunkcabbage.

**A:** Trees such as poplars and willows grow quickly and well in moist environments near water. These plants also double-up with phytoremediation capabilities. They take-up pollutants and toxins from the water and degrade them, removing harmful substances from the ecosystem. Without these plants, many of the toxins exiting the lake will continue on down-stream to salmon (& other sensitive wildlife)-bearing waters.

**B:** These plants are located on the water's edge. They help to stabilize the banks of the wetland, they provide food for mammals and birds, and they also help to cleanse the water.

**C:** Fallen trees and branches provide valuable habitat for amphibians, birds, and mammals. Large woody debris also slows water as it leaves the lake, allowing riparian vegetation to grow, and pollutants and toxins to seep out of the water.

# WETLANDS AT LAKE KILLARNEY: FUTURE VISION



A. RIPARIAN VEGETATION

B. TRANSITIONAL PLANTS

C. LARGE WOODY DEBRIS

Figure 23. Wetland Future Vision

***Cornus sericia***: Grows well in wet forest sites, frequently along streams, in ditches, or in wetland swales.

***Myrica Gale***: Known to live in wetland conditions, bogs and lake margins. Helps to stabilize soils.

***Hydrophyllum tenuipes***: Spreads by rhizomes and forms large colonies in wooded, damp areas.

***Symplocarpus foetidus***: Prefers muddy, wetland habitats, and being near streams.

***Salix lasiolepis***: Known to be a good wetland restoration plant. Willows are good at degrading pollutants.

## CONCLUSION

Anyone who has visited Lake Killarney can attest to its beauty and vibrant energy. It is a well-loved landscape. I wrote this thesis as one individual who cares deeply about this place. Over the past years I have observed that as land in the surrounding watershed has changed, the lake's ecosystem has been increasingly challenged by stormwater, loss of habitat, and the disjunction of its hydrologic systems. Residential developers of nearby land have even approached homeowners at Lake Killarney in an attempt to obtain permission to discharge stormwater from their developments into the lake- an action that we must absolutely be prohibiting.

The quality of the lake and its resources is the cumulative result of the people and activities within its watershed, including development taking place within the extended landscape. The decisions of each individual impacts the health of the ecosystem. Due to the predicted rate of growth in this area of unincorporated King County increasing pressure is forecasted for the lake which already suffers from post-industrial degradation. We must respond to this pressure by increasing our attention and efforts, aiming for improved ecosystem function and environmental protections. At the county and city level, the preservation of intact land throughout the Easy Hylebos Creek Watershed is key in this effort. That is why building relationships with policymakers and engaging in the conversation at that level is an important first step for the lake community to take. While we may not be able to slow the rate of development surrounding the lake, we can at least do our part to preserve what intact land remains as critical habitat and areas for conservation.

This management plan represents the culmination of my own personal research on the lake as well as my experience



**Image 31.** Bald Eagle at Lake Killarney

as a part of the King County Lake Stewardship Program, interacting with the UW researchers, and engaging with policymakers at the city level. Based on these interactions and my own education in the field of landscape architecture I believe that as a united group of active citizens we have the power to make positive change that supports Lake Killarney's ability to persevere for generations to come. Prohibiting further stormwater inputs from entering the lake, urging policymakers to conserve the few patches of healthy land that do exist within East Hylebos Creek, and advocating for the proper designation of critical habitat are all initial steps that we can take. While implementing green stormwater infrastructure at stormwater discharge points, restoring critical nearshore habitat, and daylighting east Hylebos Creek are part of my future vision for the lake and entire East Hylebos Creek system. With just a small amount of effort each of us can contribute to the betterment of this environment to be remembered and enjoyed for years to come.

# APPENDIX

## A: INFLUENTIAL ENVIRONMENTAL POLICY IN WASHINGTON STATE

### STATE ENVIRONMENTAL POLICIES

Following is an overview of some of the major environmental policies specific to Washington State that have implications for ecological planning.

