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"Nature is being severely altered and we need new, legible models to illustrate how nature currently works and does not work--intertwined, such as it is, with architecture. We must find ways to allow the natural landscape and the landscape of infrastructure, which occupy the same space, to coexist and perform multiple functions."

- Gary Strang, "Infrastructure as Landscape; Landscape as Infrastructure"

Introduction

According to theorists such as Gary Strang (1996) and Robert Thayer (1994), one of the barriers to widespread adoption of "sustainable development" and practices in modern society is the general society's insufficient knowledge of the inner workings of technology within built structures. Joan Iverson Nassauer (1995) describes such insufficient knowledge in the relationship between landscape **forms** and human recognition of ecological function, in her article, "Messy Ecosystems, Orderly Frames". Nassauer explains, "Ecological function is not readily recognizable to those who are not educated to look for it.[1] Furthermore, the appearance of many indigenous **ecosystems** and wildlife habitats violates cultural norms for the neat appearance of landscapes.[2] Even to an educated eye, ecological function is sometimes invisible. Design can use cultural values and traditions for the appearance of landscape to place ecological function in a recognizable context" (p. 161). As ecological functions of **built environments**[3] make up one major facet to ecological sustainability, and because the sensible, acculturated forms of technology and landscapes (such as the form of a typical front yard that appeals to culture by its orderly-framing) remain the preference for human habitats over more 'wild' landscape forms (such as the forms of a forest that are left unmanaged by humans), one way to overcome resistance to sustainability (i.e., sustainable practices, like incorporating biodiversity in your front yard, rather than simply supporting sustainability in principle) is to increase the 'sensory legibility' of sustainable technology

[1] For this discussion, everything that physically exists is perceived as having form (i.e., the configuration of the physical, which enables one to discern physical boundaries). Identifications of something (that has form) physically existing as "informal" or having "informal" properties is arbitrary, tenuous and indeterminate. Such terminology, is often used in discussion of design but would be better articulated as *unconventional* rather than *informal*. Thus, the use of *formal* in this essay is in relation to all figurations of physical matter and not used to distinguish itself from arbitrary "informal" properties.

[2] An ecosystem is: "a system, or a group of interconnected elements, formed by the interaction of a community of organisms with their environment" (Dictionary.com). Ecological functions, are the ongoing interactions within an ecosystem. Ecological sustainability and sustainable ecological functioning is interaction that supports the biological interconnectedness or sustains an equilibrium of the collective biological species involved. Biological is a term denoting anything relating to a living organism.

[3] The Department of Health and Human Services [HHS], (2004) defined the built environment as the human-made space in which people live, work, and recreate on a day-to-day basis. It includes the buildings and spaces we create or modify. It can extend overhead in the form of electric transmission lines and underground in the form of landfills.

(i.e., the infrastructure and systems that are truly better for the eco-environment) for the general public. Therefore, the question my research proposes is, how can designers make ecological sustainability sensory legible through the built environment? By *sensory legibility*, I mean the ability to read and understand through the senses how efficient and beneficial a built structure is for its ecological environment, and in what way. When sensory legible, the structure's sustainability and ecological value can be perceived immediately through the physical senses, without additional research. Furthermore, the structure (which is inextricably tied to the processes it is involved with and that make it up) tells the ecological functions it offers and the processes involved in the way it is exhibited. Thus, the designer's use of ecologically preferable practices and materials in the design, location, construction, operation and disposal of built environments, if sensory legible, can be perceived and understood simply through the physical senses.

Most theorists have contributed only peripherally to the question of sensory legibility of sustainability in the built environment. The research that many present, in one way or another, offers some recognition of the issue, but most are still concerned primarily with other design issues and do not recognize how the many problems they discuss, revolving around the topic of how to increase sustainable action and decrease unsustainable action, can largely be resolved by methods of sensory legibility. They discuss: the ecological function in the landscape; the need to design with "nature"; the relation between form and meaning; the communicative and persuasive power of landscape; the need for cultural impetus toward sustainability in the landscape; the need to establish local or regional identity; the cultural preference toward appearances over functions; and the deceptiveness of 'The Picturesque' and 'artificial' landscapes that are idyll. These issues do bear on sensory legibility to a significant degree. However, none of the previous theories, alone, sufficiently describes or prescribes the methods for sensory legibility of sustainability in the built environment as a focus for cultural and behavioral transformation, or hold the theoretical underpinnings necessary for understanding these methods in relation to human perception. Drawing together different realms of theory to one concentrated and digestible place, I will integrate the dispersed ideas from various authors and fields of study into a coherent discussion on the sensory legibility of ecological sustainability in built form. Such integration will allow for the development of a

unified theoretical framework that can act as a foundation for one's understanding of sensory legibility as it pertains to sustainability in architectural design. The framework will also fill in philosophical gaps in existing theories on psychological connections between ecological function and the aesthetics of architectural design. After organizing the theoretical underpinnings of the sensory legibility as a theoretical framework, I will derive an evaluative framework from the theoretical one to show how the theory can be applied to existing built structures. The evaluative framework can be used as a tool for evaluating existing sustainable structures on the level of sensory legibility present in the sustainable ecological functioning of a design's built form. Using only existing built environments that are recognized as ecologically sustainable under the highest sustainability certification standards of the most rigorous evaluative systems on sustainable design currently available, I will offer illustrations of the how designers make ecological sustainability sensory legible in their architecture using the evaluative framework proposed.

The significance of my research is that it may provide designers with set of strategies for making the built environment ecologically sustainable in a more sensory legible way, which may, in turn, promote sustainable practices by making them more socio-culturally accessible and by educationally-equipping people with the knowledge to make better and, more sustainable day-to-day decisions, having learned from the didactic spaces in which the people live and work. The strategies can also be implemented as criteria in "green building" evaluation systems which would create economic incentives (rewards with economical profit through either marketable branding to the public, tax-cuts, and/or other economical supportive techniques) for architects (and the like) who design genuinely eco-effective, culturally-transformative/motivational built environments (toward the advancement of sustainable practices by the general public).

Structural Layout of the Thesis:

This essay will start by offering a historical view of ecological sustainability in the United States, which is foundational for understanding the theoretical argument that follows. The following section, which will make up the bulk of this writing, is what I call the 'Theoretical Framework. I will bring together ideas in design theory, along with theoretical views from other disciplines in a way that focuses on sensory

legibility as a part of critical theory and interpretive theory. Appealing to the instrumental side of theory, in the second part of the thesis, I reveal my 'Evaluative Framework' which explains how the 'Theoretical Framework' can be utilized by designers. Finally, the thesis will end with illustrations that demonstrate the 'Evaluative Framework' in analysis of particular built environments.

United States History of the Ecological Sustainability Agenda and The Introduction of Fundamental Concepts:

Several months before the 1992 Earth Summit, William McDonough Architects and Dr. Michael Braungart published their famous 'Hannover Principles' as commissioned by the 2000 World Exposition in Hannover, Germany. The report was meant to guide architectural design to be more sustainable. McDonough and Braungart (1992) provide a set of sustainable factors that, as they aver, should be considered for every project designed within the built environment. This set of sustainable factors, labeled the "Hannover Principles", can be most simply stated as:

"1. Insist on rights of humanity and nature to co-exist

2. Recognize interdependence.

3. Respect relationships between spirit and matter.

4. Accept responsibility for the consequences of design.

5. Create safe objects of long-term value.

6. Eliminate the concept of waste.

7. Rely on natural energy flows.

8. Understand the limitations of design.

9. Seek constant improvement by the sharing of knowledge."

(p. 2).

This exposé gives the authors' understanding of the role that design can play for or in support of sustainability and how the term, "sustainability", is translated in design, stating,

> "The Hannover Principles aim to provide a platform upon which designers can consider how to adapt their work toward sustainable ends. **Designers** include all those who change the environment with the inspiration of human creativity. **Design** implies the conception and

realization of human needs and desires…**Designing for sustainability** requires awareness of the full short and long-term consequences of any transformation of the environment. [Thus,] Sustainable design is the conception and realization of **environmentally** sensitive and responsible expression as a part of the evolving matrix of nature" (p. 4).[4]

A paradigm shift within Western Culture will be necessary for the aspiring Hannover Principles, which encourage the "well-being of the planet with continued growth and human development" to be met (p. 4). McDonough and Braungart present their ultimate vision, saying, "It is hoped that the Hannover Principles will inspire an approach to design which may meet the needs and aspirations of the present without compromising the ability of the planet to sustain an equally supportive future" (p. 4). McDonough and Braungart's vision is derived from the 1987 *Our Common Future* (also called *Brundtland Report*) by the World Commission on Environment and Development (a.k.a., the Brundtland Commission of the United Nations), defining *sustainable development* as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, 41). This definition is currently the most widely-held definition of *sustainable development*, and will be used in this thesis as the general concept of *sustainability*. The generalized definitions for technical terms and phrases including *design* and *design for sustainability* will also be borrowed from the "Hannover Principles" report.

Long before nailing down an official definition for *sustainable development,* the perspective that, there exists a real need for more sustainable development than the contemporaneous developments of humankind, began to be dispersed and accepted throughout the nations. In the middle of the 20th century, a strong socio-political movement of ecological concern against human material production practices

[4] Environment is discussed in three major ways. The first is that which is external to an individual including the social and physical. The second is about all that is physically external to an individual. The third way is in particular reference to ecology and all ecological forms and functions. In accordance with the first way of discussing the environment, the definition I use for *environment* is as the Centers for Disease Control and Prevention (CDC) states, "Broadly defined, the environment includes all that is external to an individual -- the air we breathe, the water we drink and use, the land and built structures that surround us -- all of the natural as well as human-formed conditions that influence the quality of our lives" (CDC, 2014). When the term, *environmental* is cited from other sources in this paper, the term can be equated to the term, *ecological*.

(particularly, the agricultural and the more industrial) began in the Western World. This movement of 'environmental', or rather, ecological ethic spirited the formation of groups like World Wildlife Fund, founded in Switzerland in 1961, and publications like the 1962 book, *Silent Spring*, by, Rachel Carson, concerning the threat of pesticides on wildlife and humans. The movement began with a reflective attitude on the possible dangers of human practices on the environment (ecologically-speaking), followed by a sober recognition and coinciding agenda out of concern about the eco-environment, while still bearing little responsive action. The current state of the movement is as an active changer of policies and practices in reaction to the consequences of humans' ecologically damage-prone practices, but this has largely just begun. The first Earth Day in 1970 marked the "emergence of environmentalism into powerful political action" (Spencer Weart & American Institute of Physics, 2014), and set the stage for "environmental protection onto the national political agenda" (Earth Day Network, 2016). Alongside the culturally-transformative momentum of the first Earth Day, the 1969 massive oil spill in Santa Barbara, California and the threats of Climate Disaster (early 1970s) provoked the beginning of governmental policy changes specifically for eco-environmental protection in America. Such policies changes included the Environmental Protection Agency's (**EPA**) ban on DDT in 1972, ten years after the publication of Silent Spring, the same pesticide Rachel Carson warned against.[5]

The most notable boost in nationwide ecological concern with tandem responsive action may be attributed to popular acceptance of the scientific discovery of global warming resulting from increasing amounts of greenhouse gases (GHGs) in the atmosphere due to human production practices, and overwhelming research on the corresponding dangerous phenomenal consequences global warming. Since the scientific revelation of climate change on a global scale (most evident examples of this revelation happen from 1992 to 2009), the Western World has undertaken major political and economic initiatives to come into step with the chemistry and physics of our earth. To give some historical timeline on the public opinion of global warming, the earliest record of scientific research reporting that the earth

[5] The United States Environmental Protection Agency (EPA) was born out of fire, literally. The formation of the EPA was spurred by the national attention of the Ohio's Cuyahoga River that caught on fire in 1969 because of how polluted the river became (EPA, 2016). The EPA formed in 1970 (the same year as the first Earth Day, and possibly as a result of it) with the mission "to protect human health and the environment" (EPA, 2016).

was undergoing global warming due to human carbon dioxide emissions was by the Swedish chemist, Svante Arrhenius in 1896 (Weart, 2014, p. 1). Arrhenius did not elaborate on the rate or extent of warming (p. 1). In the 1960s and 1970s many speculations arose on climate instability and ongoing climate changes in the scientific community, but disagreement was prevalent (p. 1). During the 1980s, many scientists agreed that the earth was undergoing global warming, but still had to base their argument on incomplete evaluative models (p. 1).

In 1992, an international eco-environmental treaty was formed at the United Nations Framework Convention on Climate Change. This treaty led to the Kyoto Protocol (an international law) being introduced at the 1992 Rio de Janeiro "Earth Summit" (a.k.a., United Nations Conference on Environment and Development). The treaty's objective was "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (United Nations, 1992, p.9). The treaty was not ratified by the United States, and the EPA did not issue an official statement on global warming until December 2009, announcing that "greenhouse gases threaten the health and welfare of the American people" (EPA, 2016). The EPA's statement was, undoubtedly, a response to a similar statement (backed with evidence from advanced computer-based modeling) issued to world leaders earlier that year by the International Alliance of Research Universities (IARU) at the Copenhagen Climate Council, an international team of leading scientists. The IARU reports:

> "The climate system is already moving beyond the patterns of natural variability within which our society and economy have developed and thrived. These parameters include global mean surface temperature, sea-level rise, ocean and ice sheet dynamics, ocean acidification, and extreme climatic events. There is a significant risk that many of the trends will accelerate, leading to an increasing risk of abrupt or irreversible climatic shifts" (IARU, 2009, p.3).

Of course, long before the overwhelming scientific proof of global warming, much of humankind's practices and technologies have had quite sensibly harmful (however unintentional) consequences, including the destruction of many oceans, forests and other ecosystems and the corresponding landscapes that were once treasured by many humans and inhabited by many species. The advances of

technological development have shown clearly to be combative to the habitats of other species. As scientific evidence arises and **ecological guilt**[6] grows in Western Culture, regulations have slowly followed to put in place restraints on human-marketed production strategies that are ecologically destructive. Now is a time of ecological awareness with the sense of urgency, and it is growing with an increasing number of political and activist groups rallying for change. No doubt, if we spent as much time uprooting our unsustainable practices and developing new more sustainable methods as we do protesting and debating our problems, the earth would be further in route to the restoration and generation of sustainable ecosystems. Yet, the ecological guilt-trip only goes so far in such an economic-driven society. Guilt has inspired public concern enough to inspire governmental regulations forcing corporations to do better. As Cradle to Cradle suggests, regulations are a punishment and only force corporations to do less harm (McDonough & Braungart, 2002, pp. 45-67). Guilty consumers seek “green” marketed products (products that appear to have given some prudent concern toward the eco-environment). Yet, advertising often manipulates people’s concern through “greenwashing”. Greenwashing is a technical term for deceptive packaging/displaying products with labels that imply ecological concern, or have symbolic representations of biological systems or organisms (like trees, plants, water, and other animals, and their corresponding color palettes, creating the deceptive illusion of ecologically safe/proactive productions. Given the consumers drive for environmental health and the corporate appeal to monetary profit, the government has begun offering profit incentives that make eco-friendly practices economically persuasive to businesses. Working alongside the government’s efforts to encourage sustainable development are non-profit organizations like the U.S. Green Building Council. This council evaluates projects designed for certified recognition as ‘sustainable’ and offers monetary bonuses for those who design sustainable products or processes. The green evaluation systems for sustainable building and design include LEED (Leadership in Environmental and Energy Design), the Living Building Challenge (LBC), BREEAM, Green Globes, etc. With these evaluative systems in mind, my thesis seeks a different evaluative approach to supplement or bolster the evaluative criteria of these existing evaluation systems. The evaluative criteria

[6] Guilt is defined as a feeling of responsibility or remorse for an offense or crime, or violation against some moral or ethical code, whether real or imaginary. Environmental guilt (more correctly articulated as ecological guilt) is “guilt about the ill effects technological development has caused to the ecology of the Biosphere (Thayer, 1994, p. 55).

of these systems help guide designers toward sustainable design, influencing the decisions they make throughout the design process. My research seeks to offer ways to improve and speed up current efforts already at work to make human-market production practices (including that of the built environment) more sustainable, with the expectation that such efforts will not only encourage, but equip people with the knowledge to make their daily decisions and ways of living more sustainable. The method of equipping that I propose is through designing the built environment sustainably through a framework of sensory legibility. My theoretical framework for the sensory legibility of eco-sustainability in architecture can now be explained with the historical background and fundamental concepts of *sustainability* and *design* laid out as a foundational basis for further discussion.

Part I: Theoretical Framework: The Sensory Legibility of Eco-Sustainability in the Built Environment

Chapter 1: Assumption #1 - The Manifestation of Ideas in Architectural Form:

The first central premise inherent to my theory of sensory legibility is that physical form is perceived as a physical manifestation of ideas. A debated philosophical topic, this assumption deals with the relationship between our minds and the world (or reality), and issues of perception. Commonly held ideas perceived to be manifested in built environment include, but are not limited to, its symbolic representations of societal order, religion, sacredness, and dignity. The meaning derived from physical objects is only as it is perceived by humans. Without the interface between the physical objects and their perceiver, the meaning does not exist. In other words, the manifestation of ideas in form exists only as it is perceived through human experience in the human mind, and is not literally in the forms themselves. Robert Thayer gives a thorough description of the process of deriving meaning from a landscapes' sensible components, proposing:

> "As an experiencing participant in a landscape, a person must first be able to perceive light and dark and form and pattern, and to distinguish figure from ground—tasks most easily explained

> through sensation-based perceptual theory. Then, with increasing experience, a person may begin to recognize utilitarian functions in the landscape. Ultimately, the person must decipher and comprehend symbolic meanings which may have no intrinsic relationship to the more fundamental perceptual or functional properties of a landscape" (Thayer, 1994, pp. 108-109).

Likewise, according to Laurie Olin in "Form, Meaning, and Expression", "Landscapes [its figures] … can possess symbols and refer to ideas, events, and objects extrinsic to their own elements and locus…" (Olin, 1988, p. 158). One might argue even that all information is something that is not in physical matter, but is something that we attribute to it (Wiener, 1961, p. 132). For this discussion, the deciphered, assigned or abstracted meanings, beyond the identification of points, edges, and structural or form-related patterns that a brain forms in one's mind, start at the level of simple comparisons of perceptual qualities in relation to one's self (e.g., big, small, few, many). 'Higher' meanings include ideas about what the form has the utilitarian capacity to do, and then finally to the more separable, subjective, fluid, and debated ideas connected to forms, such as the forms' aesthetic values (ugly, bland, mediocre, neutral or beautiful) and meanings that have no intrinsic relationship to the form whatsoever (e.g., socio-cultural conditions like private and public; scientific knowledge; philosophical notions; and non-aesthetic values). Each 'level' of meaning has an interdependent relationship to the others, such that one may influence the others and transform or alter the meanings otherwise perceived (e.g., the perception of beauty may be viewed as dependent on or conditional to perceived ecological values), exhibiting a range of relationships between ideas and physical form (Thayer, 1994, p. 110).

Neither the reality of forms, the matter they are made of, nor the real interactions between them possess the ideas, rather the human consciousness has ideas attached to form, matter and processes (some ideas being more detachable from our perception of the forms than others). In support of the argument that ideas are perceived as manifested in form, Jon Michael Schwarting writes in his essay, "*Lessons of Rome*", "The relation between our mind and things consists in that we think about the things, that we form ideas about them… In other words, thinking is the endeavor to capture reality by means of ideas: the spontaneous movement of the mind goes from the concepts to the world" (Schwarting,1981, p. 25). Hence, our endeavor to capture reality implies that ideas and meanings are not just add-ons to our

understanding of reality, but are essential for the human experience as intermediaries between us and the world. He describes this philosophy of idealism as it relates to architecture as seen in the built urban environment of the city of Rome, Italy, revealing:

> "With postulates that the mind struggles for an orderly conception of reality, that 'vision is not a mechanical recording of elements but the grasping of significant structural patterns,' the argument delivered to architecture was that 'all creation of form involves a coping with the world of experience' and concomitantly 'visual form must be considered as a basic means of understanding the environment'' (p. 26).

Here, Schwarting posits that architects must both cope with experience before they design by deriving meaning from forms in the environment, and use form to express significance that may be understood by those who will experience their architecture. After the architect's mind has endeavored to capture reality with ideas about it, the architect preconceives a mental representation of the built/constructed form before existing in the physical world based off of the architect's understanding of his or her environment (which is necessarily influenced by a set of precedents, i.e., something that has already existed in some sort of physical manifestation). Though influenced by precedents, the architect can design a **script** (or analogous template) to guide the transformation of both the mental representation and the final architecture. The final architecture may be different in some way from what has previously existed, making it a new work to greater or lesser degrees.[7] The creation of the script should take into account the ideas that possible visitors/inhabitance of the final architecture will likely have about its particular forms (thus, having to make assumptions on their cultural background and the cultural context of the site for the final architecture). If successful, the final architecture has the configuration or composition of forms and media (wood, steel, glass, etc.) in the world in a way that stirs up in the experiencers' minds the ideas that the designer intended for the final architecture's occupants to have. The composition of forms then helps viewers to understand the intended meanings of the built environment they sense or inhabit and how it relates to its surrounding context. Therefore, not only do we find meaning in sensible forms, but when we

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[7] The script can be in the form of sketches, diagrams, blue prints, models, and other props of design that act as encodings of and instructions for creating the final product, architecture. The props of a design are similar to the final work, as much as they present the composition or formal pattern, and more or less, an identical manifestation of ideas. Working with the script may transform the designer's ideas for the final architecture as he or she creates it.

create form, the composition can be designed with an intended manifestation of ideas, such that we perceive them as if the ideas were in the architecture itself.

The reason we think about manifested ideas as if in the form itself, is because forms are idealized with particular meanings that are commonly held, shared and reinforced by groups of people. People connected by a shared context pass around these meanings (deliberately or unwittingly), allowing the ideas to carry over from one person to the next with varying levels of commonality. Thus, shared perception of these ideas about particular forms, their matter, and the interactions between accumulate to communication of ideas between people. The sharing of these ideas are often passed down from generation to generation that share a given locale. People seeking to establish social order through their physical environment and in the ways it is used, treat architecture and other objects of the physical world as a metalanguage, communicating specific messages to all those who know the symbolism of the culture (similar to idioms). Pointing out the significance of these subjective messages to the 'sense of place' and social interaction, Alan Colquhoun, author of "*Typology and Design Method*" wrote, "Our senses of place and relationship in, say, an urban environment, or in a building are not dependent on any objective fact that is measurable; they are phenomenal. The purpose of the aesthetic organization of our environment is to capitalize on this subjective schematization and make it socially available. (The resulting organization does not correspond in a one-to-one relationship with the objective facts but is an artificial construct which represents these facts in a socially recognizable way)" (Colquhoun, 1969, p. 44). Thus, the role of an architect is more than just designing buildings that stand and allow for certain programmatic functions (like capacities for selling merchandise or movement from one area to the next), optimal atmospheric conditions, and aesthetical pleasing experiences. In addition to these other roles of design, Schwarting reveals, "for the architect-planner this [manifestation of the ideas in form] would mean that existing political, social and physical conditions or realities must be analyzed as the context for design" (p. 27). When the design makes the subjective phenomena socially available through the final architecture in an intended way, consequently, it fulfills a higher anthropocentric calling.

The appropriateness of the form (as it manifests intended ideas) can change as it is dependent upon the culture, which in turn, is dependent upon contextual conditions. Certain forms in one place and

time have certain meanings, but the set of meanings related to a form are not forever the same. One might call this a problem of cultural and physical discontinuity, when forms and the content lose their original meaning. An adult born and raised in the Amazon, for example, would not likely recognize the symbolic reference to Christ triumphing over death in a triumphal arch (a notion held by cultures during the Romanesque and Renaissance periods in and around Italy), thus the form would not serve the same purpose in an Amazonian landscape, at least not by its typical audience (Amazonians). Therefore, the architect must be careful to recognize the intended audience and their understanding of ideal-real relationships in architecture. Despite the architect's endeavor to capture reality, the state of reality, or at least the perception of it is transitory such that everywhere meaning is, as J.S. Duncan and N.G. Duncan propose in "*[Re] Reading the Landscape*", unstable and plural, but not infinite—it is as constrained by the range of interpretations involved (Duncan & Duncan,1988, p.120).

Manifestation of the Eco-Sustainable Idea in Form

I propose that 'ecological sustainability' as a concept in architecture is determined based on the human perception of forms, in concord with Thayer's conclusion on landscape perception that 'environmental' meaning ultimately resides in the observer, but the observer acts as though the meaning resides in the environment" (Thayer, 1994, p. 105). Certain forms and arrangements of forms can be more (or less) lending to (or detracting from) the "environmental meanings" of ecological sustainability in architecture, due to individualistic and culture-specific ideas attached or assigned to them. This does not mean that generalizations of such form-meaning relationships cannot be made across groups of different socio-cultural backgrounds. Thayer asserts, "obviously, to at least some degree, there are sufficient, commonly held meanings presumed to be at least partially attachable to the landscape to warrant great effort and economic activity on the part of thousands of Americans in the design and visual occupations" (p. 105). Generalizations of certain forms and their sensible attributes are useful and applicable to revealing the extrinsic function of the forms for humans and by extension the ecological sustainability. Without such generalizations, there could be no cultural cues to observers of ecological values expressed through forms nor the study of ecological aesthetics in design and market production. Certainly, the functional significance perceived of some forms will have little variation from one individual to the next

(due to commonalities throughout humankind and their use of the world of forms). There may even be specific sensible qualities of forms that express certain ecological functions and are perceived with **positive associations**, reflecting eco-sustainability, no matter the culture.[8] Such sensible qualities are related to intrinsic characteristics or functions of forms that lead one to contrive the idea that such forms are eco-sustainable. The ideas of eco-sustainability applied to forms that sway from culture to culture (dependent on culture), are contrived from extrinsic characteristics and functions to the forms.

Thayer specifies that some meanings associated with landscape form "appear to be quite basic to human existence and others…require high degrees of exposure to the complexities of a particular culture" (p. 110). Whether extrinsic or intrinsic to the form itself or the form's utilitarian relationship to us, derived meanings of eco-sustainability in structures (or objects) and functions (or processes) are perceived as if the properties are in the forms themselves. Therefore, the forms and perceived meanings should be analyzed and utilized in architecture toward advancement of ecological functioning that is supportive of the survival and flourishment of humankind. Moreover, things that stand for eco-sustainability may or may not have anything to do with actual eco-sustainability. Yet, both the actual stabilization of ecosystems, and the symbolic associations of such functioning can be utilized in design. One's level of understanding of the ecological sustainability in architecture (i.e., the workings and benefits of ecosystems' components and processes by the built environment) through the perception of forms, is dependent upon sensory experience, and utilitarian and symbolic meanings combined. While there may be more substantive qualities intrinsic to eco-sustainable forms and functioning of forms, no matter the actual level of ecological sustainability the forms achieve, to the degree of variability of ideas, the level of sensory legibility of sustainability that the forms 'have' is both situational and individual. Dependent upon this premise of a semiotic quality inherent to architecture (i.e., the built environment acting as signs and symbols; architecture having sign processes and use as a means for meaningful communication), is a

[8] On positive and negative associations, Thayer explains "…each meaning dimension or significance level contributes to overall affective or emotional response, be it negative or positive" (p. 111). Furthermore, "it is a fair assumption that for a human environment or object of utilitarian purpose, a major portion of its visual meaning or significance results from the association between its form and its particular utility in human life. This, of course, is a learned relationship between the environment and the human using it. The nature of this associative meaning stemming from direct use might be positive, such as a gardener's feeling of affinity for a particular plot of soil, or a carpenter's sense of appreciation for his hammer. On the other hand, an association between place or object and its inherent function might be valued negatively, as between a convict and the prison yard, or an underpaid worker to an orchard of overripe fruit" (p. 116).

second major assumption in this research, that design can be a tool to influence a change of behavior through its ability to change understanding and equip humans with practical knowledge.

Chapter 2: Assumption #2 - Design for a Change in Behavior and Practice:

The second central premise of my research is that sensory legible architecture leads experiencers of the architecture to make more sustainable decisions and behave in a sustainable fashion. The idea that design can play a significant role in influencing our socio-cultural and physical interactions has become quite commonplace to designers and theorists alike. In this way, the design of built environments is not only intended to accommodate, but also to influence or conduce particular behaviors. According to Kaplan & Kaplan (1982) and Thayer (1994, p.309), “landscape is a principle vehicle for making sense. If landscapes cease to help individuals make sense, landscapes are not fulfilling one of their most important functions”. By sensing (through ears, eyes, etc.) and understanding the dynamic interactions of plants, rock, soil, animals, air, water, and waste systems as they are demonstrated within ‘sustainable development’ (such as sustainable architecture) more and more people will become increasingly equipped to do more than simply understand how their local ecosystems work. Through such sensory experiences within the built environment, humans will be able to understand how they can better work with and within habitats in their daily activities for the benefit of the whole bioregion. Such understanding will inevitably inspire a corresponding change of preferences and behaviors in the experiencers of such built environments toward more ecologically sustainable practices within the world due to the combination of positive associations with practical ‘know-how’. This assumption, of course, would require further psycho-analysis and experimental observations to prove, yet it is a belief that is supported by the theories of widely-respected theorists in various fields, including Edward Wilson and Thayer.

In 1988, the year after the official definition of *sustainable development* was issued by the WCED, Edward Wilson published his renowned book, “Biophilia”, in which he writes, “With the belief that understanding how a thing works will increase one’s value of it”, Edward Wilson pronounces, “the conclusion I draw is optimistic: to the degree that we come to understand other organisms, we will place a greater value on them, and on ourselves” (Wilson, 1988, p. 2). Perhaps it was Wilson’s belief that inspired

theorist Robert Thayer, who references Wilson six years later. Thayer reiterates the need to understand landscape, arguing the need for “transparency” and “congruency” within landscape architecture to allow for the sustainable-ness of built landscape to act as a guide and impetus toward sustainable behavior. He argued for more sustainable designing of landscapes, and claims that observability is an integral component of ‘real’ sustainable landscapes. The major focus of his book was on the perceived conflict between ‘technology’ and ‘nature’. According to Thayer,

> “Without being able to see into the workings of our own landscapes, we may be unable to make necessary adjustments to changing environmental conditions. The feedback of experience between habitat and organism which guides environmental behavior is a cornerstone of ecology. In transparent landscapes, a visual ecology, where we are able to assess the conditions affecting us and make cogent environmental decisions, is both possible and necessary. Since humans are symbolic animals who interpret the world through abstraction, deduction, and discourse, the feedback we receive from the environment is, of course, laden with symbolic meaning. But positive meanings (and hence constructive action) accrue more steadfastly to things that can be seen and experienced… The first step toward building a sustainable world then is to open up our landscapes to view, such that we may learn from them where we are, how we are doing, and what we need to do to make the world better.” (1994, p. 110-111)

Thayer’s argument for demanding transparency (a component of “sensory legibility”) in sustainable design is essential for understanding the need to find practical methods that introduce sensory legible sustainability. Thayer proposes that infrastructure should be transparent in its sustainability (or lack thereof) to be clearly understood. In doing so, he implicitly gives theoretical basis for the need of sensory legibility in the built environment, acknowledging the lack of transparency (a practical method of sensory legibility) as an inhibitor to the rate of adoption and spread of sustainable design. This is not to say that landscapes cannot be sustainable without transparency or sensory legibility, rather, sensory legibility (which transparency can support) in sustainable design allows people to sense and appreciate how the principles of sustainability are put into action. People can then reproduce these processes either in their own designs (as designers) or in other aspects of life. Thayer thus, helps

legitimize the claim that by achieving sensory legibility within infrastructure, the structure will enable and encourage human behavior of the "experiencer" of such infrastructure that is better for the environment in their daily activities. Others in the field of architecture add support to this notion such as Chris Hellstern, an architect of the Bertschi School Science Wing and author of "Living Building Education: The Evolution of the Bertschi School Science Wing". Hellstern declares, "As the need for a more environmentally friendly way of life becomes essential to sustaining our planet, so does an environmental education that can create a means to achieve it. Architecture should provide an environment that exposes and educates a building's occupants, even at the youngest ages, to environmentally sustainable principles that can be carried and utilized throughout their lives for the betterment of society" (Hellstern, 2014, p. 162). This premise raises the question of what methods do we have to make sustainability in architecture sensory legible, and is there a formal language of sustainability that we can read.

