Exploring Art as a Communication Interface for Watershed System Resiliency

by
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AUTHOR’S DECLARATION

"I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including, any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public."

ABSTRACT

Art has shown promise as a method of communicating the science and attendant need for watershed restoration work to both practitioners and the public. My thesis is exploratory; it explored whether art can convey concepts of connectivity, capacity, and resiliency as they relate to restoration in small socio-ecological watershed systems in southern Bruce County, Ontario, Canada and to larger hydrological systems in general. Holling's classic resilience loop was combined with qualitative observations from a beaver wetland complex using Arts Based Research and an interpretative phenomenology methodological framework to prototype an ecological art exhibit. This exhibit was presented ten times to varied and multidisciplinary audiences and informal anonymous feedback was gathered. This ecological art exhibit showed potential to broaden uptake for the methodologies and motivators for restoring connectivity and capacity to increase watershed system resiliency. Hence, the use of art as alternative medium to central textual messaging may have potential to help circumvent communication barriers encountered in ecological restoration.

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Dedicated to the memories of Adrian, Harley, Marion, and Loki.

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CHAPTER 1 - INTRODUCTION

"Climate is Culture" (Buckland, 2012, p.137).

Buckland's statement proposes that cultures shape the climate and it, too, shapes us. Both the causes and possible solutions to anthropogenic climate change have connection to diverse aspects of culture (Cape Farewell, 2007). Numerous human behaviours impact climate change, many rooted in sociological, philosophical, and creative values, that organize how we see the world (Hoffman & Hoffman, 2015). Through the collective (in)actions of societies, climate change has been occurring at an accelerated rate, and many argue that our trajectory is now dire (Barnosky, Matzke, Mindell, Revilla, & Smith, 2012). Given the current rate of consumption of natural resources, our world's population is estimated to have a less than 10% chance of avoiding a catastrophic collapse (Bologna & Aquino, 2020). Among multiple ways to increase the odds of avoiding this type of collapse, however, one course would be for societies to transform towards resilience using mechanisms of socio-ecological watershed restoration (Ogden, et al., 2013; Walker & Salt, Resilience Thinking, sustaining Ecosystems and People in a Changing World, 2006). Towards this goal of transforming how societies think about climate change, a relatively unexplored pathway is that of utilizing Art to communicate messages of a resilient climate (Roosen, Klockner, & Swim, 2017). This thesis explores whether a message of socio-ecological watershed system restoration, in relation to the global water balance specifically (Abbott, et al., 2019), can be communicated through ecological art.

To increase global climate resiliency, the United Nations has resolved that 2021-2030 will be known as the Decade of Ecosystem Restoration (United Nations, 2019). Global restoration practices that broadly encompass the restoration of ecosystems are presented as a mainstay management tool to ease the impact of anthropogenic climate change (Timpane-Padgham, Beechie, & Klinger, 2017; Strassburg, et al., 2020). While restoration approaches and techniques can be multidisciplinary, of particular interest in this thesis is the emergent field of socio-hydrology. The definition of socio-hydrology can be considered as "…a special case of social-ecological systems research that focuses on coupled human-water systems, exploring how the hydrologic cycle and human cultural traits coevolve and how such co-evolutions lead to phenomena of relevance to water security and sustainability" (Yu, et al., 2020, np, Abstract). Several studies have reported evidence of increased hydrological resiliency in local water cycles

following restoration that, in turn, enhances support for local socio-ecological resiliency (Fairfax, 2021; Kravcik & Lambert, 2015). With advances in ecological restoration at watershed scales, focus has widened from restoration of individual sites or watershed-catchment-scale sites to encompass contextualization of these sites within a broader framework of an Earth System state and a global water balance (Kotwicki, 2009; Gleeson, et al., 2020; Kravčík, Pokorný, Toth, Kovac, & Kohutiar, 2007).