#### WASHINGTON STATE ENVIRONMENTAL PROTECTION ACT

One of the first and most influential acts of the government during the environmentalism movement was the passage of the National Environmental Policy Act (NEPA) in 1969. This Act represented a governmental acknowledgement of man's destruction to environmental systems, and a large-scale push to do something about it. It was an act that seemed perfect for ecological planning and NEPA represents one of the most significant moments in the history of policy relating to the environment in America.

SEPA, the State Environmental Policy Act, was enacted in 1971 when Senate Bill No. 5145 passed in the legislature in Washington State. The first section in the original text of the 1971 Act is as follows: "Section 1. The purposes of this act are: (1) To declare a state policy which will encourage productive and enjoyable harmony between man and his environment; (2) to promote efforts which will prevent or eliminate damage to the environment and biosphere; (3) and stimulate the health

and welfare of man; and (4) to enrich the understanding of the ecological systems and natural resources important to the state and nation" (RCW Sec 43.21C.010). The rhetoric about "man and nature" which originated in the late 1800's during the time of Marsh and his fellows was now written into law, over seventy years later.

Every form of government including all government agencies in the state are subject to SEPA for new policies and new projects. SEPA is a "look before you leap" policy that forces government agencies to study the effects that their proposed projects and policies would have on the environment-both natural and built (Wildermuth 2016). This process results in the production of an environmental impact statement (EIS) which is a document of research made open to the public for comment summarizing the impacts and proposing options for the project.

The Act lists, "population growth, high-density urbanization, industrial expansion, resource utilization and exploitation, and new and expanding technological advances" (RCW 43.21C.020), as key factors in the magnitude of impact of humans on the environment. This was one of the first times that the legislature of the state admitted its knowledge of the immense impacts that humans were having on the natural environment, and gave their political approval to do something about it. SEPA places emphasis on the importance of these goals to ensure the health of the environment for future generations; the Act promotes the needs of "today", as well as the needs of "tomorrow"- one of the first responses in policy to the idea of sustainability.

SEPA is sometimes referred to as a "paper tiger" (Wil-

dermuth 2016). Meaning that while the issues it addresses are important, and the amount of additional time and money it requires significant, SEPA itself only seems serious. SEPA does not legally enforce any party or agency to do what is right for the environment. SEPA simply forces an agency to “look before it leaps”, to complete an EIS, to know what impacts it will have, and to state those impacts before it makes those impacts. The authority of how much, when, and what exactly is to be studied is up to the Department of Ecology, the agency charged with setting up the rules and regulations that enforce SEPA. But again those regulations do not necessarily enforce environmentally friendly action. There is no law of or relating to SEPA that prohibits you from harming nature. The theory behind SEPA is something along the lines of, “we ought not to be destroying the environment wantonly, we ought to only be destroying it if we study it first” (Wildermuth 2016).

This is not to say that SEPA is worthless. One significant positive aspect is that it promotes the idea of a democratic process in favor of the environment. For most projects SEPA acts as a forced pause while the EIS is being written. Community groups that are concerned about the environmental impacts of a project can then submit their comments. Upon receiving these comments the agency or developer is required by law to respond to each and every comment. Sometimes the response will be “comment noted”, and sometimes the response will be to add a new chapter to the EIS. It is in the interest of the agency to respond seriously to each comment because if they don't the commenting party can use that in litigation against the project. This is not a productive venue for airing passionate feelings about a project, but only a good place to voice environmental

concerns. If citizens are moved to try to prevent a project from happening they will have to find a different avenue for doing so; but they can utilize the SEPA process to delay the project long enough for them to find another way- perhaps gathering signatures for a citizen initiative.

## **SHORELINE MANAGEMENT ACT**

Like NEPA, ideas about the importance of the waters and shorelines of Washington emerged in the 1960's. In 1976 those conservationists and outdoor organizations “concerned about the loss of wild rivers to development proposed a bill to manage natural rivers, but the bill failed in the Washington State Legislature” (Shoreline Management Act). Following, people became increasingly aware of the encroachment of development on the shorelines around them and fearful of what would happen in the long run; they continued to push for protection.