Chapter 3: What is Sensory Legibility?

In "Toward a Psychology of Art", author Rudolf Arnheim states that "art has always been used, and thought of, as a means of interpreting the nature of the world and life to human eyes and ears" (Arnheim, 1966, p. 7). Similarly, if the art of built environments, that is, architecture, has the goal of enabling sustainable systems to be interpreted by humans through their senses, it will require some amount of sensory legibility to succeed. The sensory legibility of sustainability of an object allows for its physical form to have didactic or heuristic capabilities, revealing its sustainable essence and workings in relation to the rest of the world. The illegibility of such forms (sensible or not) obscures sustainable systems from human understanding. In contrast, sensory legible built environments, in terms of their sustainability, lead experiencers to be more educated about the workings and characteristics of sustainable systems within the built environment. Thus, illegibility of ecological sustainability in architecture can be seen as a challenge to the sustainable movement. Other obstacles to sustainability and the tendency to avoid changing to more sustainable methods include economic viability and political feasibility. Political feasibility obstacles are almost always due to policy restrictions on more inventive strategies for site-specific solutions. Economic viability obstacles only sometimes are due to such policy

restrictions, but can be related to other factors, including the lack governmental subsidies and other policy decisions that would otherwise economically incentivize eco-sustainable development.

When referring to the term *architecture* in the phrase **"sensory legibility** in architecture", I mean *architecture* conceived as a thing of physical material—a physical object of built form.[9] When architecture gives enough reference to an idea to make its intended meaning perceptible, the idea is sensory legible through the object. When a thing is fully sensory legible, the object or physical form tells you how it was made and how it works immediately as it is perceived through the bodily senses. Sensory legibility is the key to understanding not only that a development is ecologically sustainable, but also understanding how the ecosystems work and how we should work within them for the benefit of the whole.

Legibility of eco-sustainability can be achieved through both through aesthetically sensible forms or informational codes. The use of monitoring devises with displays of 'written' or lettered messages and diagrammatic pictures are a viable method toward legibility of eco-sustainability in the built environment. These lettered and diagrammatic messages may provide measurements and details about the ecological functioning of various ecological factors, offer directional cues or appeal to cultural values. Yet, legibility methods are less experiential than sensory legibility methods, requiring more prior learning about ecological systems to fully comprehend the ecological impact, and leaving one guessing as to how the impact was accomplished. In this vein, sensory legibility differs from legibility. Sensory legibility does not offer readable information on how much a built environment is ecologically sustainable. It does not display some statistical data or quantifiable measurement to be understood only by the specialist. Instead, sensory legibility gives insight into the systematic processes that achieve ecological sustainability in the built form. Sensory legibility, at its fullest, offers lessons on healthy ecological functioning in ways that

[9] After considering a plethora of different words to replace "sensory legibility", none seemed to be necessary or sufficient for the concept. A list of possible characteristics that can support or lead to the sensory legibility of an object includes, but is not limited to: pellucidity, limpidity, exposability, transparency, visibility, sensibility, observability, perceivablity, noticeability, understandability or comprehensibility, readability, as well as clear, open, prominent, salient, evident, explicit, simple, forthright or straightforward, direct, obvious and elucidative. Possible characteristics of lesser levels of legibility might include that which is capable of being experienced and considered (considerable) and appreciable, distinguishable, discernible, intelligible, and scrutable. In opposition to sensory legibility are characteristics such as: opacity, obscurity, ambiguity, vagueness, hiddenness, disguisedness, concealability, indistinctness, unknowability, illegibility, incommunicability, indiscernibility, as well as esoteric, arcane, secret, ungraspable, abstruse, and recondite.

even a child could pick up simply through sensory experience of the physical form. Such lessons can be easily engineered or reapplied by a child so that he or she can make more eco-sustainable decisions.

Thayer's concept of "congruency" of emotional states, that is, congruency between the emotion that is evoked by the appearance of the physical form and the emotion that should be evoked by the actual benefit from the physical form is an essential byproduct of sustainable architecture that has sensory legibility, not a method of sensory legibility itself. In describing congruency, Thayer says, "The second major point regarding the experience of sustainable landscapes is that once made transparent, sustainable landscapes must ultimately be congruent. In other words, the emotional state provoked by the landscape's surfaces should be congruent with and not contradictory to the manner in which the core properties of the same landscape provide for our functional needs and well-being" (Thayer, 1994, p. 312). While I agree with Thayer, that "a critical purpose of the sustainable landscape is the demonstration and diffusion of environmentally and socially sustaining principles into common usage in the everyday world" (p. 309), I propose that transparency and congruency are only partial to understanding sustainable landscapes, and do not alone bring sufficient understanding. Thayer offers little explanation on what makes technology understandably sustainable through the senses beyond its perceived positive status as *sustainable* through visible appearance (provided the emotional response induced is congruent with the real sustainable value it has). Yet, it is still possible for the technological workings to be actually sustainable even if they lack congruency. Moreover, when lacking other aspects of sensory legibility, being able to see the technological workings (the quality of transparency) does not automatically mean that the technology is understandable. Beyond transparency and congruency, I will expand upon Thayer's theory in order to shed light on the concepts of 'technology' and 'nature' and all that contributes to making sustainable technology understandable and inspirational (i.e., in a culturally-transformative way that demands responsive action). Because Thayer's makes little direct reference to the built environment outside of designed landscapes (i.e., "the outdoors"), my research seeks to apply his principles of 'congruency' and 'transparency' into a broader understanding of sensory legibility, and more specifically in architecture projects with each's immediate surrounding context as it relates to each architectural project.

While Thayer proposes that by simply increasing the transparency of landscapes, cultural transformation will move towards a greater appeal for ecological function since truly sustainable ecosystems evoke positive associations and emotional responses, a year later, Joan Iverson Nassauer, author of, “Messy Ecosystems, Orderly Frames”, asserts the very opposite—that ecological function, simply revealed as is, looks messy, which will be a turn off to many cultures. To illustrate, she explains, “the dominant culture in much of North America reads neat, orderly landscape as a sign of neighborliness, hard work, and pride. Typically, people want to achieve or know they are expected to achieve this landscape appearance and all that it signifies about themselves. At the same time, a neat, orderly landscape seldom enhances the ecological function of the landscape” (Nassauer, 1995, p. 198). Landscape appearances that do not aesthetically please the viewer (and do not align with culturally-dependent characterizations of beautiful) tend to distract the observer from recognizing the actual workings and true ecological value of a landscape. Thus, according to Nassauer, the design of sustainable ecological function in a landscape should address the surrounding cultural expectations. The “unfamiliar and frequently undesirable forms” of sustainable ecological patterns must be placed “inside familiar, attractive packages” (p. 197). Thus, to make the ecological functioning of a sustainable built environment sensory legible, the design must also be cultural-framed (which in urban America means orderly-framed) so that it can be communicative of a formal language that the culture recognizes as their own, accepts as ecologically sustainable and aesthetically appreciates. This formal language she calls “cues for care” (of the landscape), and it includes things like “flowering plants and trees”, “wildlife feeders and houses”, painted fences, “window boxes or shutters”, “bold patterns”, and unobstructed windows and doorways (p. 204).

In searching for relationships that represent sustainability in projects in America, one must consider the following: idea-associations to forms that are common to all humankind, the relationships between forms and concepts typical yet peculiar to the nation-wide (or Western Culture), and most importantly, the relationships imbedded in the subcultural context of any particular location. An example of an association that is held nation-wide is the meanings derived from the specific colors of a traffic light, which are each interpreted as having an expressive value that demands specific response: to either stop

movement, start movement, or yield to certain movements of others. To foreigners that are unaccustomed to traffic lights, the intended social meanings of the physiognomic form and colors of a traffic light will be ambiguous (Colquhoun, 1969, p. 48). Therefore, when discussing a particular built environment, the cultural context will be a key factor to determining the sensory legibility of sustainability within the architecture. While the traffic light is culturally significant in a utilitarian sense, cultural cues play an even greater role in expressing "the highest values and aspirations of American culture" (Howett, 1987, p. 4-12). Some of the highest values of America include: patriotism, progressiveness, independency, efficiency, order, equality, liberty, justice, bravery, strength, purity, fertility, life, playfulness, sacredness, dignity, freshness, victory, grandeur and prudence. All of these values may factor into what someone might call beautiful and can be signified aesthetically in the built environment to trigger a pleasing or positive reaction from the experiencer.

Thayer's "Grey World, Green Heart" and Nassauer's "Messy Ecosystems, Orderly Frames" stimulated further thought on the question of legibility of ecosystematic function in built form, such as in Gary Strang's 1996 article, "*Infrastructure as Landscape; Landscape as Infrastructure*", which speaks of the need to reunite infrastructure and landscape by having technological forms that act like "nature" and mimic "natural" processes. He also argues for integrating the educational and professional disciplines to meet the unrealized potential of our buildings and landscapes to perform multiple functions that allow people to relate and interact with them in numerous ways. Many of Strang's multi-functional approaches might be considered radical and provocative, such as his promotion that "the reconstruction of urban drainage systems, for example, can provide networks of open space shared by people and working biological systems" (Strang, 1996, p. 14). In comparing pre-industrial designed landscapes with those of contemporary American cities, Strang asserts, "These landscapes allowed the workings of nature to be revealed in the urban setting. The technology of a pre-industrial urban fountain maintained, by necessity, a legible connection to a watershed. At a tiny village in Peru, a manmade fountain was the ordering system for the town…the logic of the watershed was evident within the context of the city. In contemporary American cities, the hydrology of the place has been largely ignored. Drainage systems have been put underground unnecessarily or channelized with concrete, erasing the visual and spatial

logic of the region" (p. 13). He speaks of the need for modern infrastructural technology that is made legible through tangibility—being physically present and interactively accessible, visible and comprehensible in a way that allows people to understand its function. Not only are drainage systems hidden, but also is the once visual link between human survival and the stewardship of "natural" processes. The disappearance of this sensible link bars us from a vital method of learning how "to intervene in a way that facilitates, rather than disrupts, natural processes" (p.15). Strang's solution to reestablishing this sensible link is to specifically make "legible in the landscape" the "significant sources, paths, and transition points of our collectively owned resources" through landmarks (that are either the structure and its processes themselves or are representative of them) (p. 13). He calls for the conversion of all urban utilities (including all the centralized networks of advanced high density developments such as: sewage, steam, and water pipes; electricity and telecommunication lines; oil and natural gas lines) into urban amenities, values which Karen Bell defines as "that which maintain or enhance those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes" (Bell, 2000, p.16). Beyond visibility, this incorporation of technological systems in urban design as a prominent aesthetic feature has possible ergonomic applications to one's daily activities allowing technological infrastructure to become tangible in a multi-functional or multi-purposeful way. This theoretical work further establishes an understanding of sensory legibility, bringing to light the significance of legibility in pre-industrialized structures, and proposing the legible characteristics that should continue or be reestablished in modern infrastructure if already gone. Strang points to the implementation of "nature" and "natural processes" in infrastructure as the solution to reconnecting people to the ecosphere (i.e., to bring back urban society's realization and comprehension of the underlying order of the earth as ecologically functioning system). However, before offering an evaluative framework that incorporates all these mechanisms for making ecological sustainability in architecture sensory legible, I must first clarify what is meant by "nature" and "natural"—common terminology used in the field of architecture to describe processes that are eco-sustainable.

Chapter 4: Humans as Natural and of Nature:

Redefining *Human*, *Nature*, and *Human Application*

The theme of the 2000 World's Fair in the city of Hannover, Germany was "Humanity, Nature, and Technology". The theme, aptly chosen, aimed to address the difficult issues for a sustainable future—holding that "ideally, humanity will redefine itself, its placement in nature, and refine the role of technology within the environment" (McDonough & Braungart, 1992, p. 3). This redefining, is still at its beginnings in both an ideological as well as a practical sense. In popular literature, there is evidence of a conflicting understanding of humans in relation to 'nature', reflective of a transition period that mainstream culture and politics is currently undergoing. From an ideological standpoint, redefining humankind in relation to 'nature' in academic discourse is incredibly difficult because of the entrenched false dichotomy of humankind and nature—presuming that they coexist and interact in support of or against each other, but are, at a fundamental level, separate essences. This false dichotomy is maintained by statements like: "it occurs naturally in the environment, but also enters the environment through human application". Such a use of the term *naturally* in opposition to *human application* in the former statement is indicative of the idea that human applications are in some way 'unnatural'. Yet, we are nature, or at least a part of it.

Given these considerations of nature, humanity and human applications, and their theoretical importance to the issues of eco-sustainability in architecture that presents itself in this thesis, I will use the next section to offer and explain my working definition of the term *nature* and the related concepts of *natural* and *unnatural*. This treatment of what is admittedly a very slippery philosophical subject is nonetheless necessary for a full understanding of my treatment of the very practical topics with which this thesis is ultimately concerned. One's philosophical views inform one's practical outlook, and the meanings of *sustainability* and *nature* and their practical applications are no exception. In the process of revealing the ontological relationship between humans, human application, and nature, I will directly link eco-sustainable architecture with its ecological values to the built environment's functions that have the life-like characteristics of 'nature'. The valuing of life-like characteristics, as I will show, is something inherent to both ecological and aesthetic values. Bridging aesthetics with ecology is not novel. Indeed, my theory appropriates certain insights from other theories. At the same time, my theory is also a product of my own logical analysis. The result is a holistically new approach, which debunks disillusions about

nature often incorporated in theories, and works to show an inherent connection between the perception of living systems, ecological sustainability and aesthetic beauty. Once I have given justification for a particular linking of nature and ecological sustainability, I will bring the discussion back to how sensory legibility operates within sustainable architecture.

Debunking the Un-natural of the 'Unnatural'

Attributing our unsustainable and long term-ineffective predicament in part to our lack of understanding of the human-nature relationship, Michael Pollan, author of, "Second Nature: A Gardener's Education", writes,

> "The habit of bluntly opposing nature and culture has gotten us into trouble, and we won't work ourselves free of this trouble until we have developed a more complicated and supple sense of how we fit into nature. I do not know what that sense might be… Even once we have recognized the falseness of the dichotomy between nature and culture, it is hard to break its hold on our minds and our language; look how often I fall back on its terms. Our alienation from nature runs deep. Yet even to speak in terms of a compromise between nature and culture is not quite right either, since it implies a distance between the two—implies that we are not a part of nature. So many of our metaphors depend on this rift, on a too-easy of what is nature and what is 'a color of the spirit'" (Pollan, 1991, p., 96-97).

The conceptual dangers of the terminology we use to describe humanity, culture and nature are twofold: one, the terminology often belies the message we mean to convey, propagating ideas that are inaccurate, and two, it is often revealing of a lack of understanding on the part of the speaker. The most popular internet search engine in the world, Google, defines *natural* as "existing in or caused by nature; not made or caused by humankind." Google defines *nature* as: "the phenomena of the physical world collectively, including plants, animals, the landscape, and other features and products of the earth, as opposed to humans or human creations". These definitions of *natural* and *nature*, simultaneously include and exclude humans from the natural. To explain, if humans, through reproduction, are created by humans, then the second claim that *natural* means "not made or caused by humankind" excludes humans from the natural; however, the initial statement to define *natural* includes humans as natural since

humans physically exist in nature. The claim that *natural* means "caused by nature" is just as problematic: humans cause humans, yet humans are both phenomena of the physical world and animals, and are products of the physical world and animals (other humans). From the standpoint of macroevolution, that is, if a human was caused/reproduced by physical phenomena other than humans, then the definition is even more fraught with difficulty,

In academia, the general public, and the media, the current conceptualization of *nature* is corrupt, poor, lacking, insufficient or inconsistent, at best. The possibly less problematic definition of *natural* that I propose is: to be of or a part of nature. This would imply *unnatural* to mean: outside of, apart from, or separate from nature; not of nature and not a part of nature. The working definition for *nature* I offer is: all that physically exists as actual or potential subject matter for scientific observation and theory. Other similar and equally viable definitions would include Gary Snyder's view of nature as the "physical universe and all its properties" (Snyder, 2004, p. 3). Accordingly, an object of nature is defined as: a thing that has physical existence, consisting of physical substance (i.e., matter and energy, which are scientifically one-in-the-same). Contrary to much of the rhetoric and ideologies of previous theorists in design, I must insist that there is no way of designing built form without nature. Nature is both necessary and inescapable in all that we are and do. Designers must both use nature and be natural in order to construe or conceive of form, and must both use nature and be natural in order to bring such a construal in the imagination to life in the real world. Much in accord with this conception of *design* and *nature* is John T. Lyle's definition for *design*, meaning "giving form to physical phenomena" (Lyle, 1991). Many theorists like Lyle admit to the contradictions in ideas related to humans and nature, and many offer their own definitions for *nature*, but throughout their writing, it becomes clear that their thinking is still inconsistent or incomplete on the understanding of 'nature' and what is 'natural'. All human involvement has no choice but to include nature and be natural. Ann Whiston Spirn, in her book "The Granite Garden: Urban Nature and Human Design", attempts to set the record straight. She says that "The city is neither wholly natural nor wholly contrived. It is not "unnatural" but, rather, a transformation of "wild" nature by humankind to serve its own needs…" (Spirn, 1984). While she contends that the city is not antithetical to nature, she still holds that the city is not "wholly natural". Yet, as I will argue, even the cultural aspects are entirely natural (simply representing

the upper-level property of nature in the system of supervenience). Yes, the city is contrived in part by humans, but it is also still entirely and wholly natural, since everything that humans do and contrive is natural. Furthermore, even if all living things died out, nature would still continue to exist. Although nature would no longer be perceived, all would still be natural. For nature to end, everything would have to become nothing—all that physically "is" would have to go away and stop existing. That would be "non-natural" because it would be lacking any nature (anything physical), and it would be "unnatural" because to bring itself to absolute nothingness is out of the capabilities of nature.

The Commonly Called *Natural* and *Unnatural*

Intrinsic to my understanding of how the term *natural* is used in everyday language, is the idea of 'ease'. Consider when we refer to a room being ventilated 'naturally'. We might be simply talking about opening up the windows and letting the currents of air flow through the room and move the air inside (the 'stale' air) to flow out of the room. Such a room, one might explain as consisting of: seemingly static objects (or groups of objects) which compose the parts of the whole room, and constrict or promote the circulation of air and dissipation of heat from one place to the next (even our bodies). These seemingly static objects act as sensible links to experiencers of the process. This formal and material composition of seeming static objects usually consists of the walls, apertures, floors, roofing, which all interact with these energy flows—energy invisible to the naked eye. If the process occurs 'naturally' (in accordance with how the term is commonly used), then there is no recruitment of extra energy from a **'nonrenewable'** (or rather highly-limited) fossil fuel used to create or run an auxiliary mechanical system attached to the room with the specific function of heating and cooling a building.[10] Moreover, the built form has a formal structure whose traits lend themselves to efficacy of a function and ease of the function toward a desirable goal. In this case, the function is ventilation of air in a place of human inhabitance at a rate, quality and temperature comfortable and **healthy** for humans.[11] Daylighting, ventilation, cooling and

[10] Fossil fuels, i.e., oil, coal, and natural gas are not actually nonrenewable, they are just expended at a rate exceptionally faster than they are accumulated/produced.

[11] Health is "a state of complete physical, mental, and social well-being and not merely the absence of infirmity" (World Health Organization, 1948).

heating are common functions of buildings (as well as water drainage, treatment and irrigation with and for on-site vegetation) that may or may not be carried out in a “natural” or passive way.

When done ‘naturally’, the dynamics of wind currents are able to run themselves autonomically through the building as their own power source, and the building materials and form (primarily the building envelope) only facilitate and direct the flow of air towards the benefit of the human inhabitance. The major difference between the room with an HVAC system and the room that has ‘natural ventilation’ is that the former regulates a room, while the ‘naturally’ ventilated room regulates itself. The idea of function and regulation are synonymous with the processes of nature. The more ‘natural’ the entity is toward a certain function, the more its design is efficiently equipped to easily and sufficiently carry out the intended dynamic processes. An organism’s physiology will dictate to what degree that organism can or cannot do a particular task and how easily it can be done. In this vein, it is well to consider briefly the *natural* as that which might be innate or have a propensity to behave a particular way, as this helps to flesh out the idea of ‘ease’ that I have identified as central to my understanding of what is often referred to as ‘natural’.

<u>The Natural as: What Is Innate or a Propensity</u>

Innate is defined as: inborn or natural. Synonyms for *innate* can include ‘in the blood’, hereditary or ‘in the DNA’, unlearned, instinctive, native, existing in one from birth and deep-rooted. The definition of *innate* suggests that in as much as a person’s genetic code allows for the possibility of a person, at some point to act in a certain way, any certain behavior in the repertoire of possibilities would be natural. Under this classification of *natural*, there is nothing a human can do that is actually unnatural (with the exception of learning it, but even the ability to learn is innate as well). If humans could do unnatural (or un-innate) things—acting outside of the natural, then it would have to be something impossibly done such as grow wings like a bird on one’s own without the genetic code to allow one to do so. Even genetic mutations are innate. Something that is innate, in turn, is predisposed to being or doing some things, but not other things. Fittingly, *natural* is also commonly referred to as being predisposed or having propensity. Related to *easily* is the term, *propensity*, which is defined as “an inclination or natural tendency to behave in a particular way”. Propensity is quantifiable—such that one entity might have greater propensity for a certain task than another. We see entities of nature doing certain actions so easily, as if they were made

or designed so well as to be inclined, prone, or predisposed to do what they are doing. Thus, *easily* and *propensely* are intrafamilial terms to describe an action that is innate to a thing.

In light of these considerations, one might ask why we call ourselves and the things that we do *unnatural*, and the substances we transform *unnatural*. Since every material substance including ourselves is of and from nature, it is possible that what we really mean to say is that there is some thing or things that we do, which are completely natural, but more particularly, innately propense for humans, while not for any other **species**.[12] In other words, the things we do that are uniquely human and not in the repertoire of possible behaviors and doings of another species. Thus, the more pertinent question for determining what is so often called *nature* or *natural processes* might be phrased: While maintaining our existence as of and a part of the rest of nature, in distinguishing ourselves from all other species, what, if anything, is the illusive differentiation? The reason that other species are relevant to this topic is that other species, like ourselves, build their environments or landscapes, either passively (simply through existence) or by active cooperation (instinctive methods of survival). Consequently, any discussion about whether a human built environment or man-made landscape is natural or unnatural will involve fundamental assumptions that are best assessed by comparison to other species and the building of their environments. As I will also show, such a comparison has certain implications for how humanity and technology (including that of the built environment) relate to sustainability of the ecosystems of the earth.

Chapter 5: What is Uniquely Human?

Characteristics of Humans Versus All Other Species

The characteristics of humans that no other species have are not as simple to identify as one might first think. There are many characteristics that are falsely assumed to be solely a human quality (e.g., the ability to domesticate). There are also many qualities of other species, which people falsely assume that humankind lacks. Examples of these abound and are beyond the scope of this thesis. In any event, characteristics that appear more, if not completely unique to humans from other species

[12] By species, I mean the species of all living beings classified in the five scientific kingdoms: Animalia, plantae, fungi, protista, and monera)

include: being capable of civilization, or cultural; having complex learning mechanisms and a sense of morality; and the ability to produce or create things that are industrial or technologically-advanced. Being cultural is often referred to as exclusive to humankind. Definitions for culture vary, but it is often insisted that *culture* is by definition only a human societal manifestation. An uncontroversial illustration of culture, as a human capacity, is the sense of neglect people of American communities perceive when a neighbor in an urban area lets the turf grass in his or her front lawn grow ‘too long’ before mowing (as oppose to people of tribes in an Amazonian rainforest who are more likely to view cutting turf grass as a ridiculous waste of time). However, if we disregard ‘human-capacity’ as integral to the very definition of the word, *culture*, we might arrive at a definition that includes the capabilities of humans as well as of other species. Thayer claims in his book “Grey World, Green Heart” that, “Culture is nothing more than a system of commonly held beliefs, symbols, and behaviors” (Thayer, 1994, p. 105). A more inclusive definition of *culture* I offer is: symbolic communication and behavior imitation that passes on through customs from generation to generation, the specific expressions of which vary among the groups and subgroups that comprise a species. My definition of culture would exclude animals like certain insects that have rudimentary neural networks, such that they have very limited cognitive awareness of their environment and their behaviors are merely reflexive. This is not necessarily the case with higher level animals (animals with more complex neural networks). Much recent scientific research advances the notion that culture has a place not only in human communities, but also in other primate groups as well as cetacean groups—both having demonstrated the passing on customs from generation to generation and from one group to the next through interaction. The culture of these other species is however, less cumulative than the culture of a human civilization.

Humans also have complex brain mechanisms (a by-product of having an extensive number of neurons and neural connections). Without going into too much detail about these brain mechanisms, learning mechanisms that may or may not be uniquely human include: self-organizing or unsupervised learning, supervised learning, and temporal difference learning. A list of the intellectual mechanisms of many higher-level animals may include: abstraction, generalization, sequence pattern recognition, and associative memory. For example, positive reinforcement learning has been proven in dogs taught

through the classical conditioning experiment commonly referred to as "Pavlov's Dog". Research and scientific evidence on the associative memory of cockroaches demonstrates that even roaches can learn to run a maze (Lent and Hyung-Wook, 2004, p. 369). These are all characteristics that have been falsely assumed to be unique to humans in the past. On the other hand, humans have a higher "will power" than most if not all animals. Simply put, this will power is exemplified when the goals that originate from the cerebral cortex override goals of the lower back portion of the brain. Goals of the lower back portion of the human brain, like survival instincts (the drive for food, shelter, and sex), are also common goals of less complex organisms. Thus, although the human brain may not be alone in complex learning, the programming of the human brain is such that nothing has been proven to be more cognitively sophisticated (reflecting the many ways in which a human can learn and the level of intelligence).

Perhaps dependent upon the capacity of 'higher' goals to override 'lower' goals of the mind is the capacity to have a sense of morality in humans. Morality, is related to capacities such as the ability to control emotions or at least reactions to emotions, to feel guilt, and to have awareness of other minds. Morality as a social mechanism, acts as an enforcer and trainer of what should and should not be said, thought, felt, or done. This enforcement and training is carried out through perceived punishments and rewards that express acceptance or rejection in a group, which can vary heavily between cultural backgrounds. Dogs seem to express an understanding of when they have done 'wrong' (i.e., 'wrong' according to their human owners or those a part of their pack). Appearing to feel 'guilt', dogs are trained through their human's expressions of rejection towards 'bad' behavior. Levels of empathy and altruism, also related to moral behavior, have been exhibited in rats who choose to free a fellow trapped rat over obtaining food (Keim, 2015). While dogs, rats and other animals may have a construct of morality (depending on how morality is defined), humans still seem to possess a more well-developed sense of morality, which may be related to their level of cultural training.

Edward Wilson, in his 1984 book, "Biophilia", unpacks the workings of humankind a little further to reveal a special technique peculiar to humans:

> "It is often said that Homo sapiens [humankind] is the one species that can live anywhere—on top of ice floes, inside caves, under the sea, in space anywhere—but this is just a half truth. People

> must jigger their environment constantly in order to keep it within a narrow range of atmospheric conditions. And once they have managed to rise above the level of subsistence, they invest large amounts of time to improve the appearance of their immediate surroundings. Their aim is to make the habitat more 'livable' according to what are usually called aesthetic criteria" (Wilson, 1984, p. 108).

Wilson hits upon the one true difference between humankind and any other species. The difference is that while species, such as the ant, can biologically adapt to one's habitat, the human also adapts one's habitat to one's biology. Perhaps due to our higher level of intelligence, humans are the greatest engineers of the environment on a macroscale. Most species can make small changes to each's environment on a microscale, and some can travel far distances if the environment/habitat within the expanse is similar on a seasonal basis, yet have little choice but to be and do what is well-suited to the locale they are born into, as they already are and do if they were born into it. Humans are uniquely able to mold the planet in a way that expands their 'ideal' habitat (dramatically transforming the environmental qualities of habitats) to suit their own purposes.

In addition to being extravagant manipulators of the ecosystem, humans have the ability to reside in places that do not suit their physiology. According to Wilson, "Following inborn rules of behavior, animals turn to the special routes and crannies for which the remainder of their anatomy and physiology is particularly well suited…So precise is the habitat selection by many animals that closely related species can often be told apart more quickly by where they are found than by any obvious physical trait" (p. 107). Given that all species, besides humans, are largely confined to habitats which have the ecological qualities like the one to which they were born in (an area that is suitable for their living), it is entirely extraordinary that humans have become increasingly able to travel areas that are not ecologically-fitting for survival in terms of their biology alone. For example, unless someone puts another species in a space suit (human-made), people are the only ones known to have managed to move so far out of their homegrown habitat that they can be found on the moon (beyond our home's thermosphere) on occasion (however rare). Given the two most obvious differences between humans and the rest of the living species has to do with their ability to transform their habitats, it is likely that the buzzwords *nature* and

natural are most clearly identified by their product—products lacking human-modification, as opposed to the products that are humanly-modified.

Chapter 6: Human Products versus The Products of All Other Species

Artificial and Synthetic Products, and Artefactual Landscapes

Common terminology used that accurately describes human-made things and solely human processes as within and a part of the natural world, yet differentiates these things and processes from things that other living things create, is difficult if not impossible to find. The description would have to surpass terms that are, by definition, representative of the *unnatural*. Such encompassing descriptions of human products and built environments and landscapes that have been heavily shaped by the work of the human tools include: *synthetic*, *artificial* and *artefactual*. All these terms would be more correctly identified as simply: the products and built environments of humans as opposed to that of any other species, yet also natural. The products people call *artificial* or *synthetic* are objects made out of the natural (physical) substances and with entirely natural processes. These terms have been defined by humans imbued with the idea that when we mold something with our own hands or mechanized tools, we take that something outside of nature and into something that is not nature. The idea that humans and their doings are separate from nature has now seeped into almost every related term and corresponding definition.