Waterways and their linked riparian zones are of particular concern amidst a time of environmental change because of their critical role in the provisioning of water-derived ecosystem services (Costanza, de Groot, Sutton, & van der Ploeg, 2013; Mohan, Saritha, Rameshan, Chacko, & Gopikrishna, 2020; Fairfax & Whittle, 2020). These socio-ecological watershed systems are complex (Sanniti & Kish, 2018). They comprise eco-hydrological functions and elements of societal metabolism, including human recreational activity and industrial land and water use (Galatowitsch & Giest, 1999).

Restoration of watersheds is a complex and wicked problem that spans many scientific, professional, and social dimensions (Conklin & Basadur, 2007). A wicked problem can frustrate the established typical scientific approach of gathering and analyzing data and then forming a linear solution and implementing it (Buchanan, 1992). Part of the challenge surrounding promoting resiliency in socio-ecological watershed systems is how one communicates complex potential solution paths beyond the more insular expert audience (Boussalis, Coan, & Holman, 2019). The medium in which an idea is portrayed has been shown to influence how members of society respond to a message (McLuhan, 1977). For this reason, the use of art—in various forms ranging from visual to audio-visual to kinetic and interactive—is increasingly sought as a means to influence knowledge assimilation and communication of ecological restoration and broader environmental messaging (Roosen, Klockner, & Swim, 2017)

While the work of ecological artists is neither easily categorized nor defined, the following quotation sets some useful bounds:

> *"(Eco) artists venture beyond conventional art boundaries into uncharted territories. They typically address issues that non-art professionals claim, create works that function like objects with no pretentions as art, conduct*

processes that do not resemble studio art practices, and share creative responsibility with non-artist collaborators." (Weintraub, 2012), p. xiv)

What comprises ecological art and how it can and has been used to communicate ecological restoration and broader environmental messaging, including climate change response, will be examined in deeper detail under Chapter 2. For clarity, "climate change response" is understood here to encompass actions that help socio-ecological watershed systems to adapt to and potentially mitigate negative impacts of climate change (NASA, 2021). Within this context, Weintraub's above-quote is intended to offer broad positioning for the ecological artwork that will be presented in this exploratory thesis.

1.1 Thesis purpose

The aim of this thesis is to explore the use of ecological art as an interface for communicating a functional restoration message aimed at increasing socio-ecological watershed system resiliency- as a climate change response-—to both lay and expert audiences. Towards this goal, the thesis proposes to use an exhibit of custom-crafted, interactive ecological art as the messaging medium. The message the ecological art exhibit has been designed to communicate is that *restoring connectivity and capacity can increase watershed system resiliency.*

1.2 Research Problem and G_ap

The use of art as an interface to communicate complex problems (Blakey & McFadyen, 2015) along with suggested solutions for managing watershed systems towards resiliency represents a relatively neglected communication approach (Ahn, 2016). A specific research gap for ecological art being needed as a tool for communicating the importance for resilience in complex watershed systems has been identified. Moreover, there is a known need for water-cycle diagrams that incorporate connections between people and water across spatial and temporal planes within the context of global hydrology (Abbott, et al., 2019). This type of research gap calls for the opening of siloed disciplines and the purposeful inspection of human connection to watersheds as a means of addressing ecological management (Waltner-Toews, Kay, Neudoerffer, & Gitau, 2003). Insight into this need is compellingly provided by Abbott et al. (2019) in their recent Invited Commentary in *Hydrological Processes* wherein they identify the stark lack of accessible water cycle diagrams. Analyzing some 450 water diagrams, "[these researchers] found that 85% showed **no** human interaction with the water cycle and 98% omitted any sign of climate

change or water pollution" (p. 3046). This—despite the fact that climate change and water pollution are recognized as two main drivers of the global water crisis! Provision of visuals, including art objects created by ecological artists, will therefore help meet the need to visually incorporate connections between people and water within the context of global hydrological systems.