In 1970, environmental groups drafted a citizen initiative, what they named the Shoreline Protection Act. In only ten weeks more than 160,000 citizens had signed the initiative, the largest number ever collected at that time, and the initiative was submitted to the Legislature (Shoreline Management Act). The legislature responded by forming its own, slightly altered law, what they called the Shoreline Management Act (SMA) of 1971. The SMA was founded on people's concern for the environment; the rough idea of the Act being that we should develop our state's shorelines in a somewhat environmentally friendly way; or in other words, the goal of the SMA is “to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines” (Shoreline Management Act).

The SMA is distinctly different from SEPA. This is an Act that does more than invoke environmental assessments, it enforces the writing of rules and regulations by local jurisdictions that enforce compliance with the goals set forth in the Act. The SMA creates actual legal environmental protection for the shorelines of Washington State. The SMA has three broad policies as outlined in RCW 90.58.020:

- (1) Protect the environmental resources of state shorelines. “This policy contemplates protecting against adverse effects to the public health, the land and its vegetation and wildlife, and the waters of the state and their aquatic life” (RCW 90.58.020).
- (2) Promote public access and enjoyment opportunities. “This policy contemplates protecting...public rights of navigation and corollary rights incidental thereto... Permitted uses in the shorelines of the state shall be designed and conducted in a manner to minimize, insofar as practical, any resultant damage to the ecology and environment of the shoreline area and any interference with the public’s use of the water” (RCW 90.58.020).
- (3) Give priority to uses that require a shoreline location. “...uses shall be preferred which are consistent with control of pollution and prevention of damage to the natural environment, or are unique to or dependent upon use of the state’s shoreline” (RCW 90.58.020). Note the language, “contemplates protecting.”

Regulations for these shorelines are enforced at the local level, with each jurisdiction responsible for writing a Shoreline Master Program (SMP) which carries out the goals of the SMA (RCW 90.58.080). Within the SMA there is also special protection given to shorelines determined to have statewide significance. These shorelines are subject to additional regula-

tions which are carried out at the state level.

The SMA while in some ways stronger than SEPA, has its own weaknesses. One major weakness is the language of the rules which provides wiggle room for interpretation. Rather than the policy “protecting” against adverse effects to public health, the policy simply “*contemplates* protecting against adverse effects to the public health”; here there is significant room to not actually protect against each of the things listed in the regulations including public health and environmental health. This is the case throughout the policy except with the Shorelines of Statewide Significance where the mandates “shall” be carried out. Furthermore the Shoreline Development Permit is an avenue by which developers can get around the policies set forth in the SMA. In the end it is up to Ecology’s discretion whether or not to grant a permit for development within a protected shoreline.

## **GROWTH MANAGEMENT ACT**

Another Act that has major implications for ecological planning in Washington State is the Growth Management Act (GMA). This act creates boundaries for urban growth, deciding which land can be developed and which land is to be preserved for other uses. In some ways the urban growth boundaries (UGBs) can benefit ecosystems by curbing sprawl and funneling growth into pre-existing cities (Perlman 2005). Urban Growth Boundaries are not used to cap the amount of growth that can happen in a city, but rather to direct it into certain areas. Every now and again the UGB is reviewed and expanded to allow enough growth for the next twenty years. “If used properly, UGBs can

be an effective instrument for achieving the desirable aggregate-with-outliers pattern at the landscape scale. To achieve this goal, the UGB should be drawn to exclude lands of high ecological value— for example the core habitat areas in the [landscape conservation and development plan] LCDP— while including areas with suitable location, soils, and topography to support dense development” (Perlman 2005, 192).