Industrial. Mechanical, Manufactured, Technological and Engineered

Unlike terms that define human products and production processes as unnatural, are terms like *industrial*, *mechanical*, and *manufactured*, which are either descriptions applied to human-modified products as well as the products of many other species, or their general definitions are entirely applicable to all species, despite their typical use in relation to human products. For example, beavers, in their dam-making, are commonly described as highly-industrialized, and the webs of spiders fit the definition of *mechanical*: being operated or produced by a mechanism or machine. Whereas a machine is defined as: an apparatus consisting of interrelated parts with separate functions, used in the performance of some kind of work. For the spider to accomplish the task of catching prey for food, they use their web

mechanically or as a machine, by definition. Nonetheless, our mechanisms are different from the spider, and our industrialization is different from the beaver. To manufacture, is to produce or make something, and in this way, all species are manufacturers. On the other hand, perhaps the root of the word, ***man****ufacturer*, in itself, denotes the products of man, whether hand-made, or made by highly-industrialized machines.

The term, *technology* and its equivalents have been understood (as a social construct) differently over the years. Although often imbued with the idea of the "unnatural", *technology*, or at least *high-tech* and *technologically-advanced* are words that are typically reserved for solely human products. *Low-tech* is a description for tools of animals both, human and nonhuman alike. The term *technology*, especially *high-tech*, is the common term that appears most suffice for this discussion to signify (natural) human-marketed and human-manufactured production in contrast to the production of nonhuman species. Supporting the use of this term is its similar use by other authors whose writings are sourced in this paper, such as Thayer, McDonough and Braungart. Both the terms *engineered* and *technological* are perhaps most distinctly used for humans-contrived products, but whether there is a word for the human product that is solely for humans and not imbued with the idea of *unnatural* is largely debatable. What is more significant to understanding the relationship between humans and the rest of nature is what the differences are between technology (i.e., the ***man***ufactured products and ***man***ufacturing processes of humans) from the products and processes of all other species.

Characteristics of Human Production Versus Non-Human Modified Production

In addition to the differences in the biological makeup and abilities of humankind from all other living-kind, are the differences in the products they significantly modify by their uniquely-human production processes/practices. Concomitant to the drastic changes that have happened in many habitats since their first human inhabitance, is an ongoing evolution in the way in which we change habitats. This evolution is marked by both changes in the daily activities of human life, and the products we produce. The lifestyle evolution has gone from the nomadic lifestyles of hunter/gatherer groups, to the lifestyle of agrarian communities with permanent settlements, to the lifestyles of people in cities with agricultural outskirts (including job specialization and increased trade), to the lifestyles of people residing in either

suburbs, agricultural outskirts or cities (which included an increase in travel, in trade over distances, and in the expansion of the area covered by permanent settlements across the land per person).

As I stated previously in Chapter 4, an organism's physiology will dictate to what degree that organism can or cannot do a particular task. This statement should be qualified, as many living beings have the ability to use other organisms or objects and processes apart from themselves (their bodies) to help them accomplish tasks that cannot be accomplished with the organism's sole physiology. In like fashion, humans use tools to do what they cannot do with their bodies alone. Humans have products produced by the human body, products (and by-products) which are produced by tools, and tools produced by tools. It is our high-tech tools (tools produced by tools) that allow us to adapt our surroundings to our own biology on a macroscale.

Clearly, human beings have created mechanisms that perform far beyond their own biological capacities, such as those involving fossil fuel energy, automatic controls and computerized systems. Moreover, many human goods/products never even touch the hand of a craftsmen from input to output (unlike the low-tech tools created by other species). One might even claim that this makes human products unnatural. Our control of the landscape is indeed, far beyond simple human biological function alone. Even if one considers these technological replacements of the freehand tool to be another part of the complex capacities of a human, one must still admit to the magnitude these capacities have reached in comparison to the capacities of our bodily tools (hands, feet, mouth, etc.). Humans have the help of high-tech tools that have mechanisms far greater in accuracy, precision, efficiency, force, and overall productivity than the capacity of a human body, or even many human bodies. Yet, the capacity for producing and controlling high-tech machinery is however, not unnatural (that is, outside of or apart from nature), and thus, neither is the product which is created through this capacity correctly identified as "unnatural". The capacity to develop a high level of mechanization, the ability to use an expansive variety of material resources of the earth, and the ability to produce/modify/manufacture/engineer products with unique qualities (the qualities peculiar to the technologically-advanced or simply the characteristic of being technologically-advanced) are a few innate differences between human and all other species. Nonetheless, these peculiar capacities still do not characterize why we identify the need for more of what

is called ‘nature,’ ‘natural products’ and ‘natural processes’ as opposed to human-modified product which is either directly or implicitly labeled ‘unnatural’.

A Monotony of Habitat: Form, Material and Maker

Assuming that nature has neither died, nor is it being replaced by something unnatural, the death, itself, in the “*death* of nature”, as proposed by many theorists and historians, is perhaps better framed as the predominate characteristic of nature (or more specifically, the earth and all the physical things that are bodily sensed upon its surface), as opposed to nature actually lost or dead. As the predominant trend of the earth has been to become more and more dominated by humans and that which is human-modified, the description of the planet as becoming less and less “natural” has correlated with its description as becoming less and less ‘organic’ and ‘alive’. Thus, ‘organic’ or ‘alive’ may then be the key distinction between human-modified (or extensively human-modified) habitats from habitats built either primarily of totally through the cooperation of the many non-human species.

To be sure, the popular notions will likely identify the term, *inorganic,* with the more convoluted and paradoxical term, *unnatural*. Nonetheless, juxtaposing and contrasting the ‘organic’ with the ‘inorganic’ may reveal a pertinent message of the uniqueness behind humanly-modified products. In design, we speak of organic forms and organic shapes versus shapes and forms that are inorganic. Organic forms classify objects or built environments which are described as looking as though they were taken straight from ‘nature’ with neither straight lines nor perfect shapes. Instead, organic forms are complex in shape or figuration (uneasily discernible in pattern), as well as ephemeral (i.e., transitory and innately subject to flux), unified in pattern (harmonious in part-to-whole relationships and coherent in various details) and rich in aesthetic detail. The focus of richness of detail in organic design is often referred to in only the visual sense, such as the visible structural and spatial pattern, color, reflectivity, and visible surface texture. Richness as a matter diversity, complexity, and novelty of the physical properties in the built environment can also be detectible by other senses such as taste, scent, sound, and tactility (e.g., malleability, solidity or viscosity, density, pressure, temperature, and other texture qualities such as roughness). Inorganic forms look as though they were made by man-made machines, dominated by precise straight edges, orthogonal shapes, simple patterns and less aesthetic detail (e.g.,

having a limited spectra). Inorganic form, in relative comparison to organic form, is interminable or constant and unchanging. Organic built environments may stereotypically have great immensity or enormity (such as in the case of "Sublime" environments) and require a wide-range of kinaesthetic senses to move through, but these characteristics are also commonly found in inorganic built environments. Further research related to the visual complexity of the organic versus the inorganic can be found in the observation of a scene's fractal characteristics (which are primarily determined by measuring qualities of a scene's silhouette). Discussing the aesthetic preference for places that are popularly called 'natural', Simon Bell, in his book "The Aesthetics of Landscape", discusses current research on the fractal dimension (D-value), relaying the findings that there is a shared D-value typical of many landscapes that are considered 'natural', or more accurately described as showing little evidence of human-alteration, such as scenes of mountain ranges and coastlines (Bell, 2012, pp. 91-92). Such research indicates that scenes of places that have significant evidence of human-modification have varying D-Values, but those that have the same D-value of mountain ranges and coastlines are preferred over ones that do not.

In the construction of the built environment/landscape, organic versus inorganic applies to the certain kinds of materials used to compose the building. Organically built environments refer to structures made up of either mostly living or recently living material/tissue (being genotypic and phenotypic of that which is still alive or recently alive and functioning as so) and/or rock (which is often composed of primarily chemically inorganic material). The organically built environment is thus, made up of minimally human-modified materials like: rocks (as commonly found from the earth's crust), water, soil, plants (including trees) and other organisms or body parts of dead organisms. Inorganically built landscapes are distinguished as that which is made up of all or predominantly nonliving (and not recently living) material. Constructed by all or mostly heavily human-modified products, materials of the inorganically built environment including: metals, plastics, asphalt, concrete, and other heavily human-altered products (by high-tech tools) composed of any of the materials previously listed of organic built environments.

Other species work together in the same habitat to make and remake organic building materials. In contrast, in cities of Western Culture, people tend to be isolated from other species by their marketed products and prefer to keep their marketed products isolated from and invincible to all living things (with

the exception of a few select domesticated and highly restrained plants and animals). In as much as is in human control, their marketed products, at least those that compose their urban built environments, are designed/constructed as absent of all living things. In trying to isolate human residences (places where humans live, work and play) from the habitats of all other species, city habitats have become as monoculture as their makers, that is, one of a kind (or of one species). The majority of people in the Western World have managed to spend most of their lives in buildings that are designed to be unchanging, un-evolving, inorganic and inanimate as possible. Similarly, even in “the outdoors” of farmland, where contemporary commercial agriculture techniques are practiced, all but the particular species that the landowners are harvesting to sell for economic profit is wiped out. Thus, both urban and rural areas are becoming less and less sensibly organic, in exchange for increasing monotony.

As a concept firmly tied to the perceptual experience of our surroundings, the organic aesthetics of form or shape and material-makeup may be the two main qualifiable components we use to label our surroundings as either ‘natural landscape’ or ‘the outdoors’ or as ‘buildings’ and ‘cityscape’ (a.k.a., ‘commercial landscape’, ‘urban landscape’, ‘artefactual landscape’ or ‘industrial landscape’). Commercial landscapes are classified as having been almost entirely shaped by aesthetically simplified and nonliving components (at least within the narrow scale at which humans can experientially engage). Alternatively, the ‘natural landscape’ is a descriptive term reserved usually for habitats that are either developed by or seem to be developed by only non-human production processes and entities of the earth. These nonhuman inhabitances are predominantly shaped by the *organic* (i.e., the alive, complexly shaped, and rich in detail). Such descriptive terms like *commercial landscapes* are, of course, stereotyped and not without some variance and overlap. Overlap is quite common with the term, *the outdoors*, which might include differing amounts of organic and inorganic depending on the perceiver and the circumstance. Nonetheless, the discriminations between ‘organic’ and ‘inorganic’ within the design and construction of the built environment are clearly associated with both a particular state of being (dead, alive, or nonliving) as well as particular aesthetic characteristics (simple, complex, diverse, monotonous, etc.). The dual-association of aesthetics and states of being as the distinguishing factors between ‘organic’ and

‘inorganic’, and the general aesthetic preference for the ‘organic’ is a theme that relates to a concept of recent origin that is especially well-suited for advancing this discussion: ***biophilia***.[13]

The theory of biophilia when applied to design is indicative of a universal aesthetic preference in the environment, toward ‘life’ (as a state and act of being; having particular structure and incorporating particular processes). In other words, life is that which makes an object or entity more aesthetically attractive. Although originally coined by Eric Fromm in 1964, the more widely-known reference to ‘biophilia’ is in the 1984 book, “Biophilia” by Edward Wilson. Wilson defines *biophilia* as “the innate tendency to focus on life or life-like processes” (Biophilia, 1984, p. 1). According to Wilson, life and life-like processes are the most significant features that we are attracted to in our surroundings. Wilson’s understanding of an aesthetic preference for life and life-like processes appears synonymous to what is referred to in design discourse as ‘organic’ and ‘natural’. The perceptual factors that lead us to prefer the ‘organic’ over the ‘inorganic’ and the qualitative factors for distinguishing ‘natural’ from ‘unnatural’ seem to align perfectly with the stereotypical characteristics of life versus non-life. Thus, our delineation of products we problematically call “natural” as opposed to those which are called “unnatural” or “human-made”, might be better articulated and can be reasonably attributed to the characteristics of all life and life-like processes in contrast to characteristics of that which is nonliving.

Acknowledgement that there is an aesthetic preference for life over nonlife, leads one to question what it is about life that is so attractive. We do not always consciously recognize the factors that go into preference and are common to all life and life-like processes we experience. Offering some qualitative details to *life* (some of which were previously discussed as a part of the organic), Wilson assesses,

> “From infancy we concentrate happily on ourselves and other organisms. We learn to distinguish life from the inanimate and move toward it like moths to a porch light. <u>Novelty</u> and <u>diversity</u> are

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[13] *Biophilia*, a term that mainstream culture has yet to become accustomed to, has popped up in many areas of my research—mentioned by McDonough and Braungart in “Cradle to Cradle” (2002), in Robert Thayer’s “Grey World, Green Heart” (1994), Simon Bell in his 2012 book, “Landscape: Pattern, Perception and Process”, by Bill McKibben, author of “Hope, Human and Wild” (1995), and the Living Building Challenge books (2014 and 2016) about the buildings that I have chosen for my illustrations of sensory legibility criteria. Erich Fromm, first coined the term, *biophilia* in his 1964 book, “The Heart of Man”, in which he deliberates also on the essence of humankind (that which is only characteristic of humans as opposed to all other species). Fromm claims the difference that makes a human standalone from all other species is the ability to have self-awareness (Fromm, 1964, p. 117). Today, much scientific research makes evident that some other animals do, in fact, have the capacity for self-awareness. However, humans have a much greater level of self-evaluation and awareness of their impact on the earth than other animals.

particularly esteemed; the mere mention of the word *extraterrestrial* evokes reveries about still unexplored life, displacing the old and once potent *exotic* that drew earlier generations to remote islands and jungled interiors" (p. 1). In contrast to the characteristics of living things, he says that "artifacts are incomparably poorer than the life they are designed to mimic. They are only a mirror to our thoughts. To dwell on them exclusively is to fold inwardly over and over, losing detail at each translation, shrinking with each cycle, finally merging into the lifeless façade of which they are composed" (p. 115).

Wilson's discussion on the facets of life, including diversity, animation, exotic-ness, novelty and richness or extensiveness of (aesthetic) detail gives further understanding to the qualities that make life aesthetically preferred. Concurrently, he also helps to clarify what we envision when we speak of 'Nature'. By contrast, humanly-contrived and significantly human-modified products and built environments (a.k.a., 'artifacts' and 'artefactual landscapes') stereotypically are lacking in such facets of life, by comparison. Thus, our artefacts often diverge from the material creations of other nonhuman organisms (specifically the products of a collective and diverse group of other organisms) in what Wilson concludes to be the most significant way. Of course, our products need not lack life-like characteristics inherently or permanently. By recognizing the characteristics of life, we may use them as criteria for our modifications of the built environment and as a framework for making our products—contributing to the expansion and preservation of the acclaimed 'Nature'.

Observing and focusing on living organisms and things that exemplify these qualities of life deeply and thoroughly is, according to Wilson, the particular exalted purpose of humans—to gain knowledge and awareness of all these organisms in relation to ones' own life, such that we elevate the concept of life (p. 22). Yet, not always do we elevate living things or talk about 'nature' in such a congenial light. While general terms like *living* and *organic* are highly esteemed, in particular circumstances, we may refer to the things of 'nature' and life as something terrifying, disgusting, or troublesome. Eric Fromm might categorize these fears and displeasures as the opposite of biophilia, that is, a part of 'necrophilia'. Fromm uses this term to describe the allure of surrounding ones' self with that which is dead or seems inanimate, as well as an indifference to life (Fromm, 1964). Fromm does not

seem to fully appreciate, however, that death and dying are integral parts of living systems and inherent to all functioning healthy ecosystems. Death is not a retrogression, in itself. Retrogression occurs only if the death perpetuates that which is nonliving. Necrophilia, as an attraction to dead things, is not a common characteristic of the human public. Humans tend to reject the idea of death or being surrounded by dead things (e.g., the stigma of dead bodies and sadness about dying beings). Rather the actual attraction that commonly opposes biophilia may be better limited to an attraction to nonliving things (i.e., things that are neither dead nor alive; the non-dying, non-decaying, and non-decomposing things). This attraction is exemplified by the kinds of things we typically surround ourselves with, as our buildings are mostly made of nonliving materials.

Necrophilia or not, there does seem to be two opposing desires for humans: the fascination toward the unpredictability of living systems and the desire to control that is exemplified in nonliving structures. Promises of the reconciliation of these desires are evident in the research of Rachel and Stephen Kaplan. In discussing the research of the Kaplans, who classify the four most appealing characteristics of 'nature' as: "mystery", "legibility", "coherence", and "complexity", Simon Bell claims that many of earth's non-human dominated environments succinctly carry all four of these qualities (as perceived by humans) in a way that resolves the innate conceptual tension in the viewer between uncertainty and order (Bell, 2012).[14] As a knowable order can give someone a sense of control, the environment could conceivably satisfy both desires simultaneously. A prerequisite to accommodating both these desires simultaneously, as well as the demands of the contemporary urban setting in the built environment through design (including demands of utility and the societal order), is to obtain a greater learning and understanding of that which is living—a method which Wilson, the Kaplans and Bell would all likely support.

Wilson also finds exceptions to humanity's attraction to dwelling closely to the living, which help to explain the resolve of societies to be surrounded by nonliving things. He posits that a person can thrive in

[14] Simon Bell explains, "Coherence is the property that allows a landscape to 'hang together' as a perceptual whole, or to be identifiable, familiar, and redundant, allowing us to make sense of it in a static, present sense through perceptual means. Complexity, on the other hand, is a measure of perceived diversity or richness from a single point of view. Legibility is a more dynamic relative to coherence—a property of environments that affords humans the ability to move through and explore without getting lost. Mystery, according to the Kaplans, is another dynamic environmental property representing the ability of humans to acquire new knowledge as if traveling deeper into the scene" (Thayer, 1994, p.13).

the world of high-tech machinery exclusively without “noticeable loss”. Wilson attributes an attraction to technology (*technophilia*) to technology’s “swiftly changing and visually dramatic events, in other words to quasi-life, one might say ultimately back toward life itself.” (Wilson,1984, pp. 115-116) Wilson compares “the most attractive patterns of the physical world and technology to artistic representations of plants and animals” (pp. 115-116). Yet, considering the satisfaction of *mechanophilia* or *technophilia* to be “incomplete and temporary” (p. 115), Wilson claims that “people react more quickly and fully to organisms than to machines…They prefer entities that are complicated, growing, and sufficiently unpredictable to be interesting” (p. 116). What makes biophilic design aesthetically preferable to technophilic design, Wilson would argue, is that technophilic design is not composed by fully living things and completely life-like processes. To be sure, technophilic design can and does incorporate some life characteristics and processes; however, generally current technology is still predominantly run by and composed of the nonliving. Life characteristics and processes are always and fully present in products from the collective workings of a diversity of species (production that is, itself, dominated by living things, but not one particular species), and they can also be incorporated to varying degrees in human machinery. Now that I have identified many aesthetic characteristics of life, and humankind’s primary attraction to life and life-like processes, a question arises as to what are the processes of life, since these may heavily contribute to the aesthetic characteristics themselves. Though the definition of life is controversial, a species’ aliveness in the field of biology is determined by seven commonly accepted criteria. These same criteria, known as the *Seven Criteria of Life*, are used currently to define anything as living. Dr. Amanda Barnard, expresses the criteria in terms of processes and properties, as follows:

1. Does homeostasis: regulates its internal environment and tends to maintain a steady state. This regulation is typically a dynamic one, like the workings of a stream.
2. Has an organization where properties at one level are unique to the properties at any other level.
3. Metabolizes: breaks down organic matter or builds up nutrients to release, store or consume energy (for maintaining functions of life).
4. Grows: all parts changing over time in a self-increasing way (extension or expansion; in size, number, value, or strength), generating throughout its structure.

5. Adapts to one's environment (to become more suitable to the environment and able to advance).
6. Responds to stimuli (e.g., plants motion in response to the location of the sun; phototropism).
7. Able to reproduce individual entities as offspring either through sexual intercourse or asexually (like through binary fission). (Barnard, 2015)

If the aesthetics of the living are derived from or are the result of the processes that enable the living to exist, then our greatest attraction is to entities whose processes involve: stimuli response, reproduction, adaptation, growth, regulation, metabolization (a process which includes death, dying and decomposition), as well as a material makeup of complex organization. These processes are more prevalent in habitats that show little signs of typical human activity, and are created by a diverse group of species.

Diverse species and their biological/life processes, in a collaboration of species-specific efforts, use the best set of ingredients/supplies locally available (whether as a product of evolution and natural selection or intelligent design or both). This inherently means that the specific products, actuators, and processes are not universal across ecosystems, rather, they are conditional to local context. Production of this sort is antagonistic to the practice of universalization. Universalization is common in the market production of inorganic design and its' concomitant construction, which is characterized by a lack of life and life-like processes. Universalization of production is the practice of using one marketed product and re-creating replicas of it over and over again to be sold and to carry out a specific purpose in all possible conditions (globally). These replicas are identical in morphology or formal pattern and general makeup, as faithful copies of each other. An example of universalization in architecture is 'cookie-cutter houses'. A cookie-cutter house has a design that gives no attention to the immediate context in which it is built, such that it works no matter where it is built. This 'one-size-fits-all' strategy is dependent upon the product's design for 'the-worst-case-scenario' conditions. These universalized products, are in contradistinction to the novelty and diversity common in organic products. Having a "built for the worst case scenario" design, universalized products are typically not the most effective use of materials (the best amount of the best ingredients available) per location. They are, thus, not the most effective solution to the individual or collective needs of each local ecosystem. The ineffectiveness of inorganic and universalized production is

not just a matter of aesthetics, but is also an ecological problem and human-utility problem. Thus, the dissatisfaction with built environments primarily composed of simplified and universalized products owes to their utilitarian, ecological, and aesthetic features. One may then conclude that a significant way to change production processes to more life-like processes is for producers to figure out what are the best ingredients (or nutrients) for the creation of a product on regional basis or per locale. Admittedly, universalization often proves useful in marketing. The reduction in variation simplifies the process, and can save money for the producer (depending on the extra cost required to support 'the-worst-case-scenario'). It also allows for one prototype to be marketable to all consumers (although for some more utilitarian-effectively than others). This is a problem we must solve for our own market production processes—what are the best ingredients regionally, and how can the production be viable economically for the producer while particular to community needs and conditions. This is not to say that we can put off all production until we find it, or that every product should be completely unique to the next, but that we cost-effectively put the effort into searching for ongoing improvements in strategies and materials that can be used to better fit the needs of varying cultural and geographical conditions, and that we use the more sustainable options of what is currently available.

Chapter 7: The Eco-Ineffectiveness of Human Product

Beyond the inorganic appearance—which tends to be the first distinction we recognize about human-altered products—is the fundamental impact our product has on the ecosystem. This impact our built environments can have is either qualitatively eco-effective or eco-ineffective. A built environment's **eco-ineffectiveness**[15] is typically a product of simplification, universalization, and **cradle-to-grave design**.[16] In the book, "Cradle to Cradle", McDonough and Braungart note that:

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[15] Eco-effectiveness is "the central strategy in the cradle-to-cradle development method and seeks to create industrial systems that emulate healthy natural [or living] systems. The central principle of eco-effectiveness is that 'waste equals food.' The concept was developed in response to some of the perceived limitations of eco-efficiency which critics claim only slow down the rate of environmental depletion and don't reverse the production of unused or non-recycled waste" (Dictionary of Sustainable Management, 2016).

[16] Cradle-to-Cradle: "A phrase invented by Walter R. Stahel in the 1970s and popularized by William McDonough and Michael Braungart in their 2002 book of the same name. This framework seeks to create production techniques that are not just efficient but are essentially waste free. In cradle to cradle production all material inputs and outputs are seen either as technical or biological nutrients. Technical nutrients can be recycled or reused with no loss of quality and biological nutrients composted or consumed. By contrast cradle to grave refers to a company taking responsibility for the disposal of goods it has produced, but not necessarily putting products' constituent components back into service" (Dictionary of Sustainable Management. 2016).

> "Humans are the only species that takes from the soil vast quantities of nutrients needed for biological processes but rarely puts them back in a usable form. Our systems are no longer designed to return nutrients in this way, except on small, local levels. Harvesting methods like clear-cutting precipitates soil erosion, and chemical processes used in both agriculture and manufacture often lead to salinization and acidification, helping to deplete more than twenty times as much soil each year as nature creates…In preindustrial culture, people did consume things. Most products would safely biodegrade once they were thrown away, buried, or burned. Metals were the exception: these were seen as highly valuable and were melted down and reused. (They were actually what we call early technical nutrients). But as industrialization advanced, the consumption mode persisted, even though most manufactured items could no longer actually be consumed" (McDonough & Braungart, 2002, p. 96-97).

The difference between the impact of former production practices and the more modern ones that McDonough and Braungart illustrate here is the increased use of Cradle-to-Grave production practices (which is qualitatively eco-ineffective). Cradle-to-grave design can be best explained with regard to the kind of substances involved, and the way in which they are handled.

McDonough and Braungart classify all nutrients as either biological or technical. In their book they refer to a process of "nature", by which an ecosystem is equipped to absorb substances safely or biodegrade substances, as a *biological process*. Such processes are not just life-like, but are actually a process of life. The products that can be safely and easily handled within that ecosystem — those that can be easily taken up and utilized through local or common biological processes (i.e., being bioavailable)—are called *biological nutrients* (a.k.a., the nutrients of living beings) (p. 96-97). Living organisms play a role in biological processes by consuming and producing many different biological nutrients. 'Technical nutrients', on the other hand, are entirely nonliving and inorganic, and are only absorbed and processed by biological systems safely in only very minute doses (if at all). Technological processes may be more or less life-like, but are not in themselves life processes.

Technical nutrients include heavy metals, fossil fuels, chemically inorganic minerals, and plastics from human-made (synthetic) polymers (which are made up of non-uniform particles that would not occur

on earth without human technology). Potentially hazardous to the life and health of all earth's biomes, the extraction and production of fossil fuels and heavy metals happens in a process dominated by nonliving things. In large concentration, these technical nutrients typically occur only deep within the Earth's crust, and are brought to the surface by volcanoes or are extracted by humans for industrial purposes. Moreover, fossil fuels and heavy metals (although periodically found in ore that rises from the earth's crust) are limited in availability—regenerating at extremely slow rates. Although they are rarely sourced from the earth's surface and are incredibly valuable energy resources, these nutrients are frequently used materials in human-marketed production.

According to Thayer, "[James] Watt's steam engine [of 1781] has ushered in an age of non-animal, fossil fuel power" (Thayer, 1994, p. 138). Indeed, since the beginning of the Industrial Revolution, fossil fuels have been abundantly used for powering high-tech and manufactured tools made by humans. They are so powerful that they can make a building design universal such that the building's physiology can be isolated or indifferent to the building's particular ecological context. With air conditioning units powered by fossil fuels, if the temperature is uncomfortable, just turn up the AC to burn more fossil fuels to reach comfortability. Fossil fuels certainly have the 'natural' ability or rather, the propensity, to get the job done. Yet, there is a practical significance to why no other species harnesses fossil fuels as a productive resource. No living species consumes fossil fuels, unless as a part of a dangerous **bioaccumulation**.[17] Fossil fuels are dangerous to the health of living species, and burning them releases heat-trapping gases (GHGs) into the environment. The greenhouse gases, in turn, bring about changes in the climate and increase the probability and severity of 'natural' disasters that destroy all species lives and homes. Although fossil fuels are originally from the remains of living species—they are nonliving and far from being bioavailable (i.e., safely absorbable by living things) or a part of healthy biological processes. In addition, by depending heavily upon them as a substitute for eco-effective designs, one compromises the ability for the product or built environment to interact in a living or living-like way—a lost opportunity to contribute to the perpetuation of the ecosystems that humankind must depend on to live.

[17] Bioaccumulation is: the accumulation of a substance, such as a toxic chemical, in various tissues of a living organism. Bioaccumulation takes place within an organism when the rate of intake of a substance is greater than the rate of excretion or metabolic transformation of that substance.

Even if the toxic substance (fossil fuels and their byproducts) were prevented from contaminating biological systems, such resources are too limited in supply for society to continue to depend heavily upon them for energy. This is because, in part, fossil fuels take too much time or too much energy to produce. Fossil fuels also regenerate very slowly. The extensive use of fossil fuels demonstrates the market's set up for cheap, short-term solutions, involving small immediate gains but also big long-term losses. This demonstrates the temporary and incomplete utilitarian-effectiveness of fossil fuels. Therefore, for economic, ecological, and social facets of sustainability, it is imperative to replace the use of fossil fuels with resources and production strategies for production needs that are permanently utilitarian-effective and eco-effective. Solar power is an example of a complete and permanently effective energy for electrical power in some built environments, as McDonough and Braungart report, "…thousands of times the amount of energy needed to fuel human activities hits the surface of the planet every day in the form of sunlight" (McDonough & Braungart, 2002, p. 32).

Our current use of fossil fuel is just one example of the many cradle-to-grave designs that are found in current human-marketed production. Listing the greatest costs of cradle-to-grave design, McDonough and Braungart aver:

> "Of greater concern are the nutrients—valuable 'food' for both industry and nature—that are contaminated, wasted, or lost. They are lost not only for lack of adequate systems of retrieval; they are lost also because many products are what we jokingly refer to as 'Frankenstein products' or 'monstrous hybrids'—mixtures of materials both technical and biological, neither of which can be salvaged after their current life" (p. 98).

Thus, cradle-to-grave design is also exemplified by biological nutrients infiltrating technological processes. Productions that inextricably mix technical nutrients and biological nutrients as hybrids are most problematic because they can neither be reused in technological nor biological systems.

The eco-ineffectiveness of our production processes is problematic in two ways: one, our excesses (the byproduct and post-product) of production practices are not usable as nutrients—just waste. Waste is either harmful or not supportive to the ecosystems and their collective life forms. This is not to say that other species do not produce anything in excess, rather, their excess is completely usable

by other species. For example, the trees produce much more flowers than necessary for the spreading of more of their kind, but these excesses are used as food sources for many other species. Secondly, our production practices deplete vital food/nutrient sources for the ecosystem. Thus, when human production practices are eco-ineffective, they disrupt the lives of many other species either directly or indirectly by destroying their habitats. Without their habitats, these other species do not survive. Indeed, the greatest cause of extinction is loss of habitat (WWF, 2016). Due to our symbiotic dependency, without these species as a part of the earth's biosphere, we cannot survive here either. Moreover, as the resiliency of all species depends upon their interconnectedness to all other species, the trend of extinction has a domino-effect such that as more species go extinct, the more others will go extinct. Extinction is, however, atypical. Because of the biosphere's resiliency, the typical on-goings of its ecosystems have a tendency to avoid instability such that the ecosystem finds ways of stabilizing itself. Since the ecosystem is both a stabilizer of itself and all that makes it up, it supports biodiversity (i.e., an increased variety of services and biota types) and biodiversity reciprocates by promoting the resiliency of the whole. The ecosystems that support humankind have shown themselves to be unable to stabilize with the current on-goings of humans (e.g., drastic global warming as a result of our GHG emissions), at least not in such a way that will sustain humans. If a few parts of the ecosystem fail, many will fail, and this may just unravel the whole ecosphere and humankind with it. Perhaps McDonough and Braungart put the gravity of the situation for humankind best:

> "Nothing goes in or out [of the earth's atmosphere] except for heat and the occasional meteorite. Otherwise, for our practical purposes, the system is closed, and its basic elements are valuable and finite. Whatever is naturally here is all we have. Whatever humans make does not go 'away'. If our systems contaminate Earth's biological mass and continue to throw away technical nutrients (such as metals), or render them useless, we will indeed live in a world of limits, where production and consumption are restrained, and the Earth will literally become a grave" (p. 103).