> *Diagrams that effectively teach how nested connections influence water availability in specific geographic places will better support nature-based solutions (Bishop et al., 2009), which are more likely to establish water practices that are ecologically and socio-politically sustainable (Fandel et al., 2018; Gunckel, Covitt, Salinas, & Anderson, 2012)." (Abbott, et al., 2019, p. 3052).*

No discipline in isolation can be relied upon to tackle the complexity of just and equitable water management, especially under climate change and water scarcity scenarios (Jackson, et al., 2001) predicted by the IPCC (Pachauri & Meyer, 2014). Water is a basic Human Right (United Nations, 2010) and all people deserve access to information and decision-making power regarding its use and management. Efforts to improve communication of knowledge transfer within and between research disciplines, the public, policy makers, and the multitude of professional practitioners involved in carrying out watershed management work are vital. Currently 2.2 billion people are without access to clean water under the dominant water management paradigms; these paradigms arguably need to change (Almendros, 2020). The availability of fresh water per person on earth is predicted to decline given the continuation of current water management regimes (Jackson, et al., 2001) and could result in two-thirds of the world's population facing water scarcity by 2025 (CME Group and Nasdaq, 2020).
Water quality and quantity are of consequence to everyone, given we need it to survive, and information pertaining to sustainable water management in the time of climate change should be made accessible to as broad an audience as possible.

One approach to discussing the management of water in complex socio-ecological systems to a broad lay and expert audience is to use a combination of narrative, science, and art (Waltner-Toews, Kay, Neudoerffer, & Gitau, 2003), that necessarily draws from a multitude of disciplines. Aristotle referred to ethos (character of the scholar), pathos (empathy invoked in the

audience), and logos (logic of the argument) to convince an audience of the validity of an idea presented (Braet, 1992). This premise of revealing the researcher remains relevant to pedagogical theory (Pentassuglia, 2017; Finlay, 2002). The nature of language in formal academic and societal institutions is also an important consideration when considering knowledge transfer (Green & Yuan, 2011).

Use of plain language narrative and metaphor helped to bring the concept of the 'Black Swan event' to public attention by demonstrating how the extreme outliers to a normal statistical distribution, such as 1:100 year storms, affect socio-ecological systems in severe manners (Taleb, 2010). For example, a well-known Black Swan event is Hurricane Katrina (2005). Landing near New Orleans on the U.S. Gulf Coast, Katrina brought devasting flooding initially classified as a 1:100 year storm but later reassessed as a much stronger 1:400-year storm according to the U.S. Army Corps of Engineers (Horne, 2012). Another example of narrative found to be an effective method of evoking environmental reflectivity is the use of applied theatre (Davis, 2014). Applied theatre commonly refers to theatre that is used to translate messages to an audience, often in an interactive setting, to evoke social change or a shift in thinking (Sullivan, et al., 2008). An extension is environmental theatre which educators or interpreters use to facilitate active learning for audiences on topics that can involve risk and participation, as does engagement in the larger environmental movement concerned with addressing climate change (Heddon & MacKey, 2012).

Art and arts-based practices are increasingly seen as a powerful way of developing meaningful connection with climate change response and environmental messaging (Bentz, 2020). Art has the capacity to raise awareness, to engage creativity for addressing complex problems, and may also support transformation to sustainability (Dieleman, 2017). Sustainability transformation involves fundamentally altering interactions and feedback between human and environmental systems, which can include shifting patterns of behaviour and management regimes at multiple levels and scales (Olsson, Galaz, & Boonstra, 2014; Walker, Holling, Carpenter, & Kinzig, 2004). Apart from facilitating dialogue and the expression of learning, art can operate on a profound, transformative level (Bentz & O'Brien, 2019; Shrivastava, Ivanaj, & Ivanaj, 2012). Through making micro-macro connections between individual lives and the larger global context, all participants are invited to the narrative, and hierarchies of ways of knowing can be flattened. In this way, the potential to build community,

which might be an important prerequisite for social transformation, may be magnified (Bentz, 2020).

The interactive exhibit of ecological art that has been produced for this thesis has been inspired by the work of established and influential Ecological Artists. It also borrows from applied environmental theatre in the sense that it relies on metaphor, narrative, movement (dance) and interaction to communicate a message for restoring resiliency in a complex socio-ecological watershed system. This expression of connectivity between concept and action embedded in the art pieces of the exhibit, that will be presented, was captured in part through artistic decisions around size (scale), colours, materials and, of course, methods (Chapter 3).