While the idea of a UGB sounds good especially from an ecological perspective, there are many issues associated with it. In areas that were once located far from the urban center of a town and had plenty of breathing room and undeveloped land, this dynamic can be significantly altered by the drawing of a new UGB. When such a place suddenly finds itself within the UGB then residents may find themselves living amidst a flurry of development. In rapidly developing areas such as the greater Seattle region this is especially true. UGBs put extra pressure within the boundary by forcing all major development to happen there. An area can densify rapidly under these conditions and this can lead to a greater loss of ecologically valuable land within the UGB. One positive aspect of the act is that it does tend to support ecological planning endeavors by promoting multi-county planning. In Washington- King, Kistap, Pierce and Snohomish Counties are all encouraged to plan together for UGBs.

## KING COUNTY ENVIRONMENTAL POLICY

Each of the environmental Acts discussed previously- SEPA, SMA, and GMA- all contribute to the formation of local rules and regulations in each jurisdiction of Washington State. In King

County a set of policies relating to the environment has been developed that broadly carry out the intent of those three acts. A few examples of the most influential of these policies relating to the environment are as follows:

### **KING COUNTY SHORELINE MANAGEMENT PLAN**

This plan is derived from the principles of the Shoreline Management Act and is meant to protect shorelines from the negative impacts of development for the sake of human welfare as well as the sake of the natural environment.

### **CRITICAL AREAS ORDINANCE (KCC 21A.24)**

This ordinance is meant to protect certain areas of ecologically high quality land from development and sale. It is meant to protect land containing critical or sensitive ecosystems, or habitat for critical or sensitive species.

### **SURFACE WATER MANAGEMENT ORDINANCE (KCC 9.04 and 9.12)**

This ordinance requires developers to manage stormwater produced on site by the creation of impermeable surfaces. It is meant to minimize additional stormwater input into local streams and lacustrine systems and the subsequent adverse impacts associated with that.

### **CLEARING AND GRADING ORDINANCE (KCC 16.82)**

This ordinance is meant to minimize “adverse stormwater impacts generated by the removal of vegetation and alteration of landforms,” protect “water quality from the adverse impacts associated with erosion and sedimentation,” minimize “aquatic and terrestrial wildlife habitat loss caused by the removal of vegetation”, protect “sensitive areas from adverse clearing and grading activities,” and so on (King County Comprehensive Plan 16.82.010).

## **URBAN GROWTH AREAS**

“Under the Growth Management Act, unincorporated areas within King County’s Urban Growth Area are encouraged to annex into cities within the next ten years” (King County Comprehensive Plan 2016). These areas represent land with fewer residents that are near to incorporated cities, and growth is therefore highly encouraged in these areas.

## **GUIDING POLICIES**

In King County an update to the Comprehensive Plan was released in 2016 which outlines in great detail the specific goals of the County moving forward. Much of the document is devoted to “guiding policies” which are often derived from direct laws. These guiding policies are not the same as rules or regulations which are written in a specific and detailed manner, designed to carry out the mandates of the different state environmental acts. Rather, guiding policies rhetorically do not sound like laws, and functionally they are so broad that no person could be expected to derive their meaning or abide

by them as law. These principles simply represent statements of broad intent which the County tries to follow. Following are some of the guiding policies that relate to ecological planning from the Chapter on the Environment in the King County Comprehensive Plan 2016:

E 402: “In the Urban Growth Area, King County shall strive to maintain a quality environment that includes fish and wildlife habitats that support the greatest diversity of native species consistent with Growth Management Act-mandated population density objectives. In areas outside the Urban Growth Area, the county should strive to maintain and recover ecological processes, native landscapes, ecosystems, and habitats that can support viable populations of native species. This should be accomplished through coordinated conservation planning and collaborative implementation.”

E-406: “King County’s conservation efforts should be integrated across multiple landscape scales, species, and ecological communities.”

E-407: “Distribution, spatial structure, and diversity of native wildlife and plant populations should be taken into account when planning restoration activities, acquiring land, designing, planning and managing parks.”

E-408: “King County should carry out conservation planning efforts in close collaboration with other local governments, tribes, state and federal governments, land owners, community groups, and other conservation planning stakeholders.”