What seems to be the greatest problem for humankind's survival, perpetuation and prosperity on earth is that our production habits have evolved in a way that is no longer sustainable for the ecosystems' species (including humankind). Moreover, human marketed products and industry strategies are not often

designed with the ecological ‘intelligence’ (i.e., understanding how the product affects the ecosystems), and lack the ability to positively impact energy flows and ecosystem equilibrium and resiliency. Ecological ‘intelligence’ involves cradle-to-cradle design; a supporting or boosting the perpetuation of the circularity of material flows. Eco-effectiveness in the built environment is best represented by a high level of ephemerality and matter-energy circulation or cycling throughout the built environment, and a tandem lowering of the level of entropy. High cyclicality or circularity requires directing matter-energy from one right place to the next right place at the right time, to sustain ephemerality, increase biodiversity (through the expansion and protection of ecological niches) and reduce entropy. The majority of human-designed/built/made things can be typified as nonliving, unable to be safely absorbed by the living, and unable to be technologically-reusable without the downgrading of precious nutrients. By definition, these human products lack the ability to perpetuate circularity of material flows.

One might wonder, with possibly the most sophisticated mind on the planet at our disposal, if humanity can use its grand intelligence to stop itself from causing its own extinction. Indeed, production need not be inherently eco-ineffective—neither production that uses biological processes and nutrients, nor production by technical means and technical nutrients. Human production can be transformed in ways that the materials neither pollute habitats, nor get wasted. The ingredients, the actuators, and the processes of technology can and should work in such a way as to respect the interconnectedness of our ecosystems. As an eco-effective system, the products and strategies of other species have an embedded ability for circularity of all materials produced, which allows for permanent, complete and holistic cradle-to-cradle material flows. Perpetual cycling of materials is arguably the most defining characteristic of living systems.

Therefore, while anything human beings do is natural, just as is the case with every living organism, the particular differences in what we produce suggest that there is better natural behavior (better ways of design and better methods of production) in both an aesthetic and ecological sense. The differences between human-dominated productions and the productions of the rest of the species are multifaceted. Firstly, the predominance of inorganic, simplified and universalized products in our habitats appear less aesthetically attractive, hence the preference for views to what is so often called, ‘Nature’,

over all else. Secondly, the simplification and universalization of products is less specialized and unique to the needs of specific communities, and is often wasteful of nutrients and not of the best set of ingredients available. Lastly, predominance of the inorganic and cradle-to-grave design wastes opportunities to bring greater resilience to our ecosystems, and destroys existing habitats that do support the resiliency. In contrast, other species instinctively (or without other option) use the best set of ingredients locally available, and interact with other life forms using life-perpetuating processes, making them the most eco-effective. Other species' productions and built environments are also aesthetically diverse, novel, complex, harmonious, progressively ephemeral and rich in detail.

The Better Natural: The Future of All Species' Product

The size of impact or ecological footprint that humans have is not so much a concern as the kind or quality of the impact of that footprint on the land and its resources. This current quality of our impact stems in part from our false ideas on the relationship of humans and nature. By defining ourselves and our products as apart from nature, we distance ourselves from the rest of nature in two ways: we identify ourselves as isolated and independent from the rest and inherently against other species. In truth, the best of natural behavior for humans will consist in working together cooperatively with other species. This means that production strategies are not to be treated as a zero-sum game strategy, but rather as a team effort that recognizes and acts in accordance with the ecological order of interdependency. This will consist of designing products that mimic the way in which the ecosystem is designed—holistically, and will allow for circularity of material flows so that other species can handle and work positively with our doings. McDonough and Braungart call this holistic design "cradle to cradle" design. We can thus, learn from our neighboring plant and animal-life, what works well in our ecosystems. After all, the very materials we use come from these neighbors. Determining the best ingredients in production requires an awareness of factors including the materials' level of availability, which includes its proximity, accessibility, supply limitedness and regeneration rate, level of bioavailability or cyclical-ability, level of suitability for the solutions necessary in order to perform the intended utilitarian functions; and level of eco-benefits to other species.

Take and Give Nutrients

Human marketed production processes have been characterized as spewing out harmful living-being-killing toxins (such as dioxins) throughout the atmosphere, and as aesthetically bland in comparison to the non-human modified environments. Finding dissatisfaction with our buildings and products in comparison to the 'buildings' and products of the rest of nature, and seeing the great differences between 'ours' and 'theirs' as eco-ineffective, people assumed the human-made was not 'natural' and the only way to save 'nature' was to minimize their impact. This zero-impact solution is evident in the earliest thought behind the sustainability agenda. In 1984, Richard L. Austin defines *natural landscape* in his book, "Designing the Natural Landscape", as: "comprised of ecologically placed species of plant materials and void of any formal human manipulation in the selection, location, or perpetuation of the vegetative compositions" (Austin, 1984). Even today, the contemporary view of 'nature' and the 'natural' consists of: humans having little to no control or role in the production and transformation of physical objects/entities; no human-imposition over living systems; and letting other (nonhuman) living beings work together to do their "natural" things (i.e., the things they do passively or instinctually or actively through learning in their local habitats) without human interference. Yet, our conception of 'nature' should not be zero-human impact, nor does it have to be. The distrust in the man-made is warranted, but what warrants distrust about the man-made is not inherent to the man-made. In fact, one might argue that our movement to isolate ourselves and our habitat from other species and from living things is what is unnatural. This, too, is an illusion that may be simply resolved by admitting that we may just be the only ones 'smart' enough to figure out how to exist with so little cooperation with other species besides our own. However, as Wilson insists, we are not able to completely separate ourselves as a species from other living species, for when we do, we can do so only temporarily (Wilson, 1984, p.115).

The better natural way for humankind—the ecologically sustainable way, is not about curbing and containing human destruction so that the ecosphere lasts a little longer, or as long as possible, but eventually ending in doom. Rather it's about preserving and even restoring the ecosystem for a better future world. Ecological sustainability does not consist of less pollution being spewed, running out of resources slower, or protecting 'Nature' with less destruction. In other words, ecological sustainability does not require that we make human impact equal zero, rather, we change the kind of impact we have

from a negative impact to a positive one. While all species take something from the ecosystem, they also, in return, give something fruitful back. This give and take allows for both the ecosystem to be an effective tool for the specific living being, and that specific living being to be an effective tool for the ecosystem. All other species offer ecological services and provide food for different species. What humans typically provide is often unusable and a waste of nutrients, or harmful. Our wastes and byproducts are recognized solely as waste, other species waste and byproducts are either recognized as food or materials that offer up specific opportunities for ecological cycles. When we produce, we should have an eco-intelligence built into the product so that its materials can be used indefinitely. To take it a step further, the tree can lead by example. Most companies have a narrow focus for their operations: they provide one kind of service and wipe out a diverse network of services to carry their one service out. To improve upon our products and processes, we can ask about them, "Is the production method as well-suited as the tree and its processes, which plays a multifaceted role in an ecosystem?" Also, "how many roles can this method of production play in the given locale?" This is more than just improving efficiency, in short, it is making every aspect "designed to nourish a diverse world" (McDonoug & Braungart, 2002, p. 145). Humans have the ability to learn to adjust their techniques, to transform products in ways that mimic the organic and living form, in both structure, and function/process.

Chapter 8: The Relationship of Biology and Technology

With advancements in technology continuously evolving, it is clear that technology not only has its permanent place in human society, but also that, as technical as our products are, human technological production has the potential to a great degree for biomimicry and eco-effectiveness. Essentially synonymous with *biophilic design, biomimicry* is defined as the design and production of materials, structures, and systems that are modeled on biological entities and processes. Assuming humanity is not going to give up the use of technical nutrients and the technology it produces, no matter how inevitable or necessary technology is for humankind, strategies must be developed for technologies to coexist in harmony with our ecosystems' self-perpetuating processes. Technological systems will need to work in tandem with biological systems, and not as a replacement for biological systems. In the

foreseeable future, our technology will likely have, more or less, the same sort of efficient and effective functional capacities as biological systems.[18] Until then, we must acknowledge the current shortcomings of technology (aesthetic, ecological, social and economic) in comparison to available biological processes. Work must be undertaken to bring back biological processes as a preferred strategy of production, as opposed to current eco-ineffective strategies, provided that it meets utilitarian functional requirements.

I have thus far identified the ways in which technology tends to differ from the products of other species. This difference owes mainly to the domination of nonliving versus living characteristics in the products' structure and processes. It becomes important, however, to note that technology and living systems have much more in common than what is immediately apparent. Just as technology is often described in ways analogous to the human body and other life forms or living systems, so too are lifeforms such as ourselves identified as machines. The typical physicist would most likely define every organism as a sophisticated machine completely explainable by physics. Indeed, the living tissue of which humans are composed is made up of cells that act just as little mechanical factories. And those are further composed of nonliving nanoparticles (various atoms). Still, the physicist can see the difference in living systems from today's technology.

Our brain is like one computer made up of many computers that all work together and as individuals with great sophistication. But, unlike our brains and all living organisms, human-produced high-tech computers, as of yet, do not metabolize (at least not without the use of living organisms or biological nutrients). The one current form of high-tech that does involve metabolism is biotechnology, yet this still uses biological nutrients rather than technical ones. Thus, all non-biological-tech—being composed of hard substances made up of non-protein composed molecules—cannot fully repair itself. Furthermore, at the scale of a cell, the technology cannot evolve in a self-advancing and self-replicating

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[18] Today's technology has the ability to do specified abilities like flying, and multiplying (mathematically) faster than humans. On the other hand, the computer is not quite as intelligently-sophisticated as the human brain. This should be of no surprise, since the complex workings of the brain (both the 'wiring' diagram of how all the neurons are connected and its entire programming, i.e., how the mind works) are not completely understood. Yet, whereas there may be a set number of neurons that the human brain can have without 'artificial intelligence' supplementing, there is no limit to the number of neuron simulators that can make up a computer. If the computer's neural network becomes more complex than the brain, then we might end up with computers that are 'smarter' than us (i.e., automatons with deeper, more complex thought capabilities).

way. While technology and humans are both ‘run’ involuntarily by the equivalent of a set of computational processes, technology needs humans to organize and manage it. In contrast, humans’ core substances are constantly being destroyed from the inside and renewed or replaced from within autonomically and in a self-contained way. Due to one’s metabolism, the human body replaces every cell within a year, so that in terms of matter, who I am today (or what makes me up) is an entirely different organism than the organism I will be a year from now. According to Thayer, “the generation, deterioration, recycling, and regeneration of natural materials in the landscape is what enable life to exist” (Thayer, 1994, p. 38). Thus, these self-advancing activities are integral to the composition of living material, and are not currently a part of technology made from technical nutrients.

Despite a difference on a cellular level, at the rate technological advances are being made, the dividing line that characterizes the most advanced technology from a living being is becoming blurred. Such grey areas include the points at which scientific engineering and biology unite, such as biotechnology and nanotechnology. These areas of science involve products that are often both high-tech and living (designed to be bioavailable and go back into organic or biological cycles). Biotechnology has the ability to manipulate biology at the level of molecular biology, and since DNA is coded into individual molecules, biotechnology can control what happens inside living things and change them to be more fitted for a particular eco-environment. The products of nanotechnology are not composed of technical nutrients, yet the scale at which the technology often works is with nonliving particles. Living things do not magically do things that nonliving things cannot, rather they are composed of a configuration of molecules that can do certain things that allow them to have the complexities of life. Although not currently able to bring together the building blocks to create ‘synthetic’ or human-tech engineered life entities, nanotechnology can build these sorts of molecules and may have the potential for creating life with inorganic and ‘harder’ substances than proteins (p. 189). As biological systems, humans are a hierarchically complex structure of many components that interact with each other, yet the components are more simple elements, into which nonliving matter can be organized. Given such technological advances, eventually, there may be very few markers to distinguish the marketed products with products of non-human species, as they become more and more life-like. Eco-effectiveness is, therefore, not

inherently exclusive to organic and living systems, as technology can advance to possibly even cross the boundary line from nonlife over to life (i.e., production that begins with only abiotic matter and ends in biotic matter).

Chapter 9: Strategy Types for Sensory Legibly Sustainable Architecture

In the last four chapters, I have discussed the differences between humans and the collective other species, and the constituent products of each. I concluded that there is a connection between what is aesthetically preferred by humans and their preferences toward ecological sustainability. This connection owes to a human preference for the incorporation of life and life-like processes in production of physical things. This preference for the incorporation of life extends to habitats of the various life forms, including the human built environments. Such habitats are culminations of products or physical things, themselves. Ecological sustainability is so often identified within nonhuman-modified habitats. These are currently the most suitable to sustain all species. They are characterized by their ‘natural processes’. What we typically mean by *natural processes* and *nature* is the product and production processes that are characteristic of production that involves a cooperation of a diverse group of species (not dominated by humans). This terminology is indicative of a qualitative and normative difference. The product of a diverse group of species is indeed natural (just as are human-modified products), but it is also a better kind of natural. Excelling in the standards of ecology and aesthetics, the better natural processes are synonymous with life and life-like processes.

That which is permanently eco-effective in architecture (and thus ecologically sustainable) has life-like qualities and processes. Better natural architecture acts as a life-like system, whether with technological processes, biological processes, or a combination. This non-vitalistic view recognizes the differences between living and nonliving, yet not as absolutes. The difference is in what nonliving could be, but is not, and what living just is. Integral to life are systems designed holistically with equilibrium in the relationship between things (i.e., with dynamic balance), resulting in an indefinitely continual and cyclical exchange of nutrients between all parts of the whole. This can and should also be the case with architecture, whether through biological nutrients, technical materials, or both. The processes of life include: stimuli response, reproduction, adaptation, growth, regulation, and metabolization.

These processes all contribute to a high circularity of matter-energy flows. The aesthetic characteristics of entities which use such processes to exist include: diversity; harmony (or unity of pattern; coherence); novelty; complexity; richness of aesthetic detail as detected in each bodily sensory mechanism; progressive ephemerality; animation; and sometimes exoticness and immensity. Thus, ecological sustainability, when it is life-like, should innately or easily be made aesthetically attractive (with limited modification for cultural values). Human production is not unnatural; it is only typically not the better kind of natural. Fortunately, human production, including high-tech machinery, may be tailored to life characteristics and life-like processes to increase both the ecological and aesthetic value of the built environment. Such production would combat eco-ineffectiveness, blandness and monotonousness in the built environment.

Having discussed what people really mean by *nature* and *natural processes*, I can now return to their incorporation within the scheme of sensory legibility of sustainability in architecture. Having exhibited the various theoretical stances on sensory legibility, I propose the definition of sensory legibility within the realm of ecological sustainability of built environments to mean: the ability to read and understand through the senses how efficient and beneficial a built structure is for its eco-environment, and in what way. When sensory legible, the structure's sustainability and ecological value can be perceived immediately through the physical senses, without additional research. Furthermore, the structure (which is inextricably tied to the processes it is involved with and that make it up) tells the ecological functions it offers and the processes involved in the way it is exhibited. Thus, the designer's use of ecologically preferable practices and materials in the design, location, construction, operation and disposal of built environments, if sensory legible, can be perceived and understood simply through the physical senses.

There are a number of methods for improving the sensory legibility of the built environment (whether in the realm of architecture, landscape architecture, or urban design), in terms of its ecological sustainability. Legibility (that is, the ability to read and understand; not sensory legibility) of sustainability can be implemented in architecture through posted lettered or diagramatic signs. Such signs clarify the ecological sustainability by appealing to prior knowledge of eco-sustainability and through symbolic metaphor or analogous references. Signs can also be used to direct someone to pay attention to certain

details within the built form—helping to promote sensory legibility of eco-sustainability by directing the experience toward the built form's more ecologically sustainable components. The incorporation of biomimicry is one way to increase aesthetic value, ecological sustainability, and its sensory legibility. Strang (1996) proposes that infrastructure or built form should mimic "nature" and "natural processes", which as we have discussed is really to mimic life and life processes. The built form's biomimicry is most sensory legible when it is multi-sensory since our experience of life and life processes involves all the senses. Architecture's mimicking of life can be as little as symbolic representation. Yet, in terms of its multi-sensory aesthetics, architecture can be an imitation of life's entire repertoire of physical properties—even a complete emulation of living structures and processes. Life and life-like processes have the innate by-product of aesthetics including: diversity, complexity, novelty, ephemerality, unity of pattern etc. These characteristics can also be intentionally revealed and celebrated (through scale, repetition, hierarchical arrangement, and signs) in the design as a means for increasing sensory legibility of ecological sustainability.

Because there are several ways for architecture to imitate life including in function, makeup (structure), appearance or interface, through other nonvisual senses, and symbolically, ecological sustainability can easily be simulated in the built environment without genuinely supporting healthy ecological function. The strategy of transparency in ecological structures—to not conceal or hide, but allow to be seen in the experiencer's viewshed—can help prove that a design is truly eco-sustainable. A method explicitly supported in the writings of Robert Thayer, is the increase of transparency and visibility of form and spatial logic as an important tool to learning sustainability through the built form. Since people, especially designers, tend to be visually-dominant, transparency of sustainable structures is possibly the most obvious and direct way to increase sensory legibility. However, transparency will still have little sensory legibility if the sustainable structure is not aesthetically-fitted to the culture's appreciations.

To help ensure that the experiencers of the built form will appreciate and interpret the form as ecologically sustainable, designers can implement cultural cues that appeal to cultural expectations, norms, and preferences on an aesthetic and sensory level. As proposed by Lessons of Rome, physical-

formal structures have political, philosophical, and psychological meanings beyond the physical forms themselves (Schwarting, 1981, p. 26). These forms and corresponding associative meanings are determined to some degree by a given culture. Some forms are imbued or strongly manifested with such a significant and commonly-held meaning that the form (or group of forms) act as cultural cues—cues to specific meanings for anyone who is immersed and knowledgeable about the particular culture in which the form resides. As a prerequisite to understanding structures and processes, eco-sustainable forms, like all forms in a built environment, must be made readily recognizable through adherence to cultural values.

While compliance to cultural norms and preferences in forms acts as a catalyst towards the acceptance and understanding of sustainable systems in design, cultural cues of eco-sustainability often act in such a way as to make the perceiver aware that something appears eco- sustainable, even while the perceiver may maintain no practical understanding of the workings of the design itself in sustainable terms. A thing that acts as a cultural cue for sustainability has been popularly branded in a particular culture as sustainable, such that its audience sees the cultural cue as sustainable, no matter if the thing is actually sustainable or not. Therefore, cultural cues toward sustainability are not enough for sensory legibility either. For example, people often label high-technology as sustainable solely through cultural cues, such as the presence of solarized panels. Solar panels on a building imply that the operational functioning of the edifice is ecologically sustainable, and that a level of ecological-conscientiousness went into the planning of how the building would function within the ecosystem. The general public (of the Western World) knows that solarized panels somehow absorb energy from the sun and somehow transfer that energy to allow for the building's other functions to take place. Recognized through common cultural knowledge, the audience need not have any understanding of how the thing is sustainable in the first place. However, to perceive that the technology **<u>is</u>** ecologically beneficial and to perceive exactly **<u>how it is</u>** beneficial differ in that the latter is more complete in its sensory legibility.

To increase sensory legibility further, one can use other tactics proposed by Strang. He suggests that the infrastructure that our society depends upon be brought to the attention of inhabitants and visitors of a place by implementing multi-functional and multi-purpose forms to allow people to relate and interact

with important parts of the ecological system, in multiple ways. Multi-functional forms, having a variety of utilitarian uses or human applications, include providing and offering utilities such as communal or private space for eating, seating, playing, scenic viewing, reading etc. Multi-purpose forms may be for the purpose of entertainment, relaxation, exploration, aesthetic appreciation, and/or education. The most important parts of the infrastructure to make multi-functional and multi-purposeful are those that act as poignant indicators of the ecological functioning of the built form, including the "significant sources, paths, and transition points of our collectively owned resources" (Strang, 1996, p. 13). Related to multi-function in a non-species-specific way, increasing of the presence of diversity of species and their ecological niches in an area will increase both the ecological sustainability and its sensory legibility, since one significant way people identify ecological sustainability is through the presence of a diversity of species (although they may identify the presence of certain species as more indicative of ecological sustainability than others). The presence of biodiversity and their corresponding eco-niches is, of course, related to the utilization of life, incorporating real living systems, and can act as a cultural cue. Finally, the last method of sensory legibility is to intentionally, directly, and physically link a structure's form to the eco-environmental context. The ecological context is most clearly identified with prominent and treasured regional landmarks such as a lake, or a mountain, but may also refer to direct connections with local places that have multiple ecological niches such as a park or garden. In general, direct connections to soil, vegetation, the sun, and rain can increase sensory legibility. If the structure is linked to the ecological context, and humans are interacting with the structure, then the humans will interact with the ecological context. Conceptual connections can be further ensured through the help of lettered or diagrammatic signs and constructed walkable routes within the built environment that focus one's attention on the ecological context. Through increased duration of exposure, frequency of access and habitual appropriation, increase in hierarchical focus (through scale, size, or arrangement), and increased repetition of any of these methods throughout a design increases the likelihood that humans will perceive and understand the sustainable ecological functioning of the built form.

Aspects of Architecture that Can Be Sensory Legibly Sustainable

The strategies of sensory legibility may be more clearly distinguished in recognition of the ways in which architecture is subcategorized or typified. There are many subcategories of architecture, each with a number of instances. Each instance has set of particular characteristics belonging to it which act as necessary and/or sufficient conditions allowing the instance to fall under and share in the sub-classification. These subcategories are often called building typologies. In reference to architecture as a type, "On Typology" by Rafael Moneo discusses the evolving meaning of *typology* throughout history, answering the question, "what kind of object is a work of architecture?" (Moneo, 1978, p. 23). Moneo offers a number of ways in which architecture can be classified or categorized into certain types including by: image, style, form, space, use, function, program, morphology, and method (a.k.a., process or activity).

'**Image**' as a typology is related to branding with symbolic recognition. The surface and core of the structure of a built form is irrelevant to image, such that image can be sold as a commodity and easily transferred or exchanged without a change in the architecture itself. Sustainable image might be given through a written sign on the building labeling it as "green-certified", or depictions of living organisms painted on the building's facade. Typology by image emphasizes the communication-significance and symbolic meaning in architecture.

Typology as '**style**' in architecture refers to its characteristic appearance. Where works of architecture of the same style have a similar character by a repetition of certain physical elements on the surface. When a particular formal lexicon is displayed with enough repetition across design projects to be noticed, it can be qualified under one genre (or style). The core structure of a built form need not be relevant to style since it is surface-oriented. While there is no one sustainable style, physical elements that would likely be characteristic of a sustainable style include the presence of vegetation or even just predominance of a spectra of green colors. While not always actually eco-sustainable, buildings that have a 'minimalistic' appearance (incorporating no ornamentation, plain surfaces, exposed 'raw' materials) conform to one style of 'green' architecture that symbolizes conservation.

The '**method'/ 'process'/ 'activity'** is typified by its crafted design (i.e., the kind of craftsmanship) or the particular technique for executing its building construction. Sustainable methods in architecture

might include: passive systems as oppose to active systems, or the stereotypical methods of 'vernacular architecture' with the use of local building methods that are easily relatable to the region's ecology and whose elements interact with the surrounding ecology in a mutually beneficial way.

"**Form**" as a typology characterizes architecture by the abstracted or "deeper" geometries contrived from the overall formal structure, and is dependent on the combination of surface and core physical elements together. Sustainable form can be exemplified in a design through its overall form acting as a metaphorical connection to the overall form of a tree. An alternative example might be the copying of patterns commonly innate to the figuration of living things in the figuration or arrangement of the form—being based on the same mathematical algorithm such as the Fibonacci sequence (e.g., an abstraction of the arrangement of florets on flowers and the spiral of a nautilus shell). One may also refer specifically to parts of the formal structure in architecture as it is a composition of physical elements or entities like columns, doorways, apertures, solar panels, etc. In general, sustainable form respects and abides to restrictions of the ecological features of the site and takes advantage of its opportunities. Thus, sustainable form may be identified in the way the form relates to its ecological context, such as when the orientation of the building takes advantage of solar rays for passive heating. Related to the form is typological '**use'** which classifies the way in which the parts of the built form are instrumentalized, that is, its responsive techniques or operations. Examples of the use include the operations of the parts of the formal structure like the use of walls for holding up the roof and the use of the roof to prevent rain from falling on the interior space. Sustainable use might be illustrated by openings that allow 'fresh' air to flow into the interior with an overhang innately blocks the glare of the sun, providing shade and a "cooling effect" for interior spaces.

'**Function**' is a classification of the genre or purpose of its use in reference to social activities. Functions in architecture include entertainment, education, relaxation, trade, and manufacturing. The most sustainable architecture likely incorporates a variety of functions, but not necessarily. '**Program**' is typified by the composite relation of functions in a building. Most building programs (including bars, libraries, theaters) are not generalized as sustainable. However, high-rise apartments and parking garages are stereotypically considered more sustainable programs in comparison to single- family

housing residences and parking lots. Sustainable programs are programs that are stereotypical to extra sustainable design, such as wetlands and permaculture gardens.

An architecture's '**space**' as a type is characterized by the formal quality of the inverse of the structure. This refers to the negative space left over between that which is solid, visible, and impenetrable matter. Inhabitable space can be open, free-flowing, and continuous, or discontinuous, dispersed, and enclosed. Determining what is the most sustainable space for a project is entirely relative to its functions, program and geographical context. Stereotypically, most buildings that are sustainable allow many uses to fit in a small area (requiring limited mass of building material and limited space within). One example of sustainable 'space' may be constricted and maze-like, as a dense forest, requiring a variety of kinaesthetic movements to navigate through. Alternatively, sustainable space may be tall and open overhead for the purpose of allowing sunlight to reach the far ends of a building's interior.

Finally, **'morphology'** as a type is related to an architecture's transformation either within the context of a series of buildings or within the context of the inner formal structural evolution of the building. The more sustainable morphology in architecture for high human population is a city as opposed to suburbs. On the other hand, the most sustainable density of buildings proportionally to park area in urban settings is still disputed and is entirely dependent on the characteristics of the ecosystem. Sustainable morphology might be exemplified by a collection of buildings that allow walkable access throughout a neighborhood, but also block extremely cold sea winds from picking up speed within the site through the buildings' irregular and overlapping arrangement in relation to each other. Each of these aspects of architecture, describing what kind of object it is, can be used to express sustainability in a particular way, and each can, thus, be used in the final form as sensory legibility of sustainability indicators.

Part II: The Evaluative Framework

Chapter 10: The Evaluative Framework

The evaluative framework for sensory legibility of ecological sustainability I introduce is one that can be used across different building types and various sustainable strategies (whether energy efficiency,

water reclamation and reuse, pollution prevention, etc.). It includes a number of criteria that can be used to evaluate the sensory legibility of sustainability in any particular built environment and to guide future planning and design. The framework can, thus, be used as a set of guidelines to achieve sensory legibly sustainable design. The criteria are derived from a number of sources that help to theorize, as exhibited in the theoretical framework of this thesis, what would make a design sensory legible. While the criteria themselves can be shortly stated principles, the ideas behind them connect into a web of principles, ideas, and theories that I integrated into my previously stated overarching theory of sensory legibility in sustainability in architecture.

The overarching theoretical framework is pertinent to the understanding of sensory legibility and its importance in sustainable architecture, but the evaluative framework is a method of putting the theory to practice. Obviously, what exactly is being evaluated must be known before such a thing can be evaluated. Due to the number of ways that architecture can be classified and distinguished, the criteria can be further diversified under different types of typology, such as: morphology, program, form, space, image, style, method, use, and function. The criteria cannot only be emphasized in architectural drawings, such as plan and section, but rather, the designer must look ahead to the final experience of the built environment, and consider how the sustainable techniques and principles reveal themselves in the built form.

The evaluative framework, made up of a number of principles, only takes flesh in design through real-life factors. One's theoretical posture and recognition of real-life factors at play in a particular situation both go into the decision-making process of the built form (i.e., the final architecture). Theory can be further derived from a generalization of all the world's particular designs. In this way, design theory and design practice influence each other back and forth as if in conversation. Yet, like the plurality of design solutions within sustainable architecture, there is an infinite vocabulary of forms when sensory legibility of sustainability criteria is used as a framework for design. Forms that manifest the concepts of ecological sustainability in architecture in a sensory legible way (exhibit the design's ecological functioning) are wide-ranging and arriving at a final architecture requires decisions also based on matters of taste, teleological and ecological functioning, utilitarian purposes, cultural-influences and artistic

freedom. Compromises between these base factors are necessary in built form—ones that the context will not give just one solution to in any given project. Therefore, the criteria will not provide a ready-made solution for design, which would result in some trend or style. Rather the criteria provide a framework as a context within which the designer can operate to promote sustainability. Built forms that apply these criteria promote sustainability not only in architectural design, but also, through the design, promote sustainable activities by educationally equipping people to make better, more sustainable day-to-day decisions.

Since architecture has a perceived manifestation of ideas, which can be communicated through its own special language (i.e., through the arrangements of physical forms that make up the habitat in which we live), we can better communicate (and presumably teach) sustainability through the built form by incorporating design criteria that enhances the sensory legibility of sustainability in architecture. The criteria for sensory legibility that I propose are:

1. the increase of transparency and visibility of form and spatial logic
2. the utilization or imitation of life and life-like processes and life's multi-sensory aesthetic characteristics
3. the implementation of multi-functional/multi-purpose forms to allow people to relate and interact with forms in multiple ways
4. the intentional linking of a structure's form to its ecological context
5. the use of cultural cues/expectations/norms/preferences on an aesthetic and sensory level

Chapter 11: The Coalescence of Biophilic Design and Sensory Legibly Sustainable Design

I first happened upon the term, *biophilia*, as the title of an imperative under the health petal of the Living Building Challenge evaluation system. Upon first reading, I thought the contextual use of the term to be identical to what would be the imperative of 'Sensory Legibility', if there was one. There was a strange, but obvious connection between my criteria for sensory legibility and the patterns of biophilia. I wondered if the establishment and focus of sensory legibility criteria for design and standard evaluation systems was already in place, only under the name of 'Biophilia'. Indeed, my methods for sensory

legibility and the methods behind biophilia in design included many of the same sensual aspects of environments composed of life and run by life-like processes. While both propose that such tactics in the built environment will lead to a desired corresponding behavior in those who experience such built environments, the end goals in behavior or rather the final benefits proposed are quite different. By different, I do not mean to say in contradiction. The benefits I propose are didactic and transformative of one's actions in an ecological sense. The benefits proposed by the theory of biophilic design are health, well-being, and workers' productivity. Thus, the significance of the tandem research on biophilia is that, beyond the intended educational and inspirational benefits of sensory legibility in eco-sustainability of architecture, the practical significance of my criteria is now proven to have great health, well-being, and workers' productivity benefits.