The cumulative choices I made as artist-researcher of the thesis art exhibit will be shown to have at their nexus the intention to allow an accessible ecological restoration message to be conveyed to various specialized and non-specialized audiences. In parallel I will also bring sharp attention to some of the ways in which an art interface has possibility to circumvent a number of communication challenges that have been found to impede the progress of ecological restoration communications of specific relevance to the message chosen, tied to improving the resiliency of watersheds (Roosen, Klockner, & Swim, 2017). The methods the interactive art exhibit employed to circumvent these communication barriers can be categorized into two themes: connecting the human to a representation of interacting watershed systems making up the Earth System water balance; using the modality of kinetic art which is a powerful learning medium for some to enhance the uptake of the message.

An early conceptual drawing of the elements in the watershed system resiliency message the thesis art exhibit is meant to convey, is in Figure 1. *Hydro Logic* (below). The premise is that the utility of art can be used as a communication interface for assisting people, in whatever small or large ways, to experience an opening of their minds around watershed restoration in the time of climate change.

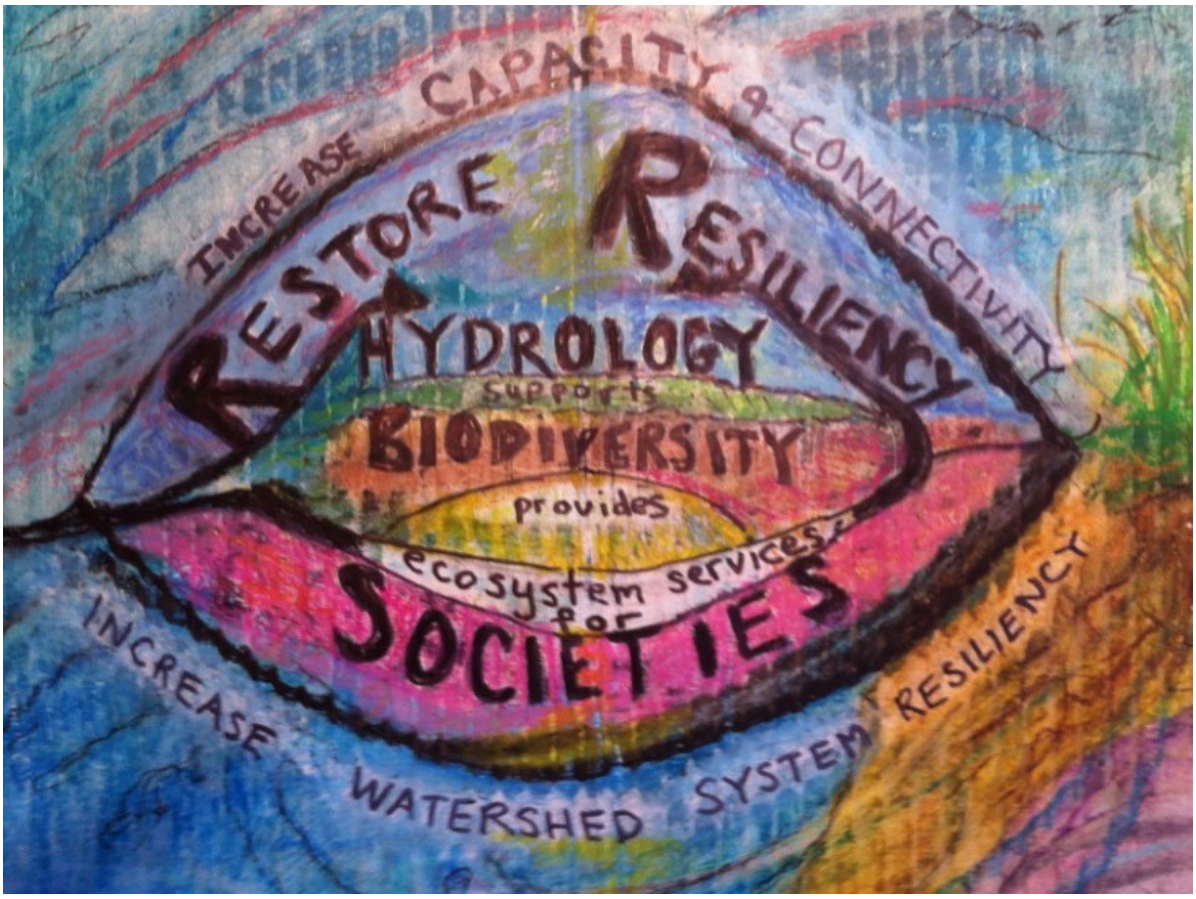

Figure 1. Hydro Logic. Source: (Mason, A. 2019)