E-409: “King County should develop a countywide landscape characterization system based on ecoregions as a key tool for assessing, protecting, and recovering biodiversity.”

E-413: “King County’s efforts to restore and maintain biodiversity should place priority on protecting and restoring ecological processes that create and sustain habitats and species diversity.”

E-414: “When acquiring land for habitat protection, efforts should be made to protect and restore areas of each habitat type most likely to be resistant to and enhance resilience to climate change.”

E-415: “King County should conserve areas where conditions support dynamic ecological processes that sustain important ecosystem and habitat functions and values, and promote structural and landscape diversity.”

E-425: “Stream and wetland buffer requirements may be increased to protect King County species of Local Importance and their habitats, as appropriate. Whenever possible, density transfers, clustering and buffer averaging should be allowed to protect adjacent wetlands and protect or improve aquatic habitats.”

E-434: “Habitats for species that have been identified as endangered, threatened, or sensitive by the state or federal government shall not be reduced and should be conserved”.

Lawful power to protect the environment is a complicated thing. It often stems from federal level Acts, which are translated into individual State Acts, which are translated by an agency into rules and regulations, which are carried out at a local jurisdiction level. There can be tension between private landowners and their perceived individual rights, and the environmental regulations that trickle down from the federal government. Yet it should be noted that for each environmental regulation that exists, so to exists a permit used to grant exemptions from the law.

One positive thing to note is that many of the guiding policies in the King County Comprehensive Plan follow the principles of ecological planning. They explain the ideas of bio-regional planning and planning for the sake of ecosystems rather than single species. However, one challenge is that since these policies are not direct rules or regulations they are only sometimes used to guide planning decisions. The fact that they are written at all does give citizens and community groups the opportunity to use them as ammunition to power their own arguments. For groups trying to protect an ecosystem, restore a place of significance, or promote conservation efforts, these guiding principles can help to justify their actions and give them weight at a County scale.

## REFLECTION

Lake Killarney has been the best possible place, in my mind, to explore the theoretical scaffolding of ecological planning: its history, evolution, challenges, progression and potential. What I have discovered through this exploration is that ecological planning stands firmly on two legs- one is environmental policy and one is ecological science. While these two fields are so different from one another, they meet in the world of planning to create a niche where designers can take a stab at envisioning a healthier future of the landscape.

By examining Lake Killarney, current in space and time and relevant to my life, I have better understood how ecological planning can have a roll in promoting community activism. By focusing on mankind's ethical responsibility to treat the landscape with care and respect, ecological planning promotes the idea of a partnership with the landscape. The idea of a partnership conveys the message that people are responsible to put in work, time and effort to promote a healthy relationship and in turn, a healthy landscape. This all comes full circle because as we know, the health of people and the community is a reflection of the health of the environment in which we live.

The complexities and unique challenges at Lake Killarney has reminded me that no matter how well you think you know a place, it can always surprise you. That is why I have come to understand that a detailed site investigation- be it similar in form to this one (an ecological health assessment), or a more standard site analysis, is a necessary and worthwhile endeavor. There is always so much to learn.

My own personal affinity with a scientific approach to

planning and design made this investigation particularly interesting. I was engaged and rewarded by the research; and I was able to learn so much about a place that I care so much about. For me this is the best way to end my graduate education- with a project that reminds me how much I love to learn, how much I care about the place that I live, and how inspiring science based planning and design can be.

Within the time I have been working on this thesis I have seen local losses for the environment. I have also, thankfully, seen victories for the environment- which happened in large part because of a loud public outcry, and citizens engaging in the system. What I have learned is that each individual can make a difference simply by voicing their opinion. That it takes just a small push, a minor effort, to become active and to find your voice. I have learned that when enough concerned citizens come together they have the power to bring about immense change.