There are fourteen patterns of biophilic design listed by the report which can are organized into three categories, according to the report: 'Nature in the Space', 'Natural Analogues', and 'Nature of the Space'. The fourteen patterns "provide a framework for understanding and enabling thoughtful incorporation of a rich diversity of strategies into the built environment" (Browning, Ryan, & Clancy, 2014, p. 23). In description of the three categories, Terrapin Bright Green LLC explains, "Nature in the Space addresses the direct, physical and ephemeral presence of nature in a space or place [See numbers 1-7 in Figure 1]. This includes plant life, water and animals, as well as breezes, sounds, scents and other natural elements…Nature Analogues addresses organic, non-living and indirect evocations of nature. Objects, materials, colors, shapes, sequences and patterns found in nature, manifest as artwork, ornamentation, furniture, décor, and textiles in the built environment" (p. 23). Examples of 'Nature Analogues' "provide an indirect connection with nature: while they are real, they are only analogous of the items in their 'natural' state" (p. 23) [See numbers 8-10 in Figure 1]. Finally, "Nature of the Space addresses spatial configurations in nature. This includes our innate and learned desire to be able to see beyond our immediate surrounding, our fascination with the slightly dangerous or unknown; obscure views and revelatory moments; and sometimes even phobia-inducing properties when they include a trusted element of safety" (p. 23) [See numbers 11-14 in Figure 1].

Figure 1: The 14 Patterns of Biophilic Design (Browning, Ryan, & Clancy, 2014)

1. Visual Connection with Nature
A view to elements of nature, living systems and natural processes.

2. Non-Visual Connection with Nature
Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes.

3. Non-Rhythmic Sensory Stimuli
Stochastic and ephemeral connections with nature that may be analyzed statistically but may not be predicted precisely.

4. Thermal & Airflow Variability
Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments.

5. Presence of Water
A condition that enhances the experience of a place through the seeing, hearing or touching of water.

6. Dynamic & Diffuse Light
Leveraging varying intensities of light and shadow that change over time to create conditions that occur in nature.

7. Connection with Natural Systems
Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem.

8. Biomorphic Forms & Patterns
Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature.

9. Material Connection with Nature
Material and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place.

10. Complexity & Order
Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.

11. Prospect
An unimpeded view over a distance for surveillance and planning.

12. Refuge
A place for withdrawal, from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.

13. Mystery
The promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.

14. Risk/Peril
An identifiable threat coupled with a reliable safeguard.

The patterns as listed are a product of a differing theory (particularly in the understanding of the meaning of the word *nature* and its relationship to humans, technology, and life) and other psychological and behavioral implications. The patterns seem to share the same underlying methods of expression and valued perceptible qualities as I have described in my principle criteria for “the utilization or imitation of life and life-like processes and life’s multi-sensory aesthetic characteristics”. The other criteria for sensory legibility I propose may, thus, be seen as enhancing biophilic design, but these are not articulated as biophilic design criteria, themselves. The implications in the report are supported by offering references to many empirical studies on the beneficial effects on health and productivity of biophilic design patterns on humans, on which Browning, Ryan, & Clancy conclude:

“Physiological responses encompass our aural, musculoskeletal, respiratory, circadian systems and overall physical comfort. Physiological responses triggered by connections with nature include relaxation of muscles, as well as lowering of diastolic blood pressure and stress hormone (i.e., cortisol) levels in the blood stream (e.g., Park et al., 2009). Physiological responses to environmental stressors can be buffered through design, allowing for the restoration of bodily resources before system damage occurs (Steg, 2007).” (Browning, Ryan, & Clancy, 2014, p. 11). Displaying how the various ways of connecting with “nature”, or rather life, offer different benefits, the following chart by Browning, Ryan, & Clancy connects the biophilic patterns to human health, productivity, and well-being:

TABLE 1. BIOPHILIC DESIGN PATTERNS & BIOLOGICAL RESPONSES

Table 1 illustrates the functions of each of the 14 Patterns in supporting stress reduction, cognitive performance, emotion and mood enhancement and the human body. Patterns that are supported by more rigourous empirical data are marked with up to three asterisks (***), indicating that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, and no asterisk indicates that there is minimal research to support the biological relationship between health and design, but the anecdotal information is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern.

	14 PATTERNS	*	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection with Nature	***	**Lowered blood pressure and heart rate** (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	**Improved mental engagement/ attentiveness** (Biederman & Vessel, 2006)	**Positively impacted attitude and overall happiness** (Barton & Pretty, 2010)
NATURE IN THE SPACE	Non-Visual Connection with Nature	**	**Reduced systolic blood pressure and stress hormones** (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)	**Positively impacted cognitive performance** (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004)	**Perceived improvements in mental health and tranquility** (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
NATURE IN THE SPACE	Non-Rhythmic Sensory Stimuli	**	**Positively impacted heart rate, systolic blood pressure and sympathetic nervous system activity** (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)	**Observed and quantified behavioral measures of attention and exploration** (Windhager et al., 2011)	
NATURE IN THE SPACE	Thermal & Airflow Variability	**	**Positively impacted comfort, well-being and productivity** (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	**Positively impacted concentration** (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	**Improved perception of temporal and spatial pleasure (alliesthesia)** (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
NATURE IN THE SPACE	Presence of Water	**	**Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure** (Alvarsson, Wiens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006)	**Improved concentration and memory restoration** (Alvarsson et al., 2010; Biederman & Vessel, 2006) **Enhanced perception and psychological responsiveness** (Alvarsson et al., 2010; Hunter et al., 2010)	**Observed preferences and positive emotional responses** (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphryes et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983)
NATURE IN THE SPACE	Dynamic & Diffuse Light	**	**Positively impacted circadian system functioning** (Figueiro, Brons, Plitnick et al., 2011; Beckett & Roden, 2009) **Increased visual comfort** (Elyezadi, 2012; Kim & Kim, 2007)		
NATURE IN THE SPACE	Connection with Natural Systems				**Enhanced positive health responses; Shifted perception of environment** (Kellert et al., 2008)
NATURAL ANALOGUES	Biomorphic Forms & Patterns	*			**Observed view preference** (Vessel, 2012; Joye, 2007)
NATURAL ANALOGUES	Material Connection with Nature			**Decreased diastolic blood pressure** (Tsunetsugu, Miyazaki & Sato, 2007) **Improved creative performance** (Lichtenfeld et al., 2012)	**Improved comfort** (Tsunetsugu, Miyazaki & Sato 2007)
NATURAL ANALOGUES	Complexity & Order	**	**Positively impacted perceptual and physiological stress responses** (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		**Observed view preference** (Salingaros, 2012; Hägerhäll, Laike, Taylor et al., 2008; Hägerhäll, Purcella, & Taylor, 2004; Taylor, 2006)
NATURE OF THE SPACE	Prospect	***	**Reduced stress** (Grahn & Stigsdotter, 2010)	**Reduced boredom, irritation, fatigue** (Clearwater & Coss, 1991)	**Improved comfort and perceived safety** (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
NATURE OF THE SPACE	Refuge	***		**Improved concentration, attention and perception of safety** (Grahn & Stigsdotter, 2010; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
NATURE OF THE SPACE	Mystery	**			**Induced strong pleasure response** (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
NATURE OF THE SPACE	Risk/Peril	*			**Resulted in strong dopamine or pleasure responses** (Kohno et al., 2013; Wang & Tsien, 2011; Zald et al., 2008)

(Browning, Ryan, & Clancy, 2014, p. 12)

In concurrence with the benefits listed by Browning, Ryan and Clancy, the health benefits of contact with vegetation, including promotion of well-being, reduced stress, and decreased recovery times from illness have been reported by several authors (for example, Rhode and Kendle, 1994; Ulrich et al., 1991; Ulrich, 1984, and Moore, 1982).

Therefore, an equally viable title of this thesis could be, "The Sensory Legibility of Biophilic Design". Biophilic design patterns present one sort of framework for subcategorizations of the sensory legibility criteria listed as number two in my Evaluative Framework: "the utilization or imitation of life and life-like processes and life's multi-sensory aesthetic characteristics". For the purpose of my own framework in relating to the theoretical prose of what is 'organic' in the built form, I sub-categorize Criteria 2 as: utilization or imitation of minimally human-modified materials (rocks, water, soil, plants and other organisms or body parts of dead organisms); utilization or imitation of life processes (incorporating various passive strategies or happenings that are commonly found in biodiverse habitats) or life-like processes (such stimuli response, self-adaptation, homeostasis, etc.); the utilization or imitation of life by its aesthetic characteristics. The life-like aesthetics include: diversity (or variation; contrast), richness of aesthetic detail, harmony (or coherence; unity of pattern), complexity (or indiscernible patterns; irregularity), progressive ephemerality (or animate; subject to flux in a self-advancing way), novelty (or uniqueness), immensity, and exoticness.

Chapter 12: Projects for Illustrating Sensory Legibility Criteria in the Built Environment

Sensory legibility can be established in a variety of ways including: cultural multi-sensory cues; visibility or transparency of structural elements; the use of more passive and life-like strategies in structural building and functioning; and the emphasis on highlighting life and life-like processes of the site through design with signs, landmarks, and multi-functional/multi-purpose applications of the ecological apparatuses for eco-sustainable built forms. As an effort to illustrate the sort of sensory legibility as I have defined it previously, I will offer examples of how sensory legibility in sustainable built environments is achieved based on sensory legibility criteria—giving flesh to the theory that only offers generalized strategies.

In choosing sites for illustrating the application of my sensory legibility criteria, I felt it pertinent to restrict the selection to urban buildings rather than rural ones, since most of the population is constrained to living in cities. Moreover, urban buildings receive the greatest number of visitors, quantifiably maximizing the importance of sensory legibility of sustainability of the particular built environment or edifice by the usefulness to the majority of the human population. Further limiting the selection of the case studies, I chose projects in the United States, given the relevance that cultural values have to the topic of sensory legibility and my greater familiarity with American cultures. To further narrow the scope of this thesis, I chose to primarily focus on one factor of ecological sustainability within the built environment: water use. A broader scope might have included other sustainable factors like healthy indoor air quality, eco-effective waste and emissions (or rather nutrients) management and disposal, and eco-effective use of building materials or energy (for lighting, heating, cooling, public transportation, etc.). Of course, the interplay of various factors as an interconnected system will inevitably require some assessment of each when these factors overlap or work in unison with the water use of a building. The reason I chose water use is because I thought it would more likely have the greatest potential for incorporation in the built form in a multitude of sensory legible ways.

Testing this criteria out on the concept of water usage of eco-sustainable urban built environments in an American city, I use published documentation on the ecological sustainability of two urban built environments as well as my own in-situ experiences of them. The architectural projects I have chosen for illustration of sensory legibility criteria are an office building, The Bullitt Center, and a building whose primary program is a children's classroom, the Bertschi School Living Science Building. Both these structures exist within an urban setting in America and excel in eco-sustainable water use at the highest standard available in sustainable building design—The Living Building Challenge.[19] Chris Hellstern, an architect of the science wing, in his book, "Living Building Education: The Evolution of the

[19] The Living Building Challenge sets strict performance standards for the built environment for full certification, one being net-zero water loss. The Living Building Challenge (LBC) is described by the Buckminster Fuller Institute (BFI) as a "holistic, performance-based building standard, measuring ecological impact over the lifetime of buildings" (BFI, 2015). Moreover, the BFI says that "The Living Building Challenge defines the highest possible level of environmental performance, envisioning a built environment that is fully integrated with its ecosystem. It pushes the building industry to re-imagine business as usual, and it transforms building occupants from passive consumers into active stewards of increasingly scarce resources" (BFI, 2012). The 2012 winner of the Buckminster Fuller Prize, LBC has been established as "the built environment's most rigorous and ambitious performance standard" (BFI, n.d.), to the International Living Future Institute.

Bertschi School's Science Wing" (a part of the Living Building Challenge book series), writes, "the idea behind the Living Building Challenge" is to create "buildings that act like living organisms to restore our environments" (Hellstern, 2014, p.24). Given that a major contention of this thesis is that eco-sustainable products and built environments are most eco-effective, and sensibly so, when they are life-like, the very goals of the challenge are well-suited to provide projects that exemplify sensory legible eco-sustainability in architecture.

The highest standard for water use in buildings currently implemented in green building evaluation systems, including The Living Building Challenge, is net-zero water loss. A building with net zero water performance is self-sufficient in terms of its water uses and management through a combination of on-site water harvesting, conservation and recycling techniques. These techniques enable a building to function entirely on its own as an off-grid water system (i.e., not connected to a city-wide sewer system or a public water-supply system). For net zero water, an urban building must incorporate techniques to treat greywater and blackwater and to prevent storm water runoff, as well as meet a building's water demands all through the immediate site and its resources. Mary Ann Thomas, author of "The Greenest Building: How the Bullitt Center Changes the Urban Landscape", defines greywater as "water that has been used in sinks, drinking fountains, dishwashers and showers" (Thomas, 2016, p. 66), and blackwater is the liquid and solid material from toilets.

Chapter 13: The Illustrations

Figure 3: The Salish Sea and its Puget Sound (Sanctuary Publishing, 2015)

The site of both the Bullitt Center and the Bertschi School is the city of Seattle, Washington. Seattle is not a Pacific coastal city, but is rather, located along the coast of an inland sea, known as the Salish Sea [See Figure 3]. The Salish Sea is the official geographical name for "the inland marine sea comprised of Juan de Fuca Strait + Strait of Georgia + Puget Sound and their connecting channels, passes and straits", covering an area of approximately 7,000 mi^2 (Province of British Columbia, 2015). Seattle is located along the southern portion of the Salish Sea, known as the Puget Sound and is a part of the Cascadia bioregion (land west of the Cascade Range) [See Figure 3 and 4].

Figure 4: Map delineating Seattle, Mt. Rainier, and the Cascade Range in Washington (Worldatlas.com, 2016)

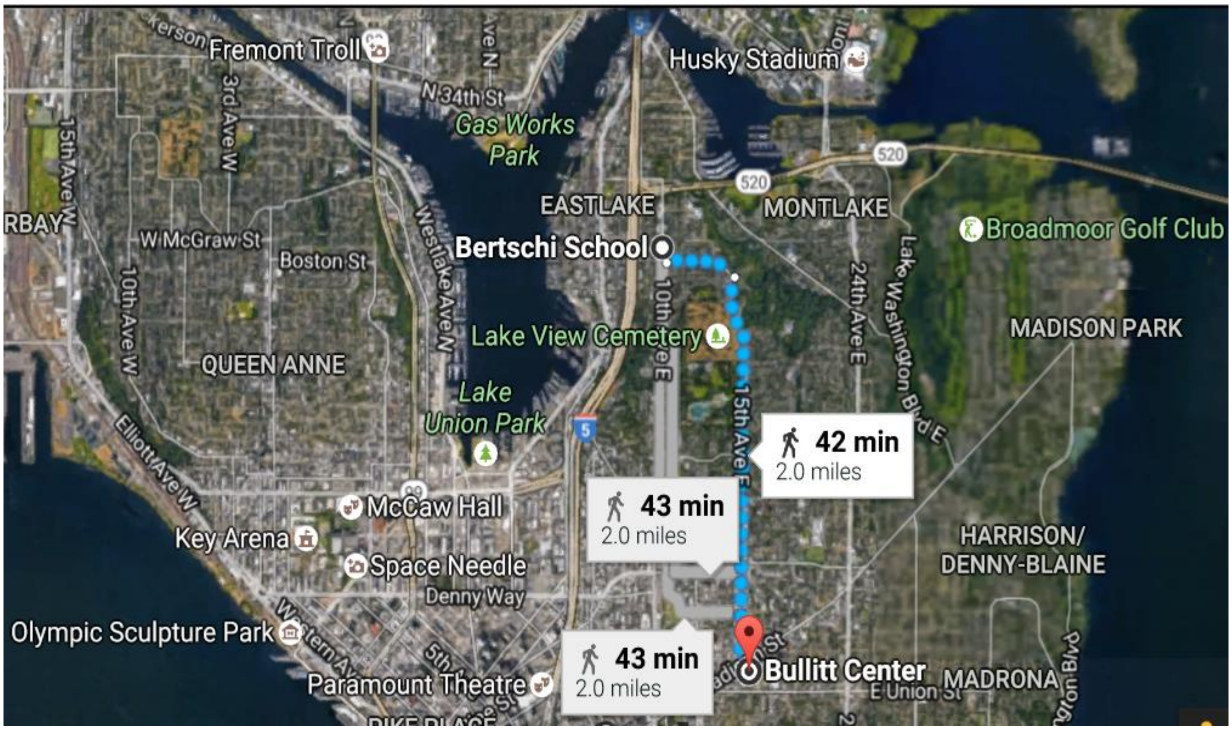

Figure 5: The Bertschi School and Bullitt Center in Seattle

Figure 6: View over Lake Union from the Space Needle toward Gasworks Park (on the left), the University of Washington campus (near the center) and Capitoline Hill (on the right), the neighborhood of both the Bertschi School and the Bullitt Center

Figure 7: The Bertschi Science Wing (during the winter season, pre-visitation of the site) (Bertschi.org, 2016 p.1)

Figure 8: The Bertschi Science Wing after recently planting the ethnobotanical garden (pre-visitation of the site) (p. 1)

Designed by a team led by KMD Architects, the Living Building project at the Bertschi School required for its program: a restroom facility, an Ecohouse (i.e., a separate greenhouse structure), a garden and a classroom. The Bertschi School website explains that the living building's "net zero water is achieved through a variety of methods including cisterns for storage, an interior green wall which treats greywater, and a composting toilet to treat blackwater. Excess captured water is absorbed by the on-site rain garden…" (Bertschi, 2016). All the water necessary for the building's utility demands are captured through rainwater and the building possesses the necessary equipment to make the water potable. However, the city grid provides for all of the building's potable water demands due to public building code regulations. For now, the rainwater is only used for demands that do not include drinking water. Bertschi can provide its own water for a whole year, were the purification system to become legalized to allow for human consumption of the rainwater that falls on-site. Students and staff can receive valuable lessons about their use of water and needs with the help of digital monitoring devises, kinesthetically interactive

Figure 9: View of the Bertschi School campus as an entire neighborhood block. The Science Wing with its ethnobotanical garden is located on the far north side of the site (Hellstern, 2014, p.19)

devises, and visually or tactically-exposed phenomena through its Living Building. The water system, in terms of its capturing, transporting and storing of rainwater is limited in its complexity by its passive approaches, which allows for easy understanding.

Figure 10 and 11: Ethnobotanical Garden (during my visitation of the site: Summer 2016)

Designed by a team led by Muller Hull architects, the Bullitt Center is now the most sustainable mid-rise building in ecological performance on the planet—harvesting its own water, generating its own power and treating its own waste (Thomas, 2016, p. 32 & p. 40). Thomas offers a summary of the Bullitt Centers features for the Imperatives “Net Zero Water” and “Ecological Water Flow” announcing,

Figure 12: The north-face of the Bullitt Center

Figure 13: The Bullitt Center (summertime)

"The Bullitt Center provides, stores, and treats its own water through a rooftop rainwater collection system, basement, storage cistern, and a basement treatment and pumping system. Rainwater supplies all of the building's potable and non-potable water needs, including drinking, and washing, dish washing, showering, toilets, and limited landscape irrigation… Rainwater collected on the building's roof membrane is diverted [through gutters, downspouts and rain leaders] to the cistern in the basement; greywater includes all sinks, showers, dishwashers, and floor drains; controlled interval pumping flushes greywater to a Recirculating Gravel Filtration System (RGFS) on the third floor, which uses evapotranspiration and microbial processes to filter the water to permitted standards; cleaned effluent is discharged to a drain field in front of the building; wastewater is treated in ten composting units; excess leachate is pumped to stabilizing tanks; stabilized leachate is picked up monthly and treated locally" (Thomas, 2016, p. 173)

Figure 14: Map of the neighborhood of the Bullitt Center

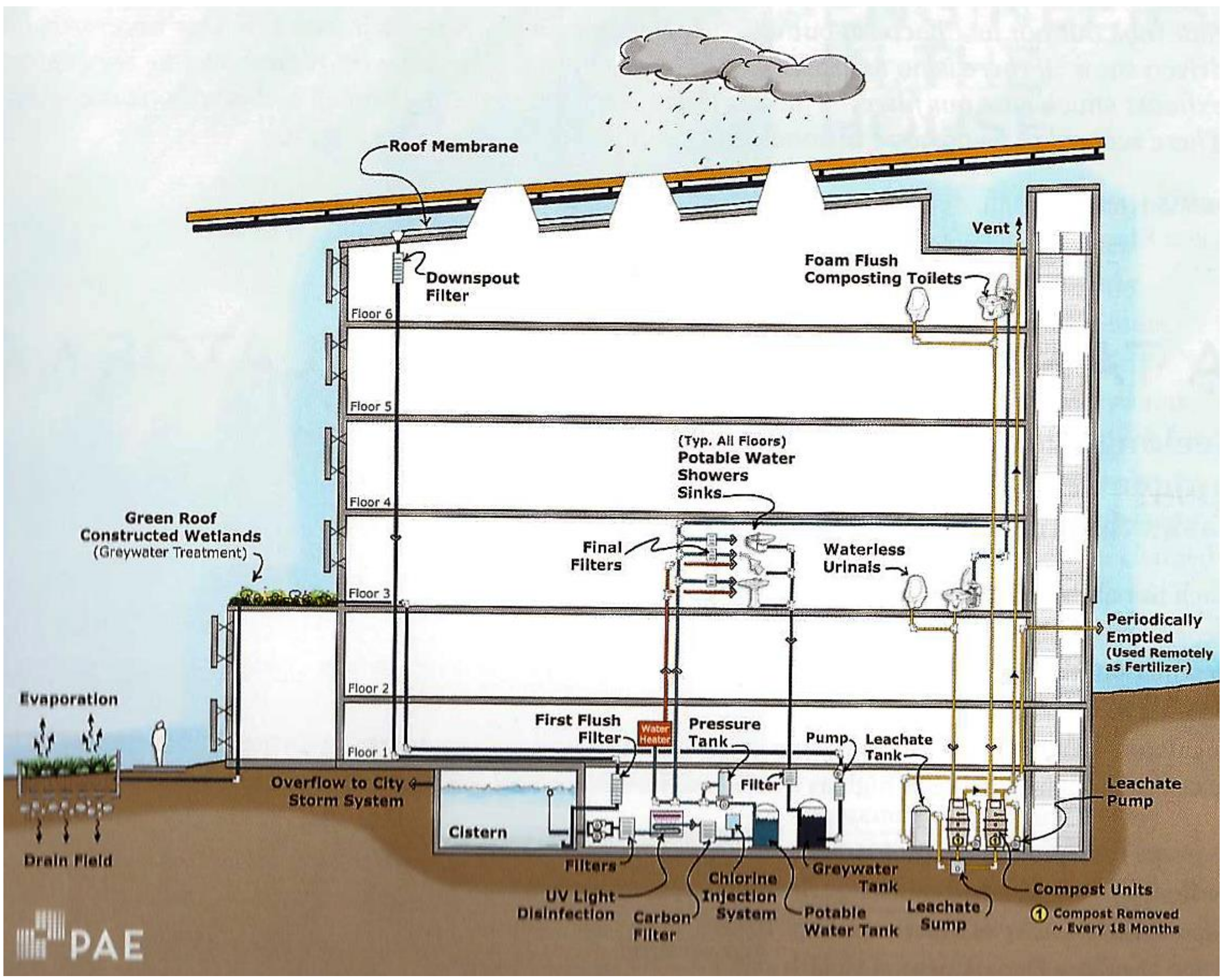

Figure 15: Diagram of water use design features

With the general eco-sustainable water processes incorporated within and around the Bullitt Center and

Bertschi School Science Wing listed, I will illustrate how each of these buildings incorporate sensory legibility in terms of their eco-sustainable water use according to each sensory legibility criteria that I have presented. For the sake of organization and minimizing redundancy, some design features that incorporate multiple criteria will be introduced under the subheadings for one criteria. Other design features are discussed under multiple sub-headings when applicable.

Criteria 1: The increase of transparency and visibility of form and spatial logic:

How does the Bertschi School Science Wing meet Criteria 1?

The building envelope of the science wing and the connecting ethnobotanical garden itself are the primary features in the built form that carryout the eco-sustainable functioning of the design in terms of its water use [See Figures 7, 8, 10 and 11]. More specific parts of the building contributing to the eco-sustainable water functioning of the project that are visible from a variety of a places (within the project's perimeter and from looking out the windows of several classrooms) include: a rain chain [See Figure 85], a green wall [See Figure 20], an interior and exterior runnel [See Figure 93, 103-104], and various rain leaders [See Figure 27, 34-35], roofs [See Figure 24, 33, 36, 39 and 81-83], downspouts [See Figure 22 and 31], tops of cisterns [See Figure 70], vegetation [See Figure 12], pervious pavements [See Figure 106] and one exterior rainwater filter [See

Figure 16: Potable water treatment machine

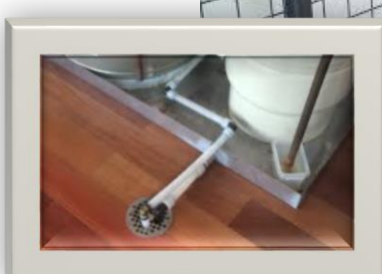

Figure 17 and 18 The water heater is visible only on the second story of the Ecohouse

Figure 24 and 25]. The water heater [See Figure 18] and the machine for treating rainwater for potable water is visible in the Ecohouse in less prominent places---on the second story loft and behind the staircase [See Figures 16, 20 and 21]. Much of the grey water facilities and black water facilities

Figure 19: Science Wing restroom: toilet (left side), greywater filter box and compost units (right side)

Figure 20 and 21: Potable water treatment machine located behind the Ecohouse staircase

are concealed behind cabinets and closet doors [See Figures 19]. The solid and opaque interface of the containers and machinery (including machines for potable water, water heating, and greywater and blackwater facilities) prevents transparency of their inner workings.

Being only visible in part, the connections between the where the rain leaders get the rain and where the downspouts lead is not always visible or navigable (**Criteria 1**). Thus, both the downspouts and rain leaders are still lacking in creating a sensory legibility of

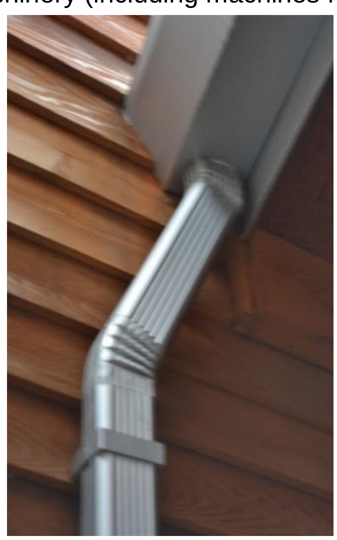

Figure 22 and 23: Downspouts: Connections from gutters to the building interior

the hydro-ecological process [See Figures 22, 23, 26-35]. To make these features more sensory legible and transpicuous, portions of the wall that surround the connections can be transparent (i.e., see through) so that one can easily trace the flow of water from its source to its destination, as well as the components that carry out the process of filtering the water within them. Hellstern discusses the use of various filters that are "included with the system to help remove any particulates or debris that may enter the system from the collected rainwater" (Hellstern, 2014, p. 79). The filters within the design are not at all sensibly legible to the building's occupants,

Figure 24 and 25: Rain water is funneled to a filter on the side of the butterfly roof closest to the Ecohouse. See Figures 26 and 27 for the interior rain leader that the water that filters here flows into.

being hidden within the infrastructure (with the exception of one filter that can be seen on the V-shaped roof, if one pays close attention, from a classroom in the old church building window [See Figure 24 and 25]).

Figure 26 and 27: Rain leader directly under filter from the roof heading from the classroom into the Ecohouse [See Figure 25]

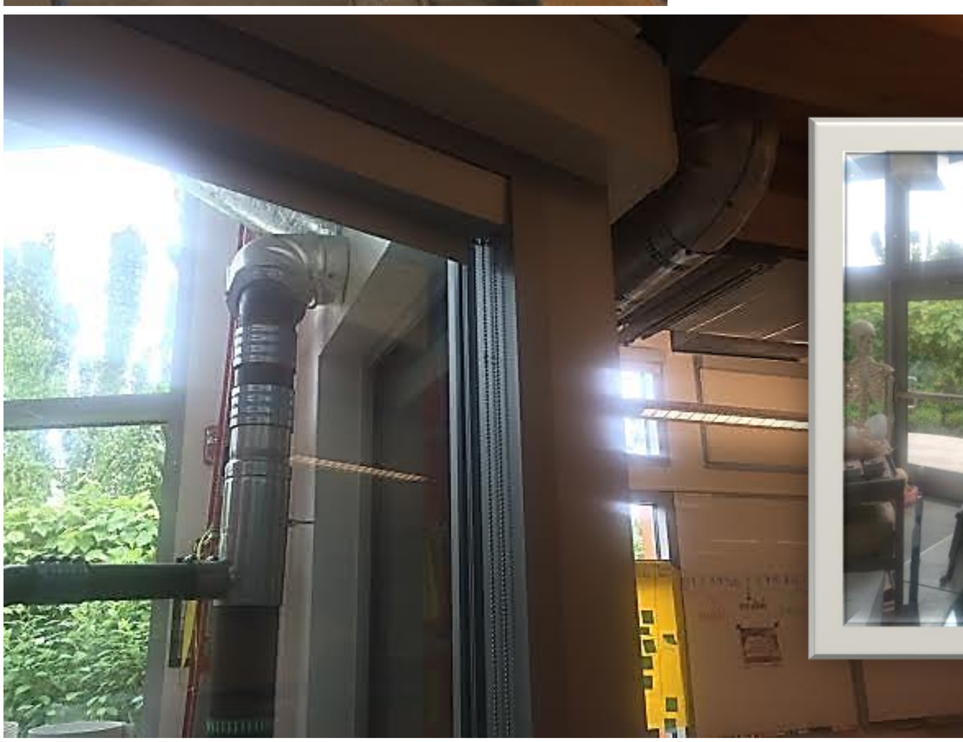


Figure 28 and 29: Rain leader connected to the butterfly roof and entering the runnel before entering the cistern in the Ecohouse

Figure 30, 31, 32 and 33: Downspout coming from the roof of the school building to which the Living Building was added onto, and entering into the butterfly-shaped roof (Figures 39 and 40 shows the rain leader the downspout connects to)

Figure 34 and 35: Rain leader entering the classroom from the downspout that leads to the butterfly-shaped roof (seen in Figures X and X) coming from the abutting building

Because of the extensive use of transparent glass on the façade that acts as an interface between the building and garden. Visibility of much of the science wing interior is available from within the garden and vice versa [See Figure 8 and 29]. The interior of the garden and the roof of the science wing is visible from windows of other classrooms on the north side of the campus [See Figure 24 and 33]. With seasonal

variance, partial views of the science wing exterior and garden can be seen from immediately outside the campus boundaries [See Figures 7, 37 and 38].