Artwork depicting logic behind the thesis message: restoring lateral hydrological connectivity and potential for water storage capacity will increase watershed system resiliency. Connectivity and capacity, across hydrological, ecological, and social dimensions appear in context to their interrelated potential for increasing watershed system resiliency. The image is meant to show a peninsula extending into the distance at sunset and the nearshore environment in the foreground with an information bubble overtop and connecting to the image. (Source: A. Mason, pastel *on* cardboard *30cm by 30cm)*

1.3 Outline

To explore the potential of artwork as an alternative interface for ecological restoration communication. The aim is to determine whether a custom-crafted exhibit of interactive, ecological art can convey to both lay and expert audiences the specific message that *restoring lateral hydrological connectivity and potential for water storage capacity will increase watershed system resiliency.*

The thesis purpose is satisfied through an exploratory research design comprised of three main objectives:

Objective 1–Evolving a watershed system resiliency message

Objective 2–Grounding the art-science-communication intersectionality

Objective 3–Using purpose-crafted ecological art to communicate a watershed resiliency message

1.4 Research Contributions

This thesis has explored the uses of interactive ecological art as an alternative communication technique for delivering an ecological restoration message. The message chosen for the artwork to embody concerns aspects of the need for, and benefits of, increasing resiliency in watersheds. Informal responses from audience members who interacted with the exhibit of ecological art showed some understanding of and agreement with the central message that watershed system resiliency can be increased by restoring lateral hydrological connectivity and water storage capacity on the landscape. Therefore, while preliminary, the responses offer some support for ecological art as a pathway for communicating ecological restoration messaging or, at its most basic, for communicating a message with science-based content to broad audiences.

My thesis was designed to determine if ecological art has potential to facilitate ecological restoration messaging in relation to climate change communication in the following ways:

- mediate barriers of discipline-specific language
- facilitate transfer of knowledge of complex science concepts
- promote message uptake under resistant socio-cultural conditions
- support navigating eco-anxiety associated with climate change communications.

A contribution has been made through adding to art objects and visuals that situate the human within a watershed system in the context of anthropogenic climate change. In terms of who may benefit from the thesis findings, besides anyone interested in the possible role of ecological art as a communication interface for ecological restoration and climate response, it holds promise for multidisciplinary teams tasked with visualizing transformative pathways, futures scenarios, or other adaptive or mitigative management decision-making or implementations.

1.5 Thesis Organization

- Chapter 1 is the Introduction you are reading now.
- Chapter 2 is a Literature Review. In particular, I focused on the feasibility and science fundamentals pertinent to the chosen message. Next, the intersectionality of communication aspects of watershed resiliency messaging. Possible barriers and opportunities for ecological art as an interface are explored. Emphasis is on understanding the contribution that ecological art can and has made to communicating environmental messaging and associated science knowledge. Of special interest is how the chosen message of watershed system resiliency can be represented in the accompanying art exhibit.
- Chapter 3 describes my methods, *sensu lato* (since this is an art focused thesis).
- Chapter 4 focuses on the main outcomes ('results' in a more traditional use of the term). It is an Ecological Art Exhibit purpose-crafted for the thesis, it describes the overarching narrative of the artwork, and a supporting exploratory case study.
- Chapter 5 is the Discussion, reminding readers this is an exploratory and artistic work (as opposed to using formal social science or ecological science frameworks). It reflects on whether ecological art can play an effective role as an interface for communicating messages of ecological restoration to broad audiences.