I was asked recently if this project is finished. And my answer is no. This project represents a milestone in what I hope to be a lifelong relationship with Lake Killarney and its community. Even as I sit here writing this reflection I am looking out at the lake, I am enjoying its light. I am listening to the birds chatter away while the neighbors chatter on too. All of the life here feels like a family; and what we have in common is this one unique place on earth that we all call home.



**Image 32.** James Gawel and his team conducting research.

## REFERENCES BY SECTION

### INTRODUCTION

Corner, J. (1997). Ecology and Landscape as Agents of Creativity. In Thompson G. F., & Steiner F. R., (Eds.) *Ecological Design and Planning* (81 - 107). New York: John Wiley and Sons.

Lister, N. M. Insurgent Ecologies: (Re) Claiming Ground in Landscape and Urbanism. Academia.

Wenk, W. E. (2002). Toward an Inclusive Concept of Infrastructure. In Johnson, B. R., & Hill, K. *Ecology and Design: Frameworks for Learning*. Washington, DC: Island Press.

### CONTEXT

Dawson, Raechel. Industrial Realty Group Purchases Federal Way-based Weyerhaeuser Property. *The Federal Way Mirror* [Federal Way] 9 Feb. 2016: n. pag. Print..

King County. (1991). Executive Proposed Basin Plan: Hylebos Creek and Lower Puget Sound.

King County. (2015). Watersheds, Rivers and Streams. White River Watershed Facts. Web.

Pierce County. (1993). Hylebos Water Quality Project.

University of Washington. Hylebos Creek Information. Web. Accessed 26 April 2016.

### THE LAKE-WATERSHED CONNECTION

City of Federal Way. (2007). *City of Federal Way Shoreline Inventory & Characterization*. Retrieved from <http://www.ecy.wa.gov/programs/sea/shorelines/smp/mycomments/federalway/Section2.pdf>. Web.

King County. (2016) The Secret Life of Lakes - King County, Washington. Web.

King County. (2013). Urban & Community Forestry Climate Preparedness & Response Web.

Lake Access. Lake Ecology- Trophic Status. Web.

Zhang, Ge, Subhrajit Guhathakurta, and Wenwen Zhang. Hierarchical Controls on Watershed Stormwater: Land Use/ Cover Composition and Connectivity. Center for Geographic Information Systems, Georgia Institute of Technology, 2015. Web. 10 May 2016.

### LAKE KILLARNEY SITE ANALYSIS

Adrissono, R. J., Neumann, R. B., Gawel, J., Hull, E., King, C., & Ryan, J. Characterizing Organic Carbon in an Arsenic Contaminated Oxidic Lake. Working paper. University of Washington.

City of Federal Way. (2007). *City of Federal Way Shoreline Inventory & Characterization*. Retrieved from <http://www.ecy.wa.gov/programs/sea/shorelines/smp/mycomments/federalway/Section2.pdf>. Web.

Department of Ecology. (1997). Lake Killarney Integrated Aquatic Plant Management Plan. Rep.

Gawel, J. E., Asplund, J., Burdick, S., Miller, M., Peterson, S., Tollefson, A., Ziegler, K. (2013). Arsenic and Lead Distribution and Mobility in Lake Sediments in The south-central Puget Sound Watershed: The Long-term Impact of a Metalsmelter in Ruston, Washington, USA. Rep. N.p.: Science of the Total Environment.

King County. (2002). King County Lake Monitor Report 2002-2003. Rep. Retrieved from [http://your.kingcounty.gov/dnrp/library/archive-documents/wlr/waterres/smlakes/lkmon\\_03/killarney.pdf](http://your.kingcounty.gov/dnrp/library/archive-documents/wlr/waterres/smlakes/lkmon_03/killarney.pdf).

King County. (2015). King County Small Lakes. King County Lake Monitoring Program. Retrieved from <http://green2.kingcounty.gov/smalllakes/LakePage.aspx>.

King County. Key Ingredients for Lake Projects: Funding and Permits.