Figure 36: Pre-existing church building converted to classrooms on the Bertschi campus, and the new science wing attached to the left of the renovated structure (located behind the wooden fence)

While visiting the Bertschi School during the summer of 2016, the vegetation of the ethnobotanical garden was in its prime season [See Figures 10 and 11]. At that time, much of the building, itself, was hidden behind the lush of vegetation growing just outside. The Science wing lies behind an opaque wooden fence in the front, an overgrowth of plants along the gridded metal fence on the north side, and buildings on the other sides [See Figures 36-39]. Being partially hidden and small in proportion to the renovated church building, the

Figure 37 and 38: Obscured views of the Science Wing from just outside the school on the public sidewalk

Figure 39: View of the Science Wing from the sidewalk out front

Living Building is neither visibly prominent nor apparent to outsiders, and in this way, is lacking in the increase of transparency and visibility of form and spatial logic. On the other hand, the classroom has vibrantly-colored wood cladding and an inverted roof top with dramatically jutting eaves (**Criteria 5: Bold Patterns**). These aspects along with the oblong second story glass façade of the Ecohouse peak over the fencing, and are visible from across the street as an unconventionally-shaped (**Novelty**) and reflective form, in stark **contrast** to the image of the old church building (now school building) next to it [See Figure 36]. The visually novel and bold patterns, and vibrant coloring and reflectivity of the living building that can be partially seen from over the fencing may lead any passersby to inquire further into what lies behind the fence This increases the transparency and visibility of form and spatial logic which demonstrates Criteria 1, but also demonstrates **life-like characteristics** **(Diversity, Novelty and Harmony)** of Criteria 2, and **bold patterns** appealing to **cultural preferences** which is characteristic of Criteria 5. Yet, requiring a certain amount of privacy as a primary school, the accessibility of the Living Building is restricted to two scheduled tours a month. Otherwise, this building is accessible only to students and staff. This privacy puts limits on the visual exposure that the building can have to the community and passersby. To get a general understanding of the building, one must enter inside the complex.

How does the Bullitt Center meet Criteria 1?

The Bullitt Center exterior is highly visible to the public from all five sides [See Figures 12, 13, X, and X]. Previously the site of a parking lot and bar, the Bullitt Center closely neighbors a school and apartment building as well as McGilvra Place Park (Thomas, 2016, p. 52). Towering over its neighbors (including the trees of the park) this 75-foot six-story building with its extended roof line is visible and prominent even at a distance [See Figure 12]. Located on a triangular lot and sandwiched between two major

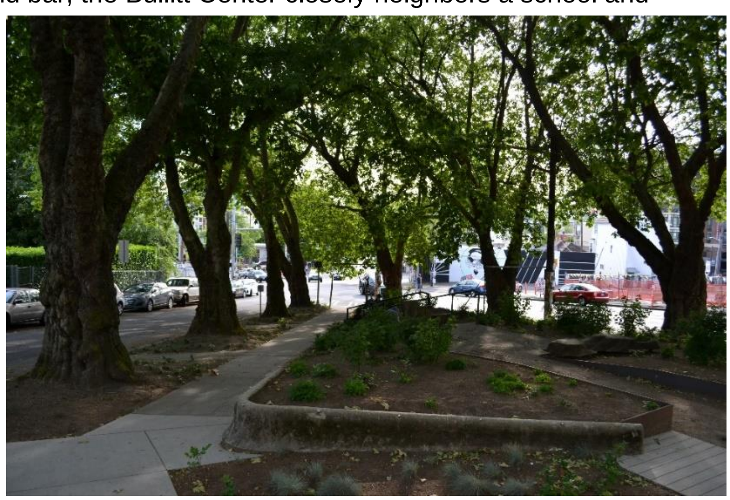

Figure 40: View from inside McGilvra Place Park

roads, the small urban park (McGilvra Place Park) connected to the Bullitt Center is visible from all angles and can be easily accessed and viewed from within the Bullitt Center and park, itself [See Figures 40 and 41]. The park's tall trees (in proportion to the area of the triangular block) stand out from the cityscape around it [See Figure 41].

Figure 41: View from inside McGilvra Place Park

In contrast to the high visibility of the overall built form, most of the water system is either on the rooftop (out of a possible viewshed), in the basement, in the first-floor mechanical room or hidden underground. People who reside and work in the office space would have to leave the room and floor where they carry out their daily activities and travel down to the basement to have any experience of most of the ongoing processes of the water system. The Bullitt Center exposes portions of its water piping to offer glimpses of the mechanisms for water

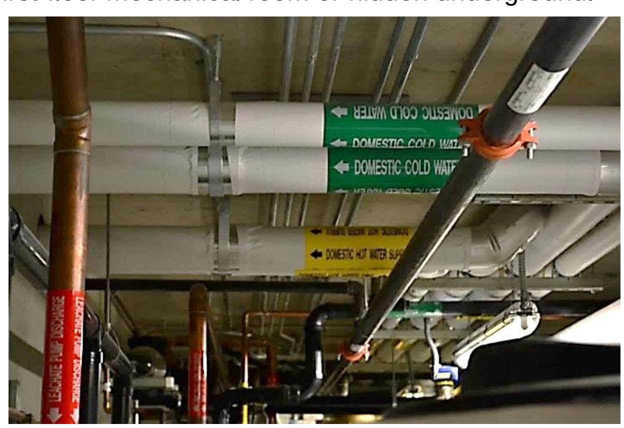

Figure 42: Water Piping exposed overhead in the basement

transportation throughout the building's interior [See Figures 42]. Otherwise, the passage of rainwater cannot be visibly tracked as it travels on the roof, from the roof to throughout the building, or out from the building.

The horsetail equisetum wetland beds used for greywater treatment are visible from McGilvra Place Park, across the street, and from the building's stairwell & office windows on the third-floor [See Figures 43, 45 and 51]. Like the rainwater piping, the transportation of greywater to the beds is unnoticeable or untraceable. The greywater storage tank and some of the

Figure 43: Bullitt Center with green roof on third floor

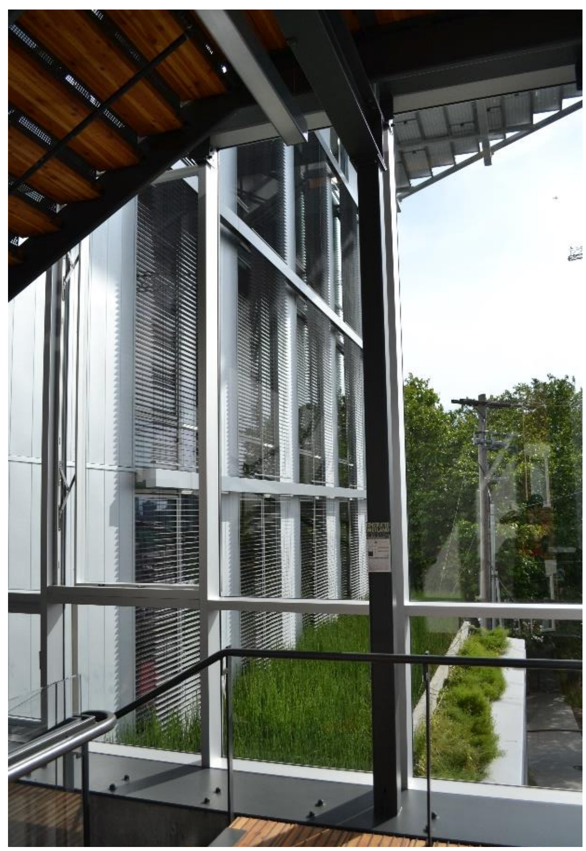

Figure 44 and 45 Constructed Equisetum Bed for greywater treatment (view from the thrid floor stairwell)

Figure 46 and 47: Grey water storage tank in the basement

piping are in view in the basement, but from that point, the <u>greywater pipes</u> disappear [See Figures 46-49]. From the third floor of the stairwell, one can get very close to the wetland planter bed. Through stairwell windows that peer over the Equisetum, one can see a sign with a diagram and summary of the building's greywater system. The diagram may be quite revealing to anyone with limited academic knowledge of ecological systems, yet these are not the built forms themselves. The diagrammatic drawings of the process appear to be more direct and simple than the true process,

Figure 48 and 49: Greywater piping in the basement

and lack the ability to allow one to experience the life and life-like systems themselves. Diagrams can only supplement one's understanding from the actual built forms. Given that the framework to house the planter bed is the building itself, an improvement to the visibility of this system could be made by revealing the pipe to the bed by making the surrounding portion of the framework transparent, thus showing the transition of the greywater. This would also reveal the

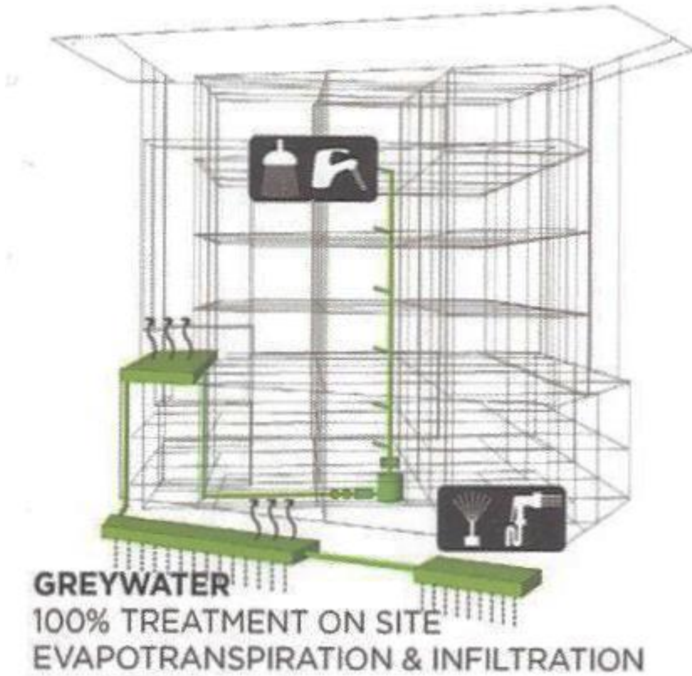

Figure 50: Greywater treatment diagram

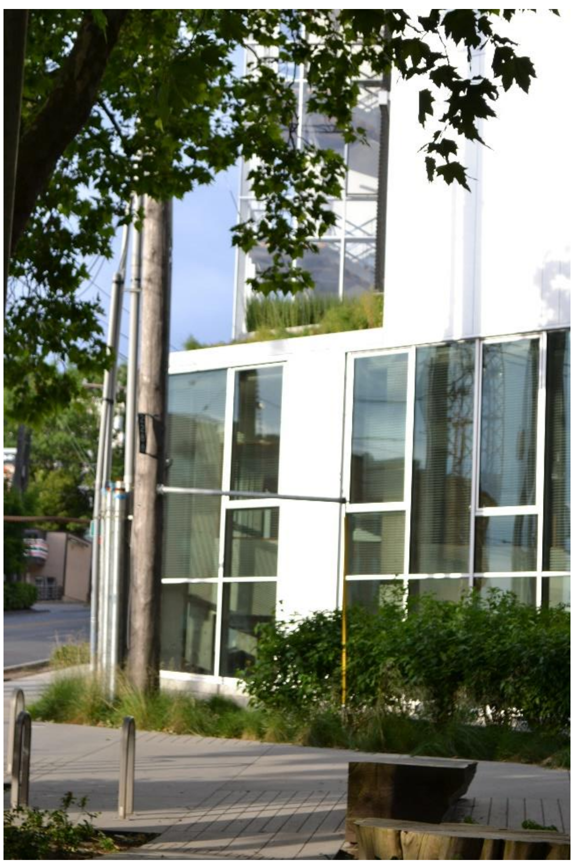

Figure 51 and 52: Greywater treatment beds on-site (on roof and near entryway

layers in the bedding which might suggest levels of filtration and implications for how water can be treated.

Figure 53 and 54: Greywater treatment beds on-site underneath entryway

From the first Equisetum bed, the water continues to travel down hidden pipes to Equisetum beds just below the walkway in front of the entrance to the building [See Figure 50 and 55]. The tops of the Equisetum plants can be found popping up above the level of the walkway from two or three feet below-grade, and can be seen by pedestrians, offering some visibility to the design feature, but not to the extent that reveals the purpose of the beds (**Criteria 1**) [See Figures 52 and 54]. The placement of the beds at a lower grade than the walkways suggests that they are meant to trap and collect stormwater, but give no hint to their actual operation of treating greywater from its nearby building. Even though there are signs posted throughout the building for greater legibility of the sustainable processes that the building undertakes, there are no such educational signs along the walkway. Given that this is the most publicly accessible design feature for the water system of the building, it has an underdeveloped potential to educate observers about eco-sustainable building practices for water use, to demonstrate relationships to the ecological context, and to encourage people to investigate the building's eco-functions further.

Figure 55: Greywater treatment beds on-site underneath entryway

Various potable water features (sinks, drinking fountains, toilets) are visible as much as one might find in a typical office building. Some mechanics for water treatment and storage are visible from the basement, such as composters and leachate storage tanks [See Figures 56-59]. The leachate containers are somewhat translucent, indicating that they are filled with liquid of some sort but are no way visibly connected to the process of extracting the leachate [See Figure 57].

Figure 56: Composting blackwater in basement

Figure 57: Leachate storage in basement

Figure 58 and 59: Leachate piping, storage and discharge

Criteria 2: The utilization or imitation of life and life-like processes and life's multi-sensory aesthetic characteristics:

How does the Bertschi School Science Wing meet Criteria 2?

Present among the water utilities at the Bertschi Science Wing are many **minimally human-modified materials** like water, rock, wood siding, a biodiversity of plants, as well as symbolism to animal-life biodiversity [See Figures 61, 10 and 20]. **Imitations of life**, plant and animal-like artwork is located right next to the runnel and green wall.

Figure 60: Interior runnel with salmon artwork

Figure 61: View from inside the classroom toward the garden (see rocks below)

Artistic representations include salmon and sea anemone like that of the Puget Sound, placed on or near the runnel, and the symbolic representation of a river (See section "Exemplary Illustrations of Sensory Legibility" on page 111) [See Figure 60]. Bronze castings of local insects are found on the green walls [See Figure 62].

Figure 62: Bronze casted beetles next to the Green wall

Bertschi's Living Building **utilizes and imitates many life processes** [See Figure 63]. While most roofs intercept rainfall, most do not uptake that water deep within the interiors of the building (unless there is an unintentional leak). Hellstern admits that the shape of the roof was necessitated by functional concerns, as he states, "In a true case of form follows function, often a necessity in sustainable design, the main roof of the Bertschi building is a butterfly shape to funnel rainwater to rain leaders directly inside the building" (pp.78-79). Derived from its functional purpose—the propensity for directing and capturing rainwater—the form of the roof is visibly and spatially indicative of the hydrological processes of the building. In imitation of the hydrologic cycle[20] of the earth, rain falls on the classroom roof and, like

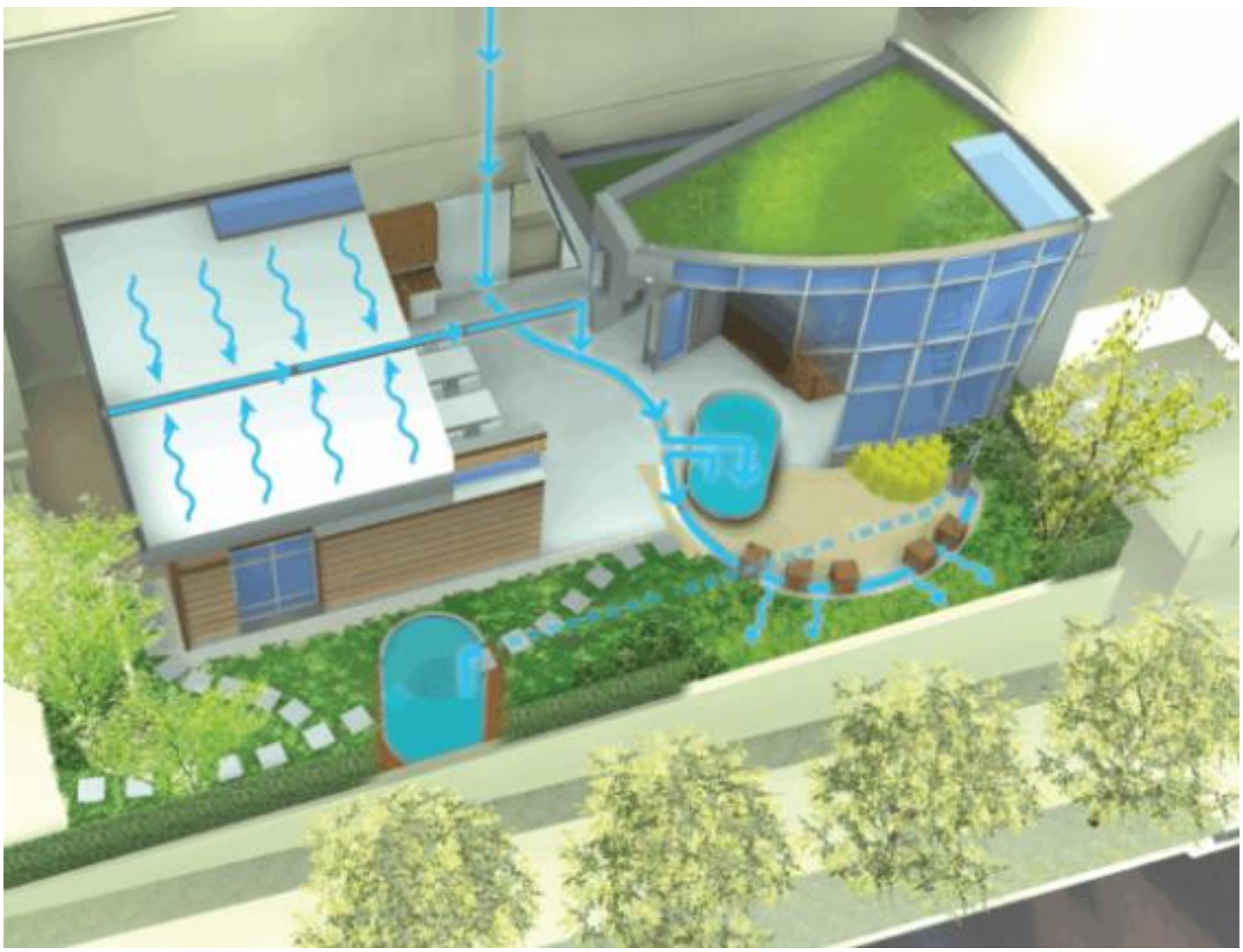

Figure 63: The process of capturing rainwater, transporting it, storing it, and releasing it back into the soil for irrigation

[20] The hydrologic cycle, also known as the water cycle, "describes the existence and movement of water on, in, and above the Earth. Earth's water is always in movement and is always changing states, from liquid to vapor to ice and back again… all life on Earth depends on it continuing to work" (USGS, 2016). "The water cycle is an important process that recycles water and nutrients. In doing so, it brings freshwater to people, animals and plants all around the world" (Reference, 2016)

surface runoff, flows downslope till it reaches the lowest point on the surface of the roof, the filter, at which point it filters through and “infiltrates” the building. Like water infiltration into soil, the water from the rain leader pipe is quickly transferred by gravity downward until it hits the floor of the science wing (an “un-infiltratable” surface). Much like interflow, by route of the interior runnel that slopes downward from the pipe, the rainwater is propelled by the force of gravity down to the cistern. The water from the runnel falls into the underground storage cistern (located below the Ecohouse floor) and resides until the cistern fills up, or the water either leaks out by evaporation or is extracted out. Imitation of the hydrologic cycle, water filtering and “infiltrating” the building, interflowing by gravity, residing in a cistern then evaporating or being extracted out are all aspects that add to Criteria 2 in terms of **utilizing and imitating life processes**. The transfer of water from the runnel to the cistern water storage is analogous to ground water storage below the water table, in which rainwater eventually seeps into an area that concentrates large amounts of water and travels no farther toward the core of the earth.

After running through the greywater filter boxes, the greywater from the classroom and restroom sinks is pumped up to the Ecohouse green wall. Called “the most expressive sustainable design feature and teaching tool for the project” (p. 87), the green wall acts like a vertical wetland, treating greywater through phytoremediation [See Figure 64]. “Phytoremediation is the direct use of green plants and their associated microorganisms to stabilize or reduce contamination in soils, sludges, sediments, surface water or ground water” (EPA, 1999, p. 11). (Behind the vegetation, “The plants are held in a non-soil

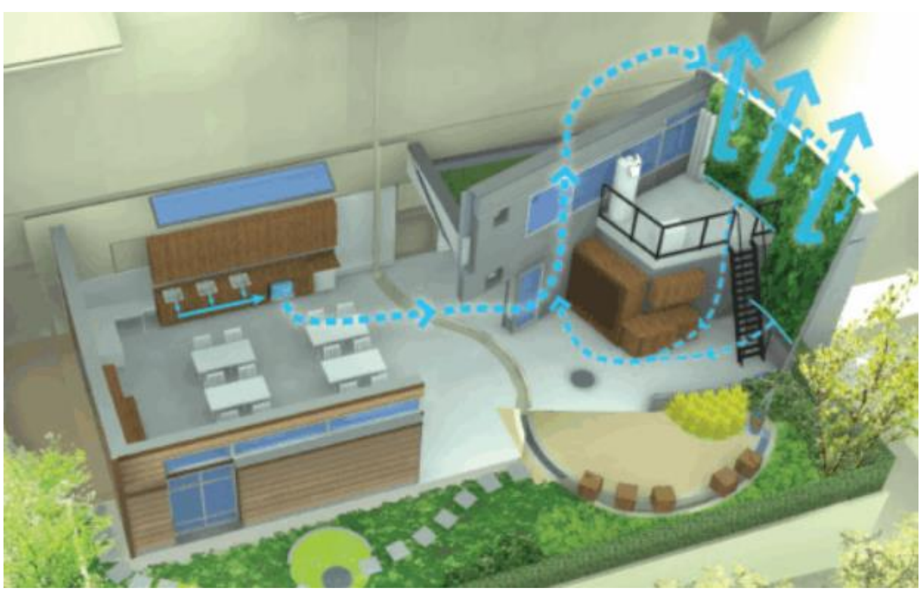

Figure 64: Greywater from sinks are pumped to the green wall after passing through greywater filter boxes to irrigate and transpire

structural growth medium composed of coconut husk which reduces erosion and maintains plant longevity while also reducing maintenance [See Figure 65]. The plants and coconut husks are housed within one foot by one foot aluminum planter boxes. Each box is mounted on a metal support frame attached directly to the interior exposed concrete wall of the Ecohouse. Running throughout the entire framework of planter boxes is a series of irrigation lines that delivers the greywater from the science room's sinks through slow drips directly to the growth medium" (p. 87). After absorbing the greywater, it is released by the plants as water vapor through transpiration into the air. The processes of the green wall describe a passive system except for the pump that feeds the water back through the cycle until it fully transpires. The wall consists of a variety of three common household plants, which on the surface look as if they are in no particular arrangement or pattern. The plant **diversity** and **undisguisable pattern** within this living wall gives this part of the greywater treatment process a clearly organic form and composition and, thus, **a life-like aesthetic**. The two-story green wall has the quality of immensity, being the largest interior wall in the Living Building and entirely covered in vegetation. Since the sink water is used as the plants primary irrigation water, the plants must absorb any particulates that are not filtered out by the Aqua2 Greywater filter box. The green wall serves as a learning experience to students and staff of their true water use impact, as they have to manage how much the sinks are used and the quality of water (e.g., sending black paint down the drain may cause the green wall to exude grey foam). In meeting Criteria 2, the green wall utilizes plant-life and life processes for the built forms water use, such as the

Figure 65: growth medium and structure of the green wall

slowing soaking and spreading of water through infiltration of the coconut husk medium (a **minimally human-modified material**), and phytoremediation and evapotranspiration through the plants.

There are many life-like characteristics in terms of aesthetics and symbolism that are related to the Science Wing's water features. The overall built form carries **novelty** through its glass curvilinear façade; V-shaped roof; and green wall inside [See Figures 8 and 20]. **Ephemerality** is expressed through the evolution of plants in the garden/green wall/green roof. Consistent with the qualities of a living system, the immediate exterior of the site is quite **ephemeral** in appearance, form and space, subject to seasonal changes as well as progressive and evolutionary annual changes [See Figures 13, 14, 21 and 22]. Every angle and view of the exterior of the Bertschi School Science Wing is continually undergoing change in a **self-advancing** way. There is also a **transitory** and **animated** variation in the flowing of water in the runnel, on the rain chain [See Figure 85] and in the level of water in the cisterns. **Complexity** and **irregularity** are exhibited in the meandering and indiscernible planting pattern of the garden, and in the unpredictable growth of migrating plants on the green roof from wind-blown seeds [See Figures 81-83]. Along with biodiversity of plantings in the garden, the aesthetic of **diversity** is presented in the contrast between the classroom (angular and primarily wood façade with a metal V-shaped roof), the Eco-house (curvy and primarily glass façade with a flat green roof), and the dull-colored old church building (now school building) next to it [See Figure 8]. There is **harmony** and **coherence** in its conformity to the local use of western red cedar siding. **Coherence** is also shown in the combination of glass/cedar siding/steel on both the classroom and Ecohouse. From inside to outside the building, there is site **coherence** through the presence of vegetation (on the green wall and green roof, and in the ethnobotanical garden) and the runnel (which is **uniform** in size throughout its length) [See Figures 93 and 103].

The roof, itself, is a mixture of organic and inorganic qualities. The roof has a **novel** form that is suitably-shaped to its purpose (adapted to the wet climate in a self-advancing way), yet its visible outer interface is made of one nonliving and non-bioavailable technical nutrient (tactilely and visibly monotonous): steel. Made of metal and simplified and geometric in form, all are characteristics in opposition to the aesthetic characteristics of life. The roof acts as a **diverse** component to the site when its metal angular V-shape is viewed in contrast to the Eco-house curvy and primarily glass façade with a

flat green roof and the dull façade of the old church building. The metal roof harmonizes with the metal-framing of the Ecohouse curtain wall façade. Thus, **Criteria 2** is exemplified through the roof with life-like aesthetics including **novelty**, **diversity**, **harmony**, as well as in its obvious figural adaption to the rainy climate in a self-advancing way (**a life-like process**), which is aesthetically expressed through **progressive animation** of water when it rains on the roof.

Sensory legibility of eco-sustainability is present within design when the solution to the design problem presents itself to those who live and work with the product in a way that is respectful and beneficial to ecosystems, giving occupants a suitable basis for the built form in their own practical understanding. The Science Wing's design solution for tackling rainwater is clearly expressed through the roof in the propensity of its form to capture rainwater and the visibility of rainwater gathering into the runnel at the center of the roof from the windows of classrooms in the abutting building (**Criteria 1**). Thus, the design is sensory legible in its eco-sustainable water use for this part of the hydrological process. For further expression of Criteria 2 as illustrated by the Bertschi School Science Wing, see section: "Exemplary Illustrations of Sensory Legibility" located at the end of this chapter.

How does the Bullitt Center meet Criteria 2?

As the tallest building in the neighborhood with a large overhanging solar panel roof (used to capture rainwater) that extends past the sidewalk perimeter and over the street, the Bullitt Center's most dominant life-like characteristic is **immensity** (as well as **novelty** in its the roof shape and make-up, i.e., completely solar panels) The form of the building is recognized by many passersby as having the metaphorical form of a tree. The roof is made up of solar panels which are noticeable even from the ground upward (as the panels are translucent such that the grid of pentagonal-shaped solar cells is distinguishable when the light is shining down on them), creating further symbolic reference to the photosynthesis of trees (**Imitation of Life**) [See Figure 66]. Thomas purports that "at the Bullitt Center,

Figure 66: solar panel roof (view from ground level)

gutters function like the concave leaves of a plant—designed to funnel water so it can stay on sit to serve the structure's systems and eventually replenish the ground" (p. 61). Yet, one has no way of sensing that the rainwater is captured and funneled by gravitation through gutters beneath the solar panels and piping inside the building from the interior or exterior (Imitation of a tree's water-intaking process). The evolution and movements of plants around the exterior of building and in the urban park, as well as the motorized blind system gives the site a sense of **ephemerality.**

The **coherent** use of long rectangular-shaped equisetum wetland beds (**Utilization of Life and Life Processes**), both on the third floor building exterior (**Novelty** of the green roof), and at ground level in front of the building connects the building with the rest of the site in a harmonious way. The presence of wood furniture, décor and structural framing, and potted plants contributes to the interior's collection of **minimally human-modified materials** within the building, and its **utilization and imitation of life**. These also act as cultural cues to eco-sustainability (Criteria 5)—the potted plants being a **cue for care**, and the

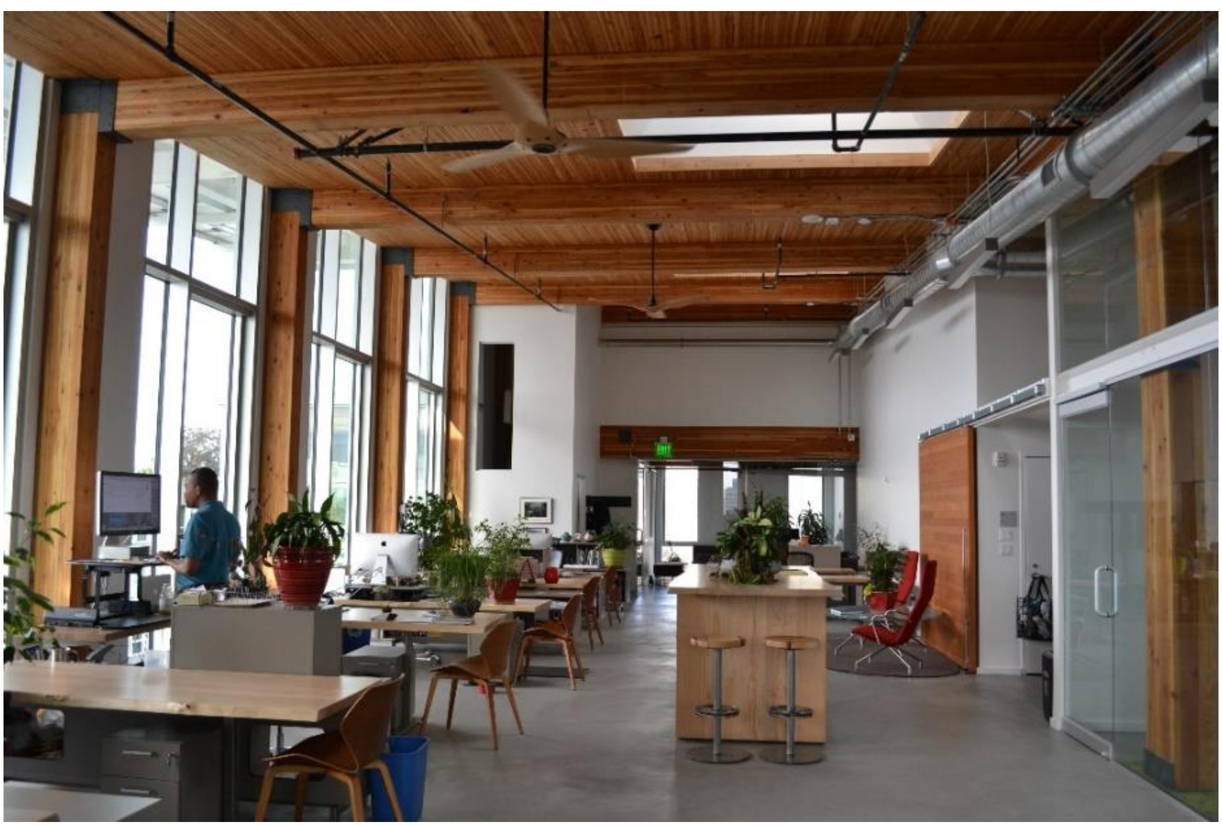

Figure 67: Sixth floor of the Bullitt Center (view of potted plants and wood décor))

wood construction and décor is a common regional building craft and expresses the unique ecological character of the region (having an abundance of lumber resources). The eco-sustainable toilets on site. Imitate life in their **diverse** use aesthetics, **novelty** (diverging from the conventional toilet) and **animation**. The automatically dispensing foam (noisily) and the strange cool breeze one feels from the vacuum suction contributes to the toilets unique set of multi-sensory effects.