CHAPTER 2 – ECOLOGICAL ART, ENVIRONMENTAL COMMUNICATION AND WATERSHED SYSTEM RESILIENCY

In this chapter, selected studies, research, and knowledge that underpin both the context and grounding for the exploratory research are provided. The thesis aim has been to explore whether an exhibit of interactive ecological art can convey a specific environmental message, relevant to watershed restoration methodology, to both lay and expert audiences. And, if so, does art then hold promise as an alternative mechanism for ecological messaging? The message created to form the central communication of the ecological art exhibit prepared for the study is this: *restoring lateral hydrological connectivity and potential for water storage capacity will increase watershed system resiliency.* The chosen medium is kinetic and interactive artwork which was created to embody this message.

> "Watershed resilience is the ability of a watershed to maintain its characteristic system state while concurrently resisting, adapting to, and reorganizing after hydrological (for example, drought, flooding) or biogeochemical (for example, excessive nutrient) disturbances." (Lane, et al., 2022, p.1)

The literature review journey covers a diverse terrain, beginning with a look into climate change and climate response science under a narrowed perspective of restoration ecology and watershed resiliency. As well, I present some of the barriers and opportunities for environmental communication that have emerged in the literature. These topics have been twinned with an exploration of what artists have done and are doing around environmental messaging. I have been in pursuit of messaging content and mechanisms that appear promising in terms of furthering watershed restoration narratives in some meaningful way. For these reasons, the presentation of the literature review has been organized to correspond with two of the three research objectives framing the study design, namely Objective 1–Evolving a watershed system resiliency message and Objective 2–Grounding the art: science: communication intersectionality. Key findings and contributions from the literature are linked to each of the specified research objectives. Collectively, this chapter relates the scientific and restoration ecology understandings that were integral to evolving the message content; explores the communication barriers and opportunities that led to the decisions to create the art pieces used to express this environmental message; and explores ecological art through the works of prominent artists in this field.

2.1 Background and Geographical Context of Research

The Great Lakes contain roughly 21% of the world's fresh surface water (United States Environmental Protection Agency, 2021), making the region an important one in which to study, conserve and restore water quality. Broadly, the Great Lakes region is home to 30% of Canada's population and accounts for 25% of the nation's agricultural production (Environmental Protection Agency, 2023). The watersheds of the Great Lakes represent complex socio-economic and ecological systems. Not surprisingly, despite the freshwater abundance, management of the Great Lakes' water resources has been and remains challenging (Lake Huron Framework, 2021).

Lake Huron represents a key area from which many of the thesis motivations, materials, and fieldworks are drawn or focussed for examples. Lake Huron is the second largest of the Great Lakes, covering 59,565 km^2, and the world's third largest freshwater lake by volume (3,538 km^3 of fresh water) (Lake Huron Framework, 2021). It has the longest shoreline (6,164 km) and largest watershed area (13,400 km^2) of the five Great Lakes (Lake Huron Framework, 2021). Lakes Michigan and Superior supply Lake Huron with 13.4 billion litres of its inflow whereas the streams and subsurface watershed drainage accounts for approximately 10.4 billion liters of inflow (Lake Huron Framework, 2021). Protecting the health of Lake Huron's inland watershed regions is therefore an essential component of ensuring continued water quality in the Great Lakes.

As climate change accelerates, drought and flood events have been increasing in severity and frequency, a trend that has been measured since the 1950s regarding rates of streamflow in the eco-regions surrounding the Great Lakes (Dethier, Sartain, Renshaw, & Magilligan, 2020). Invasive quagga mussels have altered the available phosphorus by affecting what has been called the near shore shunt. Nutrients are moved out of the nearshore region and sequestered in the benthos (Li, et al., 2021) altering the trophic structure of the Great Lakes Ecosystems. At the same time, nutrient loading from agricultural runoff is contributing to hazardous algal and Cyanobacteria blooms in Lake Erie. The adverse impacts have led to neurotoxins entering the drinking water for urban centres that draw from the Lake, as occurred in Toledo, Ohio (Chaffin, et al., 2019; Shrubsole, Walters, Veale, & Mitchell, 2017). Algal blooms were also observed in Lake Huron in the early 2000s during historically low water levels along the southeast shores (LaPorte, et al., 2012). Indeed, their presence prompted the formation of the Healthy Lake Huron working group.