King County. (2008). King County Potential Annexation Areas. King County Annual Growth Report. Web. Retrieved from <http://your.kingcounty.gov/budget/agr/agr08/08AGRCh7b.pdf>

Washington State Department of Ecology. (2006). City of Federal Way Shoreline Inventory and Characterization Report. Rep. Federal Way: Washington.

## **INDUSTRIAL CONTAMINATION**

Adrissono, R. J., Neumann, R. B., Gawel, J., Hull, E., King, C., & Ryan, J. Characterizing Organic Carbon in an Arsenic Contaminated Oxidic Lake. Working paper. University of Washington.

Aggett J., O'Brien, G. A. Detailed model for the mobility of arsenic in lacustrine sediments based on measurements in Lake Ohakuri. *Environ Sci Technol* 1985;19:231-8.

Couture R. M., Shafei B., Van Cappellen P., Tessier A., & Gobeil, C. (2010). Non-steady state modeling of arsenic diagenesis in lake sediments. *Environ Sci Technol*; 44:197-203.

Gawel, J. E., Asplund, J., Burdick, S., Miller, M., Peterson, S., Tollefson, A., Ziegler, K. (2013). Arsenic and Lead Distribution and Mobility in Lake Sediments in The south-central Puget Sound Watershed: The Long-term Impact of a Metalsmelter in Ruston, Washington, USA. Rep. N.p.: Science of the Total Environment.

Glass, G. L. (2003). Credible Evidence Report, the ASARCO Tacoma Smelter and Regional Soil Contamination in Puget Sound. Final Report, Seattle, WA.

MacDonald, D. D., Ingersoll, C. G., Berger, T. A. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch Environ Contam Toxicol* 2000;39:20–31.

Nittrouer, C. A., Sternberg, R. W., Carpenter, R., & Bennett, J. (1979). The use of Pb-210 geochronology as a sedimentological tool: application to the Washington continental shelf. *Mar Geol*

31:297-316.

Revised Code of Washington. WAC Title 173-204-563. Sediment cleanup levels based on protection of the benthic community in freshwater sediment. Washington State Legislature. Web.

## CREATING CHANGE

Beck, T. (2013). *Principles of Ecological Landscape Design*. Washington, DC: Island Press.

Franklin, C. Fostering Living Landscapes. in Thompson, G. F., & Steiner, F. R., (Eds.) *Ecological Design and Planning*. Chichester: Wiley.

## CONCERNS, GOALS & ACTIONS

Beck, T. (2013). *Principles of Ecological Landscape Design*. Washington, DC: Island Press.

King County. (2016). King County Comprehensive Plan.

Manzo, L.C., & Perkins, D. (2006). Finding common ground: The Importance of Place Attachment to Community Participation and Planning. *Journal of Planning Literature*, vol. 20 pp.335-350.

Revised Code of Washington. 17.10.

Washington State Department of Ecology. (2006). City of Federal Way Shoreline Inventory and Characterization Report. Rep. Federal Way: Washington.

## APPENDIX

Department of Ecology. (2012). Chapter 2, Shoreline Management Overview. *Shoreline Management Plan Handbook*.

King County. (2016). *King County Comprehensive Plan*.

Perlman, D. L., and Milder, J. C. (2005) *Practical Ecology for Planners, Developers, and Citizens*. Washington, DC: Island Press.

Revised Code of Washington. 43.21C.010-43.21C.020.

Revised Code of Washington. 90.58.020-90.58.080.

Wildermuth, T. (15 January 2016). Personal interview.

## FIGURES

Figure 20- Stankey, G. H., R. N. Clark, and B.T. Bormann. (2005). Adaptive Management of Natural Resources: Theory, Concepts and Management Institutions. General Technician Report PNW-GTR-654. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station.

## IMAGES

Image 10- Patrick, Kenna. "Lake Killarney". 2014. JPEG file.

Image 11- Patrick, Kenna. "Swimmers enjoying the lake in summer". 2014. JPEG file.

Image 12- Patrick, Kenna. "A bald eagle above the lake". 2016. JPEG file.