Figure 68 and 69: First floor public compost toilet

<u>Criteria 3: The implementation of multi-functional/multi-purpose forms to allow people to relate and interact with forms in multiple ways:</u>

How does the Bertschi School Science Wing meet Criteria 3?

Figure 70: The underground cistern in the Ecohouse accessible through removal of the manhole (Bertschi, 2016)

Figure 71: Hand pump that extracts rainwater from the cistern within the Ecohouse (Bertschi, 2016)

There are two underground cisterns used by the Living Building, one underneath the floor slab that the interior runnel connects to, and the other is located underneath the ethnobotanical garden just outside the building (See section: “Exemplary Illustrations of Sensory Legibility” located at the end of the chapter) . In combination, they can store enough water “to supply enough water [for the site’s water demands] year-round based on rainfall” (Hellstern, 2014, p. 78). One item on the student wish list was for cisterns that are “clear” to allow students to monitor the rainwater being stored on-site. Yet, Hellstern explains, “In order to fit our two cisterns on the tight urban site while meeting zoning codes prohibiting the exposed size of cistern we would need on-site, we located them below grade” (p. 79). Being below grade, the cisterns had to be of the durability of concrete. Therefore, to allow students to assess the amount of water stored in the cistern located under the garden at any given time, a few different strategies were implemented into the design.

The first underground cistern is physically accessible from inside the Ecohouse. It has a metal cover on the surface of the floor that can be removed by hand to do water testing by the students (**Criteria 1 and 3**). Water can also be extracted from it with a hand pump located a few feet away from the opening to the cistern (**Criteria 3**). To teach students about the consequences of wasting water or using it inefficiently and the importance of conserving and reusing water, “the old-fashioned hand-operated pump located in the Ecohouse was installed…” by requiring “a little effort into extracting water from the Ecohouse cistern using the pump” (p. 91) (**Criteria 3**). By making the water in the cistern visible, tangibly accessible and multi-purpose (for education and academic curriculum activities), and by incorporating a sense of work required to pump water against the forces of gravity, the design allows for greater sensory legibility of the ecological processes at play than the typical turn of a faucet or water hose (**Criteria 3 and 2: Life-Like Processes and Tactilely Novel**). Meeting Criteria 3, the first cistern incorporate multiple tools for water measurement—the pump, top access and a digital tacker of the amount of rainwater, while it also stores rainwater.

Figure 72: Rainwater cistern monitoring system

Supplemental to sensory legible features, legibility features of the eco-sustainable features within the building include many monitoring systems and lettered signs scattered throughout the building, which can be read by any of the staff or students [See Figures 44 and 54]. The Bertschi School website reports, “As part of the Science curriculum, Bertschi 4th and 5th graders monitor and record these things with the help of the instruments in the building” (Bertschi, 2016). Signs, of course, can also be misleading, like the one below, which suggests that the water in the cisterns is potable. The water in the cisterns is actually rainwater and not potable water. Secondly, the water level is measured in percentage, which gives little indication of the true amount of water in the cistern.

Another example of multi-functional water use features is the green wall, which covers a whole interior wall that the stairwell of the Ecohouse extends across to allow interaction with plants as one travels up and down. At the same time, it treats greywater and allows for plant irrigation. Illustrations of multi-functional design features that also have a role in the water use of this site abound and are further discussed in later sections.

How does the Bullitt Center meet Criteria 3?

The design feature that incorporates the constructed wetlands for greywater treatment also serves human purposes as the main entryway into the building, such that one crosses/walks over the wetlands for access in and out of the building to the urban park, and over which there is a bench to sit at [See Figure 53

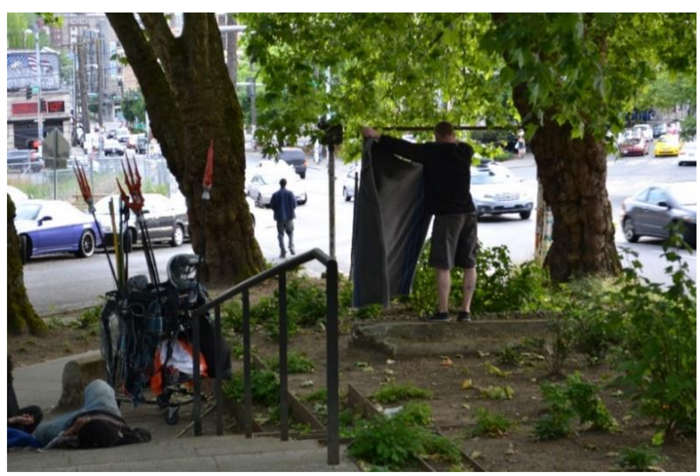

Figure 73: Park for the homeless

and 55]. The bridging over the wetlands could have been designed in a way to encourage a passerby to go up and look over the wetlands by drawing attention to them through a change of kinaesthetic (going up and over, slowing the pace). Instead, these were designed to be flat and conceal the interlinking of one wetland bed to the next. The urban park is

Figure 75: Parkour

multi-functional as a place for ping pong, sitting, Parkour, relaxing, running, as well as stormwater management. This multi-sensory urban park adds to the richness of aesthetics and ephemerality/animation of the site with singing trees, dappled lighting, and seasonal vegetation variations.

Criteria 4: The intentional linking of a structure's form to its ecological context:

How does the Bertschi School Science Wing meet Criteria 4?

There is an intentional linking of the science wing interiors directly to the garden by door access allowing one to enter directly into the garden from the science wing, and window apertures allowing the smells, sounds, sights and feel of the garden to penetrate the classroom and Ecohouse. The 'V' Form of the roof is insinuative of capturing rainfall, and intentionally connects the Science Wing form with its hydrologic processes to the climate conditions of the site, allowing the rainwater to be visibly seen falling and flowing into the roof. Moreover, the roof meets **Criteria 1** its spatial logic being visible (from inside the classroom, in the garden, off campus, and from looking out of windows in nearby classrooms). The roof meets **Criteria 1, 2 and 4** by directly linking the spatial logic of the form ('V'-shaped) to its ecological context as a rainy climate, being insinuative of capturing rainfall. Mimicking life processes, the built form allows the rainwater to fall on the roof and flow by gravitation toward the runnel located along the mid-line of the roof. The flow of water towards the mid-line and into the roof can be seen from various classroom windows near the science wing and can be visually inferred within the classroom, off campus, and in the garden.

How does the Bullitt Center meet Criteria 4?

Figure 76: Sixth floor view to Olympic Mountains

Figure 78: Looking out toward the park from the Bullitt Center foyer

Figure 77: vegetation views just outside office space windows

With large floor-to-ceiling windows and a curtainwall of windows in the main stairwell, the building does create visual links (spectacular views) with immense ecological features around Seattle including the Olympic Mountains and Mount Rainier. On the immediate surrounding site,

the park, the greywater treatment beds and the stormwater runoff managing planting strips can be seen from various window views. From the interior, none of these can be sensibly connected with to the water use and flow within the building. There is also direct entry and exit from the Bullitt Center into the urban park.

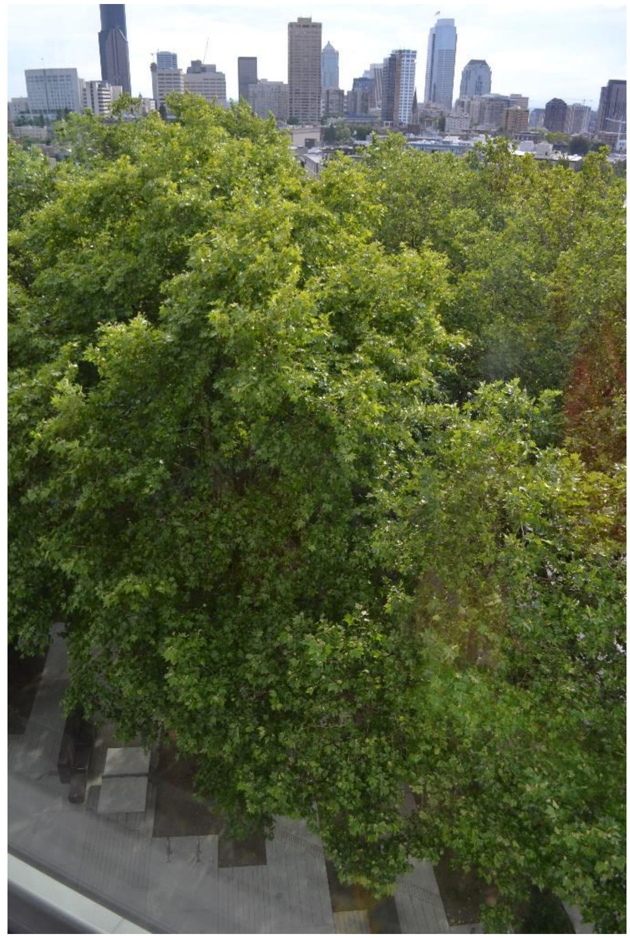

Figure 79: vegetation views just outside office space windows

Criteria 5: The use of cultural cues/expectations/norms/preferences on an aesthetic & sensory level:

How does the Bertschi School Science Wing meet Criteria 5?

The cultural cues exhibited at the Bertschi Science Wing include the **orderly-framing of vegetation** such as the green wall, which is geometrically-constrained by its wall perimeter. Despite the unpredictable growth and 'messiness' of the plantings on the moss matt roof (from the randomness of migrating plants), **orderly-frames** are built into the design using pebbles (pebble-

Figure 80: Moss roof top over the restroom and classroom entry with its orderly pebble framing (shape derived from a geometric abstraction of a nautilus shell

framing) [See Figure 80]. Also aligning to **cultural preferences**, the Science Wing incorporates many **bold patterns** such as the figuration of pavement [See Figure 106], the circular-shaped grass bed around the outdoor cistern [See Figure 107], and the configuration of the building itself. The plants in the ethnobotanical garden are significant to the historic tribal background of the region and are thus appealing to a particular subculture of the region (See section "Exemplary Illustrations of Sensory Legibility"). The runnel in the classroom has a sinusoidal form which fits the **cultural norm** of how flowing streams should look and at the same time symbolizes a river (**Criteria 2: Imitation of Life Processes**) from whence the cultural norm likely developed [See Figure 93].

Figure 81: View out the windows of the Ecohouse over-looking the moss matt roof of the restroom and entry to the science wing

Green roofs are one of the most obvious cultural cues in America toward eco-sustainability (**Criteria 5**). The roof can be seen from the classrooms in the abutting school building, allowing the roof a level of visibility (**Criteria 1**). The rooftop moss can also be seen directly from the second story Ecohouse windows overlooking the roof of the restroom, **increasing the transparency of the spatial logic within the design**, such that one can get close and personal to see the direct effects of rainfall on the roof. Such

use of life as a material of the built form makes the building not only life-like, but in part, alive (**Criteria 2: Utilization of Life and Life Processes**).

Figure 82 and 83: Roof top view from other Bertschi classrooms

Western red cedar, a longtime-standing tree common to the region and well-adapted to regional climate, physiography and soil, was used as the lumber siding of the school science wing. The design of the siding is a concept borrowed from the Salish style plank wall, a vernacular building technique, named after the Salish Sea. Like the vernacular prototype, an arrangement of overlapping western red cedar planks effectively sheds rainwater from the sides of the building, protecting the micro-climate of the building interiors from water moisture, and shedding water from the walls to the pervious rock bed below. However, as effective and familiar to Northwest architecture overlapping wood siding is, the overlapping arrangement of panels (of varying materials) as siding is frequently used in non-eco-sustainable buildings. Unlike the wood of the vernacular prototype, the strong scent and visible uniqueness of each individual board has been exchanged for a more refined (heavily processed with technical machinery) and universalized beveled panels with a smoother finish, cleaner straight edges, perfectly rectilinear shape and a more vibrant color. The wood grain is still visibly obvious and thus draws some visual connection to the ecological context (**Criteria 4**) and the living organisms from which the wood came (i.e., local trees of the region) (**Criteria 2: Imitation of Life**). Yet, the forms spatial logic can be conceptually grasped instantly with its strict regularity. Thus, the forms themselves only scarcely resemble the pattern and texture of living organisms. The choice of material exposes the high impermeability of the wood, in being able to restrain from heavy saturation and water leaks on the interior. The uses of the western red cedar siding for water drainage (renown for it high impermeability

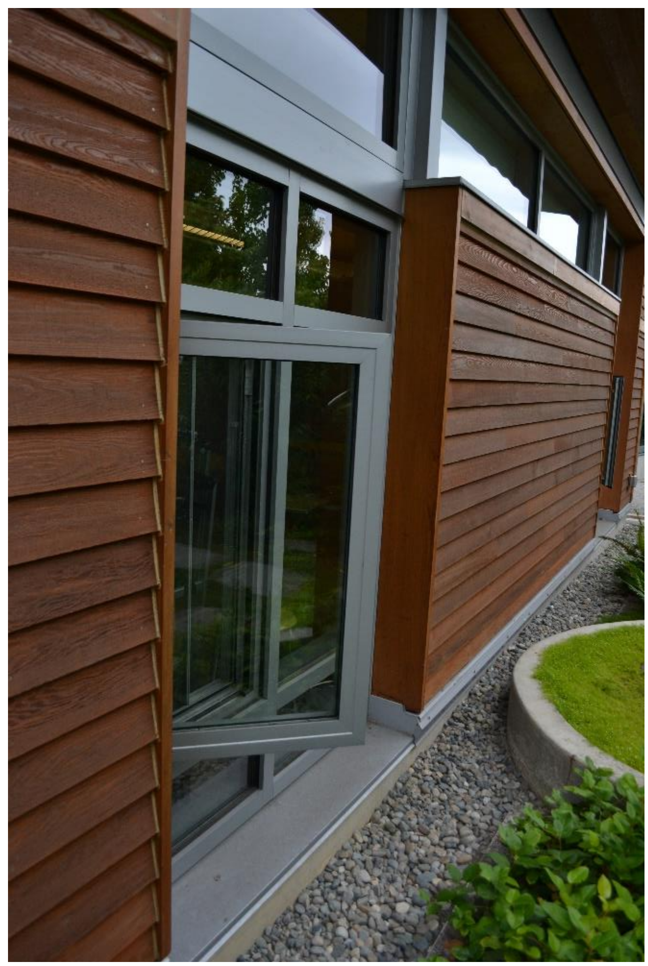

Figure 84: Western Red Cedar Facade

to liquid) on the science wing is easily discernible when it rains (**Criteria 1**). **Culturally**, the style appeals to historical roots that supports the unique identity of the area, and, thus, adds to an overall **unity of pattern** to many buildings in the region, as well as with other buildings on the Bertschi School campus (**Criteria 2 and Criteria: 5**).

Most people in America, even those who have never been to the Northwest, consider Seattle to have a rainy and cloudy climate (although the average annual precipitation is not as much as it is given credit). With this cultural 'knowledge', when the perceiver sees this V-shaped roof within its context [See Figure 24-26], the perceiver is likely to draw the conclusion that the building's design purposefully captures and utilizes rainwater. Thus, the roof is sensory legible according to **Criteria 5** through its bold pattern and its appeal to cultural knowledge. In addition, minimalism in the built form, which includes an absence of any ornamental features and an exposure of building materials, is often attributed to ideas in Western Culture of conservation and thus, sustainability. Acting as cultural cues, the materials of the exterior resemble the minimalistic style, such as the all-metal roof, along with the exterior façade of glass and simple wood cladding. Exposing the structural materials is often seen as an attempt of the designer to achieve ecological sustainability in terms of conservation. It can also be regarded as an attempt to be forthcoming in revealing the ecological uses of the structure, or as an attempt to show off, with full visibility, the materials that are easily recyclable and toxic chemical-free.

Hellstern, Bertschi staff, designers, and many design critics describe the classroom roof as butterfly-shaped or mimicking a tree canopy. Thus, the building has attained symbolic or analogous reference to a butterfly or tree, which is potentially a true resemblance in the eye of other acculturated perceivers. Instead, this description seems more likely to be a tool of embellishment of the design in speech by supporters of the Bertschi cause to further appeal to cultural innuendos that relate to the concept of sustainability. In other words, although the roof does intercept rainfall from the soil like a tree, such pictorial characterizations of what the roof resembles are probably more of an afterthought to embellish the sustainable aspects of the building, rather than an intentional mimicking of form by the designer. Such cultural innuendos might trace back to ideas in Christian culture like the butterfly, which is

symbolic to resurrection and immortality, and the tree—symbolic to life (Stafford, 1942, 92, 145). When referencing butterflies and trees, the implications infer the building is life-like in form and function.

The rain chain is used as a means of transporting water from the roof to the ground, much like a downspout, yet in a less concentrated, more attenuated way—effectively spreading out the flow of water. This design feature is another **cultural cue** in America, demonstrating **care** for the eco-environment. It is also multi-sensory—creating a **unique** sound (**Criteria 2: Novelty**), and allowing one to watch as rain travels down it (**Criteria 1**), **animating** the glass cups on the chain (**Criteria 2: Ephemerality**), and splattering water over a large area (**Criteria 1**). This rain chain looks like a work of art, serving as another interactive and fascinating water amenity (**Criteria 3: Multi-purpose**) that is visible from within the Ecohouse and near the entry to the Ecohouse in the garden (**Criteria 1**).

Figure 85: Rain chain

How does the Bullitt Center meet Criteria 5?

Orderly-framing is used throughout the site for all vegetation in urban park, greywater constructed wetlands and stormwater runoff managing planter beds, and interior plants (Potted plant-life and a handful of

Figure 86: Orderly-framing of vegetation

artistic representation of plants in picture frames are in office spaces and conference rooms within the building). There is also consistent **bold geometric patterns** throughout the site, including: the urban park pavement and the configuration of the building itself. Wood construction is frequently understood within the culture of Seattle as eco-sustainable to use as a

Figure 87: Orderly-Framing of the urban park

construction material, and as a material that connects to the unique ecological character of the region. Other cultural cues in this building for eco-sustainability can be found in its 'honest' of structural materials

Figure 88: Orderly-Framing of the urban park

Figure 89: Orderly-Framing of the urban park

(exposed and unornamented surfaces; cracks left intentionally in the concrete). In addition, the building interior uses primarily hues that are common to plant-life—greens, greys and browns. The **vegetative coloring** in artwork and décor acts as culture cues to further imply eco-sustainability.

<u>Exemplary illustrations of Sensory Legibility (Incorporating four or all five of the criteria)</u>

The Bertschi School Science Wing

The runnel and second underground water cistern:

Hellstern asserts, "When designing a building's stormwater management system, the place to begin is with stormwater. In the case of the science building, all stormwater that falls on the site must be

managed through natural means. The idea is to mimic the natural pre-development conditions of the site (the Cascade Forest)" (Hellstern, 2014, p. 84). Instead of having the project's downspouts and rain leaders lead to a sewer main line, like in the Cascade Forest, all rainwater is recycled on-site. As water recycling is an important ecologically sustainable feature of the site, the implemented methods of recycling rainwater on-site can be celebrated through sensory legible design. The demonstration of such a system over such a small area can be beneficial to the understanding and promotion of water recycling

Figure 90: Semi-circular exterior runnel

methods, because even though, the system cannot be fully experienced from one viewpoint, it can be relatively easily understood by a short walk through the concentrated area (the total site footprint is 3,380 ft^2). Moreover, the density and compactness of the site can add to the general sense of eco-sustainability that the built environment has in terms of its typological morphology and program (i.e., a dense use of the land). An integral part of the stormwater management system is the runnel located within the building which continues out into the ethnobotanical garden.

Figure 91: End of exposed exterior runnel

The interior runnel shown in Figure 41 is a design feature that seems to be entirely existent for emotional and educational effect. The water from the downspout that transports rainwater from the rooftops of other buildings on site [see Figures 35-38] could have easily been diverted to the rain leader that connects to the low point of the butterfly-shaped roof [See Figure 29-31]. Instead the designers added a separate rain leader [See Figures 39 and 40] that drops into the classroom along the surface of an interior wall and connects to an interior runnel in the floor slab allowing a sensible presence of water (a minimally human-modified material) in the building [See Figures 39-40] (**Criteria 1**). The sign in Figure 41, which is located next to the rain leader, is

Figure 92: Dry exterior runnel

Figure 93 and 94: The downspout and rain leader from the abutting building's roof leads water rainwater into the runnel in the floor slab

Figure 95: The interior runnel, leading travelling underneath the wall and into the Ecohouse

slightly misleading in that currently some of the water on site is not rainwater, but rather potable water from the city grid (due to city regulations). However, the sign is used to help guide people as they experience the design features to understand the eco-sustainable value of the system in terms of water use. As the sign suggests, all the rainwater on site does not leave through the city sewer but is collected and used for the building's water utility demands and irrigation.

An integral component to the water cycle on the site, the 'river' is a design feature that was inspired by students and based on research of a retail store's design in downtown Seattle (p. 76). The store had an interior runnel in the floor covered by transparent glass running in serpentine fashion throughout the store, such that shoppers could see the water flowing through underneath the surface of the floor as they walk over top of it (without getting wet). Adjustments from the precedent's design were incorporated to accommodate the desires of students and other perceived malfunctions of the original design (e.g., prevention of the unwanted condensation on the otherwise transparent cover of the runnel). The store runnel was demolished with the rest of the building shortly after Bertschi salvaged the pebbles laid within the store

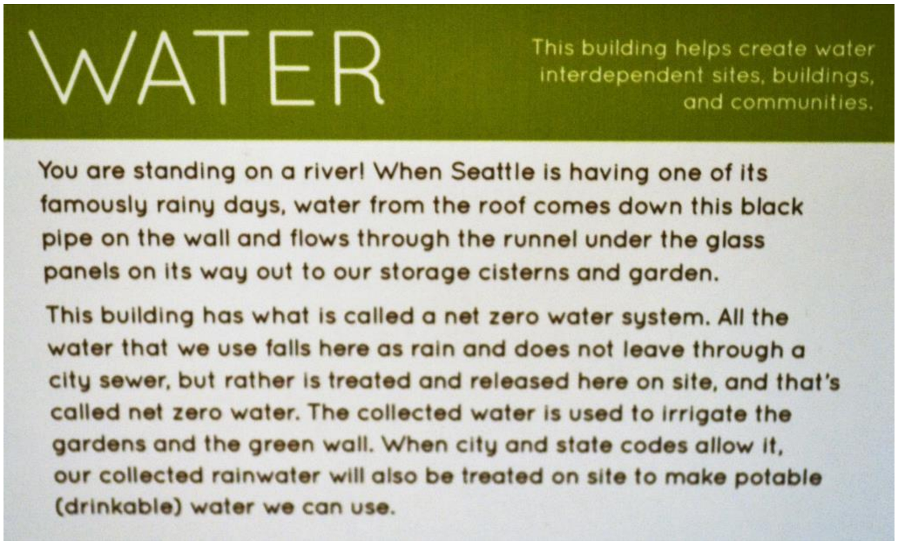

Figure 96: Sign posted next to rain leader that diverts rainwater into interior runnel

runnel. The adjustments were each related to increasing the sensory legibility of the flow of water, including the ability to physically touch and interact with the water within the runnel (**Criteria 3**), and to clearly see the water flowing beneath the surface (**Criteria 1**). Aiming to “reconnect with how we meet our basic needs through interactive experience” at Bertschi (p. 76), the original precedent that served as the student’s inspiration was, of course, a river itself. Though not alive themselves, rivers can be life-like in many ways (e.g., extreme ephemerality, complex in shape, and diverse in composition and structure, and made up many organic or bioavailable materials and organisms), especially ones we call ‘healthy’, ‘mature’, or ‘natural’ (i.e., ones that sustain and perpetuate life and species diversity). Healthy rivers are integral to the biosphere’s hydrologic cycle.

The pebbles in the walls of the runnel, although salvaged and recycled from the store downtown, serve as common occurrences in fast flowing rivers, which cause rocks to smoothen and round-out over a series of collisions along the riverbed. The pebbles are not serving the same purpose or undergoing the same processes as they would in a ‘real’ river. They serve as an aesthetic appeal and means to meet LBC criteria for recycled materials. Yet, they also serve to help the runnel symbolize a river, the system that carries and molds such pebbles (**Criteria 2: Life Imitation and Minimally Human-Modified Materials**). The interior runnel, itself, is not just an imitation of a life system in appearance. The runnel also serves a similar function to a river as a part of the hydrological system in its funneling (the movement and direction of the flow) of the rainwater (**Criteria 2: Life-Like Process**). Serving an integral function in meeting the imperative of net zero water, the interior runnel is used to transport captured rainwater from the roof into the underground cistern for storage (and to other parts of the site). In addition, the runnel allows students to keep track of water flow from rainfall, and serves as a means

Figure 97: Bold sinusoidal stream pattern (Solaripedia, 2016)

for educational experimentation allowing students access to perform water tests (**Criteria 3**).

Figure 98: The sinusoidal pattern in the landscape of Washington

Described as a 'sinusoidal form' by Hellstern, the stream running through the classroom attains characteristics often present in mature creeks and river beds, yet on a smaller scale (**Criteria 2: Life Symbolism and Irregularity**). Along with proportioning the runnel to the size of the site and to functional demands, this smaller scale is likely an intention of the designer to allow children to grasp the workings of the funnel, making it more relatable, cognitively accessible and thus, scrutable. Wavering like a sine function mapped on a Cartesian plane, this form, innate to older riverbeds—is created by the river's water flowing over the soil for an extensive period of time. The form is 'propensious' to the slowing, spreading, and soaking of river water into nearby soil, which is in turn 'propensious' to the expanded growth of ecotones (habitats conducive to the survival, perpetuation and prosperity of a diversity of species). The runnel differs from a riverbed in that its parameters are unchanging and impervious, such that the width and shape of the river cannot evolve and water cannot percolate through the bedding. In fact, the width of the runnel is exactly the same throughout its length (expressing a formal regularity not common to 'real' rivers. In 'real' rivers, the water travels from inland to a sea, while in canals, water flows usually connect one river to another or some other body of water (Reference.org, 2016). The runnel does not flow to the sea and is in this way more accurately called a canal. Of course, this description would be less culturally appealing than a river. Rivers are a source of fascination and life, symbolic of life itself in many cultures (**Criteria 2: Life Symbolism and Criteria: 5**). Light, water, trees are all major symbols for life in the Bible, and reasonably so as these resources are the greatest sustainers of living organisms. Unlike a typical river or tributary that travels across the land, this system is designed such that the stream cannot overflow the runnel and flood the surrounding area, which in this case would be an overflow into the classroom. Differing from the traditional definition of infiltration in the hydrologic cycle of the building,

the infiltration is not traveling through soil, but rather through the building envelope (**Criteria 2: Novelty and Life-Like Process Symbolism**). The 'infiltration' is human controlled, such that the water's exact course is set, stable and determined. Additionally, unlike 'real' rivers, the interior runnel is isolated from vegetation growth and restricted from being a habitat for other animals. Most of these differences are intentional to execute the water features of the site as a miniature eco-hydrological system that is geared toward specific human utilitarian demands, safety and comfortability. The building provides its own water resources to be able to run itself, and yet, less interconnected to a diversity of living species than a 'remote' habitat or a pre-Colombian forest of the Northwest. Just as the runnel would be more accurately called a canal than a river, the Living Building is more accurately called a "life-like building" than a "living building".

Figure 99: Students watching baby salmon grow in the fish tank in the Science Wing

Although rivers are not alive (per the Seven Criteria of Life), the conditions of a river can be incredibly conducive to life and a diversity of species within and around it. In Bertschi, the imitation of a river that supports the life of our ecosystems is also expressed through symbolic representations of salmon along the outside of the interior runnel (**Criteria 2: Life Symbolism**). These are not actual salmon, or course, only an artistic representation of salmon through bronze castings. Although the salmon is not real and the salmon impressions are not inside the runnel itself, the message the design conveys is to bring one's attention to the lifecycles that a river of the Puget Sound might support, and to instill a sense of value for such rivers and species (showing that salmon are worthy of artistic expression) (**Criteria 4**). Located near the runnel, in the season of salmon spawning, the classroom hosts a fish tank full of salmon eggs. After they hatch, they are eventually released into a life-supporting river by the students. In addition to related curriculum activities, the connection between the small living salmon in the

fish tank, and the five species of adult salmon artistically imposed in the concrete can help create a fuller understanding of river ecology and the practical implications and value of making sure rivers are protected for the perpetuation of living beings like salmon (**Criteria 3**). Moreover, the runnel expresses the interconnectedness of rivers, other species' lives, and humans (recognizing that salmon from the Puget Sound is a major marketed food source) (**Criteria 2: Life Symbolism**).

Habitual appropriation to the runnel, its characteristics, the hydrological process it carries out (**Criteria 2: irregularity, ephemerality, novelty; rain water transportation**), the analogies the art refers to (**Criteria 2: Life Symbolism**), and the functioning of the ecosystem that it symbolizes (**Criteria 2: Life Process Symbolism**) is inevitable for those who use the class room every school day. To enter and exit the classroom, people must walk directly over the runnel (**Criteria 3**). The runnel is rich in aesthetic detail in several ways. When precipitation occurs over the site (i.e., when overhead clouds rain, which happens quite often in Seattle), the water flowing through the runnel can be heard while sitting at any desk in the classroom, possibly more audible because of the air gaps between the panels (designed to prevent condensation on the inside surface of the panels) (**Criteria 2: Audible Diversity and Novelty and Criteria 3**). The visual, audible and tactile variation in the flowing of water in the runnel adds to its progressive ephemerality and animation (**Criteria 2: Ephemerality and Diversity**). It is tactile because the water and insides of the runnel can be felt—easily accessed by removable floor panels (**Criteria 2 and 3)**. The transparent tiles also reflect light such that the runnel catches one's eye when scanning the room (**Criteria 1 and 2: Visual Diversity**). Such aesthetic characteristics add to the purpose of the runnel as a source of fascination for the students (**Criteria 3**).