The multidisciplinary Healthy Lake Huron team reflects larger trends of Integrated Watershed Management in the Great Lakes region as well as in Canada as a whole. The group's *Clean Water, Clean Beaches* Initiative consists of many cooperative partnerships. These include Environment Canada; the provincial ministries of Environment and Climate Change and of Agricultural and Food; municipal governments; private engineering firms; four Conservation Authorities; public health offices, and NGOs such as the Pine River Watershed Initiative Network (PRWIN). All these partners, and more, have intersecting roles in managing this most precious resource: the health of the watersheds that flow into Lake Huron's Southeast shore. Within Ontario, 36 Conservation Authorities are responsible for monitoring and land use planning for the ongoing health of the region's surface water and its effect on the people, including flood warning at a watershed scale (Shrubsole, Walters, Veale, & Mitchell, 2017).

Since the 2000 Walkerton Water Crisis where groundwater was contaminated by surface water containing E.coli and two municipal employees were found negligent (Shrubsole, Walters, Veale, & Mitchell, 2017), it has not been unusual for private corporations such as Veolia to test the groundwater used by Ontario industry and municipalities (O'Connor, 2002). The International Joint Commission (IJC) is also involved in governance of the Great Lakes. Formed of equal members of Canadian and U.S. representatives, the IJC is tasked to co-operatively manage the water in the Great Lakes Region for the wellbeing of present and future generations. The main IJC legislation is the 1909 *Boundary Waters Treaty*, created to reduce and resolve disputes over the use of the waters shared by Canada and the United States and to settle other transboundary issues.

The Canadian/Ontario shoreline of Lake Huron comprises the south and southeast shores of this Great Lake. This area is a fairly homogenous, rural agricultural region dominated by low gradient streams that have often been engineered into straightened drainage channels and contribute to nutrient pollution and soil erosion from the landscape (LaPorte, et al., 2012). In 2011, the Healthy Lake Huron team selected five priority or sentinel watersheds to contribute to a Rural Stormwater Management model funded by Ontario's Ministry of Environment "Showcasing Water Innovations" grant. The three-year program provided funding for leading edge, innovative and cost-effective solutions to managing drinking water, wastewater, and stormwater systems in Ontario communities. The priority watersheds can be seen on the Heathy Lake Huron website Priority Areas (healthylakehuron.ca).

The Healthy Lake Huron group selected the headwaters region of the South Pine River as a basin in the Pine River watershed where event-based nutrient, sediment and stream flow data would be collected to field truth a Rural Stormwater Model (RSWM) under development. The model would provide further understanding of rural stormwater movement across an agricultural landscape. I was a member of the Healthy Lake Huron's working group. My professional experiences working with the Pine River and Healthy Lake Huron groups in the area position my interest in these watersheds along with my familiarity and lived experiences within them.

2.2 Evolving a Watershed System Resiliency Message

This first objective functioned to consolidate the scientific foundation for the message that restoring connectivity and capacity can increase watershed resiliency. This message forms the central theme for the ecological art exhibit that has been produced. This objective was important to extracting specific message elements, processes and concepts that would later be represented in the art production. To evolve the scientific basis for the proposed message, it first needed to be unpacked into its component parts. The core areas of literature from which this message emerged were found to be resilience theory from Holling (see p. 22) and watershed restoration literature and practice via my applied work as a restoration ecologist.

The related literature review also sought to uncover links to how the artworks' central message aligns with work in North American and European watersheds where the complexity of adaptive water management regimes has been mapped in reference to restoration (Sendzimir, et al., 2007). A main reason for reviewing the watershed management regimes of these two continents was to make explicit the historical, social, and cultural connections between the European settlers who transplanted their ideologies for water management, including intensive drainage, into the North American landscape. These intensive drainage practices have since been discovered to bring a plethora of negative impacts to aquatic systems (Pierce, Kroger, & Pezeshki, 2012).