Image 13a- Patrick, Kenna. "Lake output". 2016. JPEG file.

Image 13b- Patrick, Kenna. "Stream 0006". 2016. JPEG file.

Image 13c- Patrick, Kenna. "0006 daylights". 2016. JPEG file.

Image 14a- Patrick, Kenna. "New neighborhood cuts into woodland buffers". 2016. JPEG file.

Image 14b- Patrick, Kenna. "Stormwater detention in the new development". 2016. JPEG file.

Image 14c- Patrick, Kenna. "Recently clear-cut land". 2016. JPEG file.

Image 14d- Patrick, Kenna. "Many homes, no mature trees". 2016. JPEG file.

Image 15- Patrick, Kenna. "Weyerhaeuser". 2016. JPEG file.

Image 16- Patrick, Kenna. "Tributary 0006". 2016. JPEG file.

Image 17- Patrick, Kenna. "Lake output point". 2016. JPEG file.

Image 18- Patrick, Kenna. "The stream exiting the lake". 2016. JPEG file.

Image 19- Patrick, Kenna. "English Ivy". 2016. JPEG file.

Image 20- Patrick, Kenna. "Fallen tree". 2012. JPEG file.

Image 21a- Patrick, Kenna. "Riparian wetland". 2015. JPEG file.

Image 21b- Patrick, Kenna. "Lake Killarney". 2014. JPEG file.

Image 21c- Patrick, Kenna. "Douglas-fir community". 2015. JPEG file.

Image 22a- Patrick, Kenna. "Bald Eagle". 2015. JPEG file.

Image 22b- Great Blue Heron [Photograph]. Retrieved from Dune's Center <http://dunescenter.org/dunes-in-flight-the-great-blue-heron/>

Image 22c- Wood, Sally (Photographer). Pileated Woodpecker [Photograph]. Retrieved from <https://sallywoodnaturephotography.com/tag/pileated-woodpecker/>

Image 22d- Wood Duck [Photograph]. Retrieved from <http://ibc.lynxeds.com/photo/american-wood-duck-aix-sponsa/male-wood-duck>

Image 22e- Ingram, Tom (Photographer). Hooded Merganser [Photograph]. Retrieved from <http://www.tomingramphotography.com/hooded-merganser>

Image 23- Patrick, Kenna. "Stormwater discharge". 2016. JPEG file.

Image 24- Patrick, Kenna. "Riparian forest". 2016. JPEG file.

Image 25- The ASARCO smelter plant in Ruston, Washington [Photograph]. Retrieved from <http://postdefiance.com/son-of-tacoma-father-of-dune/>

Image 26- “Tacoma Smelter Plume”. Retrieved from [http://www.ecy.wa.gov/programs/tcp/sites\\_brochure/dirt\\_alert/studies\\_and\\_maps/sources.html](http://www.ecy.wa.gov/programs/tcp/sites_brochure/dirt_alert/studies_and_maps/sources.html).

Image 27- Patrick, Kenna. “Lake Horizon”. 2015. JPEG file.

Image 28- Patrick, Kenna. “Lake Water”. 2015. JPEG file.

Image 29a- West, Liz (Photographer). Purple Loosestrife [Photograph]. Retrieved from <http://www.lakescientist.com/purple-loosestrife/>

Image29b- Tansy Ragwort [Photograph]. Retrieved from <http://www.nwvisualplantid.com/tansy-ragwort-senecio-jacobaea-j-vulgaris/>

Image 29c- Patrick, Kenna. “English Ivy”. 2016. JPEG file.

Image 30a- Patrick Kenna. “Current Wetland Conditions”. 2016. JPEG file.

Image 30b- Patrick, Kenna. “Current Stream Condition”. 2016. JPEG file.

Image 31- Patrick, Kenna. “Bald Eagle at Lake Killarney”. 2016. JPEG file.

Image 32- Patrick, Kenna. “James Gawel and his team conduct-

ing research”. 2016. JPEG file.