When the cistern located underneath the Ecohouse fills up with water, its overflow travels back into runnel at a lower point from whist the water went into the cistern. Unfortunately, I was not able to investigate the entry and exit of water from the runnel to see if they were visibly apparent in the experience of the built form due to cluttering of science projects within that area of the Ecohouse [See Figure 34]. After entering back into the runnel, the rainwater flows out toward the outdoor ethnobotanical garden, which is at this point visible through the transparent covering over the runnel within the Ecohouse. The flow of water from the interior of the building to the exterior is easily inferred as it can be

seeing flowing outward, and then water can be heard and seen flowing in the runnel on the exterior. The exact transition from the interior runnel to that of the exterior is not transparent, which leaves some mystery as to the sort of apparatus that might be used in the transition from water inside to outside (such as a filter to prevent animals from crawling inside through the runnel). Once outside of the building, the rainwater travels to the other cistern through the exterior side of the runnel. The movement of water in the exterior toward the cistern is somewhat underemphasized since the runnel appears to simply wrap back

Figure 100, 101 and 102: Stone Pathway heading toward cistern and aligning with the profile of the metal grate


Figure 103: rainwater-filled exterior runnel

around in a semi-circle toward the Ecohouse [See Figure 91-93]. When, in actuality, it diverts underneath the pervious pavement after reaching the end of the exposed exterior runnel and runs east down the length of the building (underneath the stepping stone path section of the garden) until it reaches the cistern. The entrance of the runnel into the ground is marked by a cylindrical container of rocks. Unable to sensibly recognize that there is a pipe underneath, one might easily think that the water infiltrates the soil never to underneath the rusty metal grate (at the beginning of the exterior runnel) or through some other route. Although hiding the flow of water, which would have given viewers understanding of how the design features manage the process, the artistically ‘carved’ grate also acts a visual marker, covering the runnel from the exterior wall of the Ecohouse and stopping just as it reaches the path. This visual marker is somewhat misleading as it seems to mark a transition for the runnel to divert under the pathway. On the other hand, the basic shape of the exterior runnel suggests that the water would have a greater propensity to flow in the direction of the semi-circle. Thus, in experience, whether the runnel travels underneath the pathway or closer toward the perimeter of the building is sensibly left to be determined, return to the building again. One might wonder if the water goes to the final cistern in an entrance but the metal grate suggests that the water diverts where the grate ends. Experiencing the process on a rainy day might

Figure 104: Sea anemone art carvings in metal grate covering the exterior runnel

help one to discover through the senses that the water travels first around the exposed runnel and then underneath the pavement and pathway to the cistern, but the pipe underneath the ground is untraceable and insensible (virtually non-existent to the perceiver).

Figure 105: Ethnobotanical Garden

Having similar symbolic effects as the artistic salmon around the interior runnel, the carvings in the metal grate represent other sea creatures such as sea anemone. The grate carries a level of complexity in terms of the sea anemone forms. The grate is mostly opaque and the forms are created through small openings that can only be seen through at a closer distance, but with small openings to see through if one gets closer. This added complex artwork might draw one's attention to inquiring what lies hidden behind the grate. The grate itself seems to serve as protection for the interior side of the runnel and as a safety measure to prevent students from tripping over the runnel when passing through the garden. Contributing to Criteria 3, the runnel is **multi-functional** and **multi-purpose** as it bridges parts of the garden and classroom as a walkable surface, has applicability for testing and interacting with rainwater through removable floor tiles, all while still allowing the transportation of rainwater across the site. Meeting Criteria 4, there is a visible and tangible link from the interiors of the science wing to the garden in the flow of water from inside to outside through the runnel.

Like the other cistern, when the final cistern fills up, the water flows back through the underground pipe and exterior runnel, which allows the water to overflow into the soil and vegetation in the garden [See Figure 63]. The holistic process of the water system is described as "a representation of the hydrologic cycle right in the classroom", where "the students are able to see how rainwater as it is collected from the atmosphere, enters a stream, is used as needed and then discharged back into the

water table to begin the cycle all over again” (Hellstern, 2014, p. 79). While Lake Union is down the street from the building, there are no special landforms or bodies of water that the project directly connects to through in a sensible way. An example of this criteria, if it were to be implemented on this site, might include featuring the interior runnel as directly linked with or attached to a major body of water, or if following the layout of that design feature might lead an occupant of the site to a scenic view of some major ecologically significant landform such as Mount Rainier (which significantly impact the region’s climate, hydrological patterns and lifeforms). While the project does not unveil views to Lake Union, the mountains, or the sun, it does align to the ecological context by an intentional and perceptible linking of the building to rainfall and the garden (a living and life-supporting system). The water use in the building is such that it obviously connects the presence of rainfall to the presence of flowing water in the interior runnel—without rainfall, there will be no water flowing in the interior runnel. In addition, the water use is directly connected to the garden by following the runnel as it travels along the walking surfaces of the site. With the building’s extensive use of windows, water can be seen from the interior, flowing from the runnel into the garden and soaking into the ground.

Figure 106: Ethnobotanical garden and exterior runnel encircling the pervious pavement

The Second Rainwater Cistern:

One of my favorite parts of the Bertschi School Science wing is the designed method for the students to assess the amount of water in the second underground cistern. The students can measure the water level above ground using a mobile pole that floats on top of the surface of the water in the cistern. As the water rises and falls, so does the pole. The students can push down on the pole all the way to the bottom of the cistern and watch as the pole rises back to the surface of the water—a technique that is so simple yet innovative in its ability to reveal what is normally hidden underground.

Figure 107: Measuring the height of the floating mobile pole to assess the amount of water in the cistern

Figure 108: Second cistern with floating mobile measuring

<u>The Ethnobotanical Garden:</u>

Hellstern states, “All of the stormwater that falls on the Bertschi site (since we cannot use rainwater for potable use yet) eventually makes its way to the ethnobotanical rain garden. Here, rainwater either falls directly on it, overflows into it from any excess that the cisterns can handle or is piped in from other parts of the campus” (p. 85). Gardens are cultural cues for Americans to eco-sustainability in the built environment. As an ethnobotanical garden it appeals to both common culture in America and the particular historical culture of the region, adding to the sense of place or genius loci. Hellstern clarifies that “the term ethnobotanical comes from ethnobotany: the study of how people of a particular culture and region (in Bertschi School’s case, Coastal Salish Tribes) make use of indigenous (native) plants. Essentially, it is the relationship between people and plants” (p. 62-63). Appealing to the heritage of the Seattle that references a time when people of the region shared a greater value, and a greater practical understanding of their neighboring species and surroundings. Such surroundings were habitats not dominantly-altered by humans, but rather a product of the collective diversity of species that inhabit the area. Thus, by appealing to a relationship that once was, the ethnobotanical garden engenders both hope and education of a better kind of natural—a built environment that is interconnected in such a way that humans and surrounding life forms and life systems mutually benefit each other. Moreover, such a built environment establishes a “reconnection” with humans and human production to eco-sustainable practices. Stones are engraved with names of all the kinds of Salish tribal plants and set next to the corresponding plant kinds within the garden to educate students about the plants that have been well-adapted to the hydrology of the climate. Plant names like “Indian Plum” give legible hints to their ethno-background. Adding to the list of functions for water use on the site, is the irrigation of plants in the ethnobotanical garden, a design feature itself which offers even

Figure 109: Ethnobotanical garden's culturally significant plants and identification rock

greater functionality for the Bertschi School. For example, the plants in the garden are not ornamental, but rather have utilitarian purpose (food, medicine, art supplies, etc.). Diverse in plant species, the garden takes on an incredibly organic aesthetic (per all the bodily senses). The garden is thus, both alive and life-like in aesthetic characteristics and processes.

Adding to **Criteria 3**, the pervious pavement in the garden acts as walking surface and allows water to infiltrate. The garden has plants with many utilitarian, educational and cultural uses, and is inhabitable by humans and other species + stormwater management & irrigation.

One intentional **bold pattern** introduced in the design, based on the shape of a nautilus (**Criteria 2: Imitation of Life and Criteria 5**), is supposedly seen from the fourth and fifth grade classrooms. Having visited one of the classrooms that peers above the roof, I was unable to see the pattern. From a different classroom, the shape might be viewable, but from within the garden, the Fibonacci pattern is not apparent. In the design, a tree marks the core of the nautilus from above, but in the built form, the tree is not present. The rest of the shape is delineated by the curvature of the runnel (perhaps the **boldest pattern** in the garden) and the pebble boundary lines on the roof tops. Other strongly emphasized curves include the circular patch of grass that radiates around the cistern and its mobile pole, the square stepping stones, the curvy concrete steps just outside the east side of the classroom, and the figure of the building itself. All these aspects help to provide an orderly frame to the vegetation. Furthermore, the irrigation techniques and water storage include the boldest patterns within the garden, which highlights these design features and emphasizes their role.

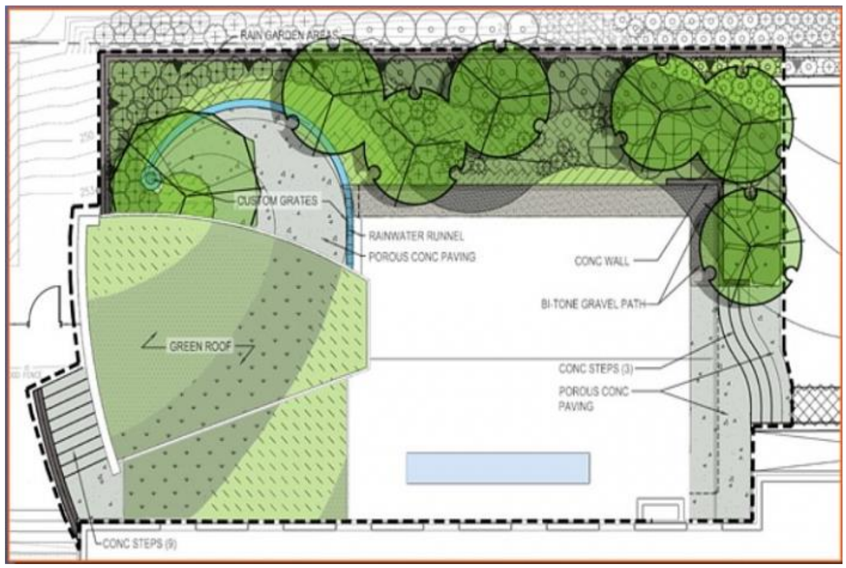

Figure 110: Original nautilus shell design when viewed from above

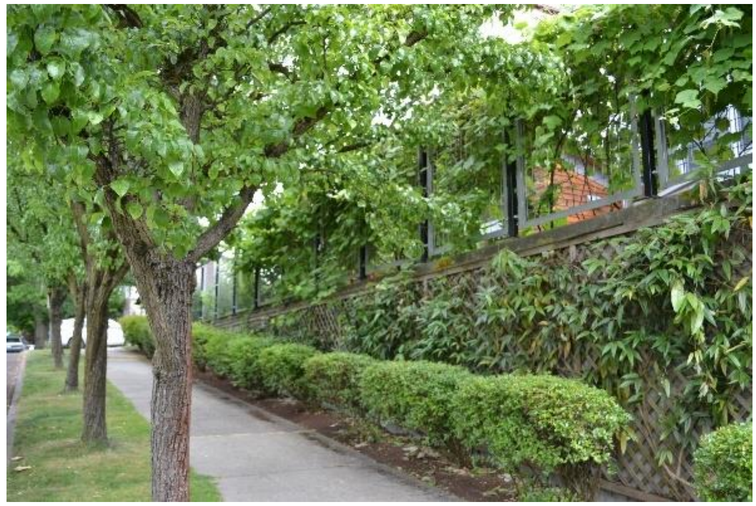

Figure 111: Concrete wall and fencing that divides the sidewalk from the garden

An example of improvement of the sensory legibility of the ethnobotanical garden's method of infiltrating water might include the use of durable transparent material (such as a transparent HDPE sheet) along portions of the concrete receding wall that separates the garden from the sidewalk below. Hellstern avers, "Designed to handle a 100-year storm, the rain garden consists of a minimum depth of 18" of compost amended soil containing course washed sand, pumice, sphagnum peat, and a top layer of fine bark that filters out particulates, heavy metals, hydrocarbons and other pollutants before water infiltrates into the ground" (Hellstern, 2014, p. 85). The garden is raised three to four feet above the abutting sidewalk and provides the perfect opportunity to show off the structure of the soil and its processes. Other ways to incorporate more sensory legibility in the ethnobotanical garden might include more cues for care, such as: bird houses or feeders, flowering plants, painted fences, and multi-functional aspects like a fountain or benches for seating.

Pervious surfaces:

Figure 112: Pervious pavement in ethnobotanical garden

Describing another design feature interactive with water the falls on the site in an eco-sustainable way, Hellstern says, "In addition to the rain garden, porous concrete pavement was also used throughout the site. This concrete, which acts like sand to allow water to filter through rather than run off, also filters sediment and particulates. Biological like that exists within the pavement section and the chipped rock that serves as a base just below the surface provides further filtration of hydrocarbons and other pollutants before rainwater is ultimately infiltrated back into the earth. These concrete hardscape spaces allow the students to have access to the garden during wet times while not compromising the site's ability to naturally infiltrate stormwater" (p. 85). Accessibility is key to sensory legibility, and while hard surfaces tend not to be inherently the most eco-sustainable material for the job, a certain level of safety, utility, comfortability, and order are necessary for a site. In accommodating for these features, the entirety of the hydrological processes on the site become more sensory legible. The pervious pavement is, thus, a multi-

functional tool allowing for infiltration of water without infiltration of your shoe, such that you can walk on it whether rain or shine and perceive the soaking of water into the pavement.

The Bullitt Center

Stormwater runoff planter beds:

On the exterior sides of the Bullitt Center building, the stormwater runoff planter beds on the site are visible from the park, nearby neighborhood and from some office space windows of the Bullitt Center [See Figures 113-115]. The planter beds are used to catch surface runoff that flows from uphill or is not captured by the roof. From outside the building, the use of these beds create quite sensory legible eco-sustainable water processes on the site. These beds, living systems in themselves (**Criteria 2: utilization of life and life processes**), are orderly-framed (**Criteria 5: Orderly-Framing of Vegetation**) and located along moderate pedestrian traffic areas where they will most likely be noticed (**Criteria 1**). Beds visible along the walkway that intersects the park and building serve as part of the entryway for the building, and a bridge to major roads (**Criteria 1**). They can be seen, touched and even walked upon (**Criteria 3**). Aligning the main walkways, they also serve the purpose of irrigation, biodiversity, and stormwater management (**Criteria 3**). Although I was unable to be on-site during rainfall, the beds are situated in places that would obviously catch rainwater flowing down the alleyway (downhill) and around the back of the Bullitt Center (**Criteria 4**). The prominent placement of the stormwater management beds where they can be accessed close-up and viewed in the round as well

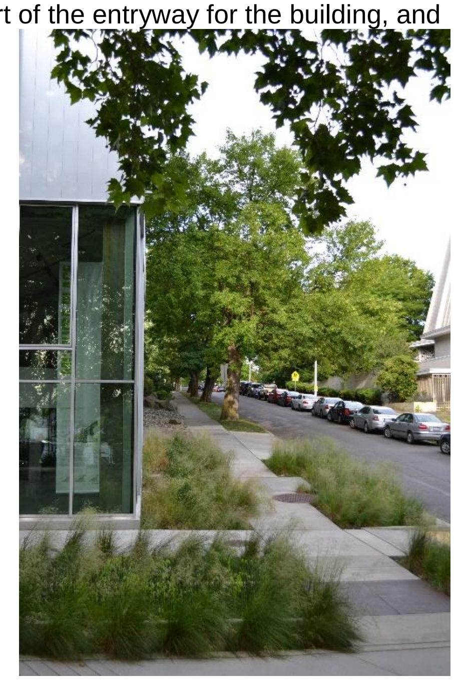

Figure 113 and 114: Stormwater surface runoff planter beds

as at a distance from the building interior and the outside areas of the site adds to the **transparency and visibility of form and spatial logic** of this water use design feature.

Figure 115: Stormwater surface runoff planter beds

Chapter 10: Discussion

Limitations

The practical significance of my research is strongly dependent upon a hypothesis with little scientific evidence. The practical value is based on the assumption that sensory legibility lends to positive cultural transformation of behaviors and practices of daily occupants. There are several limitations to this research concerning the case studies that must be considered. The concerns include the restricted number of illustrations I incorporated and the inability to do full case studies which would require IRB approval and possibly a more developed evaluative model. Being able to visit existing sites proved to be a great benefit to being able to evaluate sensory legibility of the built environment. However, my ability to do a thorough case study was inhibited by my limited access to the projects. I could only visit the building interiors of the Bertschi Science Wing and Bullitt Center no more than an hour each through a visitor's tour. The tour offered by the Bullitt Center Foundation allowed access to only certain parts of the building (the first floor, basement, and staircase). The tour guide allowed me and an architect in my tour group extra access to parts of the third and sixth floor immediately after the tour. While the park outside the Bullitt Center is completely available to the public, the Bertschi School does not allow for public access to the campus beyond the half hour visitor's tour. Without habitual appropriation, my evaluation cannot fully

access the sensory legibility of the site that is available to daily occupants. A larger sample of built environments would have added to the inventory of sensory legibility methods, and provided greater room for comparison to more thoroughly evaluate each structure. My research is qualitative and case-specific, such that I have not presented a way of quantifiably measuring the total sensory legibility in the built form. Although not always necessary, quantitative criteria would be more conducive toward my evaluative framework's implementation into existing green building evaluation systems. There is also a risk of a certain level of observational bias involved in qualitative measures. A large sample of case studies would provide additional examples of the framework and may further limit the subjectiveness of the user of the proposed framework in determining sensory legibility and the level of observational bias involved in qualitative measures.

Suggestions for Subsequent Fields of Inquiry

There is an open frontier of new opportunities for furthering the research on sensory legibility. One might begin with an expansive set of case studies, to develop comparisons made between the cases and to identify scales of sensory legibility and quantitative measurements for sensory legibility. Further beneficial case study research might include a discussion of all aspects of eco-sustainability in terms of their sensory legibility, not just water use. Diversifying the selection of case studies on projects of varying cultural contexts, building programs, and scales like neighborhood-wide projects would also help to develop a better understanding of how applicable sensory legibility criteria are and a more extensive list of specific methods that can be used. One could also conduct a set of case studies on the sensory legibility of eco-sustainability on built environments that meet different green standard evaluation systems. By investigating the use of sensory legibility criteria in existing green standard evaluation systems, one can reveal the current operationalization of sensory legibility by professionals and develop ways to implement sensory legibility criteria within the systems that lack it. Analyzing built environments that must meet the needs of drier climates (xeriscapes) for their sensory legibility of eco-sustainability in terms of their water use might show how sensory legibility might take form in drastically different climates.

Other options include conducting a series of interviews on sensory legibility of a specific built environment by asking open-ended questions about the site's perceptual qualities to detect the principles

of sensory legibility at work. To test the significance of sensory legibility, another study could involve experimental surveys to evaluate actual attitudinal and behavior changes of on-site users of sensory legible sustainable systems of architecture. Similarly, one could do participant observational studies on the behavior of occupants of eco-sustainable buildings with varying degrees of sensory legibility, and score each occupant's personal eco-sustainable practices and non-eco-sustainable practices. A related but simpler research goal could be met through extended on-site evaluations to test the effects of sensory legibility through the habitual appropriation of ecologically sustainable built forms. Finally, for scientific evidence of the side-effects of sensory legibility, experimental psychological tests can be under-taken with a focus on the sensory legibility of a figure or space to determine exact factors and measurements for the legibility of a scene based on particular qualitative factors.

Conclusion

As my research shows, ecological sustainability can be made sensory legible in architecture through an evaluative framework using a set of sensory legibility standards. Derived from my theoretical framework, I proposed five sensory legibility criterions: the increase of transparency and visibility of form and spatial logic; the utilization or imitation of life and life-like processes and life's multi-sensory aesthetic characteristics; the implementation of multi-functional/multi-purpose forms to allow people to relate and interact with forms in multiple ways; the intentional linking of a structure's form to its ecological context; and the use of cultural cues/expectations/norms/preferences on an aesthetic and sensory level. This criteria can be used in developing methods and designing sensory legible eco-sustainability in design features of the built form. In addition, the sensory legible criteria can be used to evaluate already existing architecture and to develop an inventory of methods guided by these criterions for each ecological process in connection to the corresponding design features and functions on the site.

In the illustrations of the Bertschi School Science Wing and Bullitt Center, I provide real world examples of the theoretical prose for sensory legibility that I offer, and how the five basic sensory legibility criterions can be applied. The design features for each building's ecologically sustainable processes involving water use have some aspects that were sensory legible through the design of the built form, and

others that were not. The criteria generated ideas for how the sensory legibility of the designs might be improved. The two built environments, allowed me to reveal the relative level of sensory legibility present in built forms that also meet the high standards set by the Living Building Challenge.

Lastly, I discussed the limitations of my research and suggested further studies under which my research may serve as a theoretical foundation and the groundwork toward developing an extensive inventory of design and construction methods that support and motivate eco-sustainable practices through sensory legibility. Having explored both the sites for illustration of the criteria and the larger context of the city, Seattle assures me that American cities can take a more active role in promoting sustainable living. This city sets high standards and has made advances that can be taken to change our built environments for the betterment of habitats for all species. The built environment that the designers of Seattle have helped transform is only just beginning to serve as an educational tool to positively impact an individual's awareness of how their buildings may impact ambient ecosystems.

References

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksadahl-King, I., Shlomo, A. (1977) *A Pattern Language: Towns • Buildings • Construction.* New York, NY: Oxford University Press.

Arnheim, Rudolf (1966) Toward a Psychology of Art. Oakland, California: University of California Press.
Austin, R.L (1984) Designing the Natural Landscape. Washington, DC: Van Nostrand Reinhold

Barnard, A. (2015) Are Nanoparticles Alive?, video lecture, funded by the Australian Academy of Sciences, October 16, 2015. Available at: http://physicsdatabase.com/2015/10/16/are-nanoparticles-alive/ (last accessed October 26, 2016)

Bell, K. (2000) Urban Amenity Indicators: The Livability of Our Urban Environments. For the Ministry for the Environment. *Environmental Performance Indicators, Technical Paper No. 63 Urban Amenity*. June, 2000. Available at: https://www.mfe.govt.nz/sites/default/files/publications/rma/live-work-play-jun02/resources/pdf/63.pdf (last accessed 10/23/16)

Bell, S. (2012) The Aesthetics of the Landscape, Landscape: Pattern, Perception and Process. 2nd ed. New York, NY: Routledge.

Bertschi School webpage. (2015) Where Science Lives. *Living Building Science Wing* Available at: http://www.bertschi.org/who-we-are/our-campus/science-wing (last accessed: October 26, 2016)

Bertschi School (2015) *BERTSCHI SCHOOL LIVING BUILDING SCIENCE WING*. Bertschi School. http://www.bertschi.org/docs/LivingBuildling_ver2.pdf (last accessed October 28, 2016)

British Columbia Government website (n.d.) *BC Geographical Names, Salish Sea*. Available at: (http://apps.gov.bc.ca/pub/bcgnws/names/53200.html (last accessed October 26, 2017)

Browning, W.D., Ryan, C.O., Clancy, J.O. (2014) *14 Patterns of Biophilic Design*. New York: Terrapin Bright Green, LLC. Available at: http://www.terrapinbrightgreen.com/wp-content/uploads/2014/09/14-Patterns-of-Biophilic-Design-Terrapin-2014p.pdf. (last accessed October 26, 2017)

Buckminster Fuller Institute. (2012.) The Living Building Challenge. Available at: http://www.bfi.org/ideaindex/projects/2012/living-building-challenge (last accessed February 19, 2016)

Buckminster Fuller Institute. (n.d.) The Living Building Challenge. Available at: https://bfi.org/challenge/media/partners (last accessed October 27, 2016)

Center for Disease Control and Prevention. (2014) About Healthy Places. Healthy Places**.** Retrieved from: http://www.cdc.gov/healthyplaces/about.htm (last accessed 10/27/16)

Colquhoun, A. (1969) Typology and Design Method. *Essays in Architectural Criticism: Modern Architecture and Historical Change*. Chicago, IL: The MIT Press.

U.S. Department of Health and Human Services. (2004). Obesity and the built environment. Retrieved October 27, 2016, from http://grants.nih.gov/grants/guide/rfa-files/RFA-ES-04-003.html

Dictionary of Sustainable Management. (2016) Available at: http://www.sustainabilitydictionary.com/ Hosted by TriplePundit.com (last accessed October 26, 2016)

Duncan, J.S. and Duncan, N.G., (1988) [Re] Reading the Landscape. *Environment and Planning D: Society and Space 6*. SAGE Publications Ltd.

Ecodistricts webpage (2016) At the Heart of the EcoDistricts Protocol Are 6 Priorities, *6 Priorities: Achieving Meaningful Outcomes*. EcoDistricts. Available at: http://ecodistricts.org/get-started/the-ecodistricts-protocol/priorities/ (last accessed October 28, 2016)

EPA. (2016) *EPA: EPA History.* Retrieved October 23, 2016 from EPA website https://www.epa.gov/history

EPA. (2016) *EPA: Our Mission and What We Do* Retrieved October 23, 2016 from EPA website https://www.epa.gov/aboutepa/our-mission-and-what-we-do

Earth Day Network. (2016) The History of Earth Day. Earth Day Network**.** Retrieved from: http://www.earthday.org/about/the-history-of-earth-day/ (last accessed 10/27/16)

Fromm, E. (1964) *The Heart of Man: Its Genius for Good and Evil*. Riverdale, NY: American Mental Health Foundation Inc.

Hellstern, C. (2014) *Living Building Education: The Evolution of the Bertschi School Science Wing.* Portland, OR: Ecotone Publishing.

Howett, C. (1987) Systems, Signs, and Sensibilities, *Landscape Journal 6, no. 1, pp. 4-12*. University of Wisconsin Press.

International Alliance of Research Universities (2009). Key Messages from the Congress. *The IARU International Scientific Congress on Climate Change: Global Risks, Challenges and Decisions in Copenhagen*. International Alliance of Research Universities, Available at: https://www.ethz.ch/content/dam/ethz/special-interest/mavt/process-engineering/separation-processes-laboratory-dam/documents/People/IARU2009_Keymessages.pdf (last accessed October 27, 2016)

International Living Future Institute. (2015). Bullitt Center. *Living Building Challenge*. International Living Future Institute, Available at: http://living-future.org/bullitt-center-0 (last accessed February 20,2016)

Keim, Brandon. (2015) The Intriguing New Science That Could Change Your Mind About Rats. *Science 1/28/15*. Available at: https://www.wired.com/2015/01/reconsider-the-rat/ (last accessed October 26, 2018)

Lent, D. and Hyung-Wook, K, (2004) Antennal movements reveal associative learning in the American cockroach *Periplaneta Americana. Journal of Experimental Biology* 2004 v.207 September pp. 369-375. Available at: http://jeb.biologists.org/content/207/2/369. (last accessed 10/26/16)

Lyle, J.T. (1999) *Design for Human Ecosystems: Landscape, Land Use, and Natural Resources,* 2nd ed. pp. 15-21. Harriett Lyle and Island Press.

McDonough, W. & Partners (1992) *The Hannover Principle: Design for Sustainability*, Willam McDonough Architects. Available at: http://www.mcdonough.com/wp-content/uploads/2013/03/Hannover-Principles-1992.pdf. (last accessed 10/26/16)

McDonough, W. & Braungart, W. (2002) *Cradle to Cradle*. New York, NY: North Point Press

Moneo, R. (1978) On Typology. *Journal for Ideas and Criticism in Architecture,* v. 13. Summer 1978.

Nassauer, J.I. (1995) Messy Ecosystems, Orderly Frames, *Landscape Journal* 14, no. 2, Fall, pp. 161-169. Available at: http://www.ncrs.fs.fed.us/pubs/jrnl/1995/nc_1995_nassauer_001.pdf. (last accessed December 16, 2014)

Olin, L. (1988) Form, Meaning, and Expression. *Landscape Journal,* v.7, no. 2, Fall, p. 158. Madison, WI: The University of Wisconsin Press

Pollan, M, (1991) *Second Nature: A Gardener's Education*. New York: Grove Press

Perez de Arce, R. (1987) *Urban Transformations and The Architecture of Additions. n.p.*

Province of British Columbia (2015) Salish Sea. *BC Geographical Names.* Province of British Columbia. http://apps.gov.bc.ca/pub/bcgnws/names/53200.html. (last accessed October 27, 2016)

Reference.com (2016) *Geography: Bodies of Water, What is the difference between a canal and a river?* Available at: https://www.reference.com/geography/difference-between-canal-river-246711856d5e3d22# (last accessed: October 26, 2016)

Reference.com (2016) *Why is the water cycle important?* Available at https://www.reference.com/science/water-cycle-important-c491ffb9d9287987 (last accessed: October 27, 2016)

Sanctuary (2015). Salish Sea Bioregional Marine Sanctuary & Coastal Trail ~ Map & Overview. *Salish Sea Marine Sanctuary.* Sanctuary Publishing. http://www.salishsea.org/salish-sea-marine-sanctuary-coastal-trail-map/.

Snyder, G. (2004) The Practice of the Wild. [Orig. 1990, North Point Press*] The Etiquette of Freedom* (pp. 3-26) Available at: https://www.coursehero.com/file/62458/anthro101snydergary2004/
(last accessed October 29, 2016)

Solaripedia (2016) Bertschi School Science Wing Goes Net Zero (Seattle, USA). *Project.* Available at: http://www.solaripedia.com/13/343/4274/bertschi_school_science_wing_floor_plan.html. (last accessed October 28, 2016)

Spirn, A.W. (1984) The Granite Garden. *The Granite Garden: Urban Nature and Human Design.* pp. 3-5. New York: Basic Books.

Strang, G. (1996) Infrastructure as Landscape, *Places* 10, no.3, pp. 13-15. Available at: http://places.designobserver.com/toc.html?issue=407 (last accessed December 16, 2014)

Schwarting, J.M. (1981). Lessons of Rome. *Harvard Architecture Review.* v. 2, 1981. p.25-27

Stafford, T.A. (1942) *Christian Symbolism in the Evangelical Churches.* New York: Abingdon-Cokesbury Press

Thayer, R. (1994) Three Dimensions of Meaning, *Gray World, Green Heart,* New York, NY: Wiley, John & Sons.

Thomas, M. A. (2016) *The Greenest Building: How the Bullitt Center Changes the Urban Landscape.* Portland, OR: Ecotone Publishing.

United Nations. (1992) *The United Nations Framework Convention on Climate Change.* Article 2: Objective, p.9*.* Retrieved from: http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf (last accessed 10/26/16)

U.S. Geological Survey (2016) Summary of the Water Cycle. *The USGS Water Science School*, USGS. http://water.usgs.gov/edu/watercyclesummary.html. (last accessed October 27, 2016)

Weart, S. (2014) Simple Models of Climate Change. *The Discovery of Global Warming*, American Institute of Physics, February. Available at https://www.aip.org/history/climate/simple.htm#L_M018. (last accessed October 24, 2016)

Wilson, E. (1984), Biophilia. England: Harvard University Press.

Whirlwindcreative. (2015) *Challenge*. The Buckminster Fuller Institute. Available at: http://www.bfi.org/challenge. (last accessed February 19, 2016)

World Commission on Environment and Development. (1987) Chapter 2: Towards Sustainable Development. *Our Common Future***.** Retrieved from: http://www.un-documents.net/our-common-future.pdf (last accessed 10/27/16)

World Health Organization. (1948) Preamble to the Constitution of the World Health Organization. *Official Records of the World Health Organization*, no. 2, p. 100. International Health Conference, New York.

World Wide Fund For Nature (2016) Impact of Habitat Loss on Species. Habitat Loss, WWF. http://wwf.panda.org/about_our_earth/species/problems/habitat_loss_degradation/. (last accessed October 27, 2016)