As large-scale European water management paradigms superseded these imported practices in North America, the same issues of associated degradation of watersheds that Europe faced also arose here. In turn, as Europeans adopted a shift to large-scale basin wide restoration and conservation projects parallel watershed restoration approaches, also appeared in North America (Haigh & Eden, 1994). Moreover, through this timeline we can see how strategies that

developed in Europe came to serve as examples for integrated watershed management planning in North America (Haigh & Eden, 1994). The final major component of literature review towards establishing the watershed system resiliency message was to frame small watershed systems as part of larger water regions that have untapped potential to be managed as hydrological units to better support Earth system state resilience (Gleeson, et al., 2020). Specifically, Rain for Climate: a new water paradigm (Kravčík, Pokorný, Toth, Kovac, & Kohutiar, 2007) offers findings salient to restoring watersheds by increasing water storage on the landscape. Use of this approach has been found to increase localized precipitation, which can help regions mitigate and adapt to aspects of the climate crisis such as severe drought conditions (Gleeson, et al., 2020; Makarieva, 2010; Gorshkov & Makarieva, 2008). The next sections serve to establish both the message and the critical science components that have been extracted for incorporation into the ecological artwork exhibit (Chapter 4).

2.3 Anthropocene: Approaching a Global Tipping Point

. Visually, a tipping point (related to the threshold concept) is most commonly represented as a cup and ball diagram that, in turn, symbolizes a basin of attraction for a system (Walker & Salt, Resilience Thinking, sustaining Ecosystems and People in a Changing World, 2006). The cup represents a regime state of system function and when the system reaches the threshold point, it tips over into a new functional regime state (Walker & Salt, 2006). For instance, a watershed system can be viewed as having a threshold point for resilient hydrological function. A total rate of discharge would be one parameter to measure this, for it denotes periods of flood and drought.

In complex systems, thresholds are a major reason for nonlinear behaviour. Likewise, in the systems-sense, a tipping point represents a critical point after which the system shifts radically and potentially irreversibly into a different equilibrium state (Resilience Alliance and Santa Fe Institute, 2018). This is one reason that identifying tipping points that we have already crossed in real world systems and working out where they may be in the future has become a major scientific endeavour. For example, anticipating tipping points in social-ecological systems is critical for the sake of people's lives, livelihoods, and social wellbeing. We must try to avoid the catastrophic changes of tipping into an unfavorable Earth System state before they occur (Lenton, et al., 2023). Earth System state resilience will require humanity to deliberately

manage largescale bio-physical systems and their functions, interactions and feedbacks (Steffen, et al., 2018) to maintain conditions similar to those that have supported the Holocene epoch (Rockstrom, et al., 2023)

2.4 Ecological Restoration

> *"Ecological restoration is inherently hopeful."*
> *(Society for Ecological Restoration, 2020)*

Ecological restoration refers to "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (Society for Ecological Restoration, 2019). It has the potential to reverse land degradation, increase biodiversity, and deliver important ecosystem services. Ecosystem services are the functional outputs of ecosystems that provide essential contributions to social resiliency (Costanza, de Groot, Sutton, & van der Ploeg, 2013). These services can be envisioned as functioning natural capital that influences human well-being, such as filtering and storing surface water (Costanza, de Groot, Sutton, & van der Ploeg, 2013).

Human land use has a long history of degrading and impairing ecosystems, often reducing, or destroying the ecosystem services that support societal needs (Diamond, 2011). Ecological restoration is a growing discipline specifically targeting the rehabilitation of these land and waterscapes. Climate change is a confounding factor in most restoration work and must be incorporated into the design and management planning stage in hopes of achieving a resilient final restoration project site (Timpane-Padgham, Beechie, & Klinger, 2017). Looking at ecosystems as dynamic systems with a flux between nature and human disturbance is viewed as a key step in the development of restoration ecology (Chapman, 2006). It is integral to the framing of a socio-ecological system that human and myriad other biotic and abiotic factors are considered during the analysis of watershed system resiliency (FAO, IUCN CEM & SER, 2021; Voicescu, et al., 2022).

Ecological restoration work to create "healthy connected floodplains" (Johnson, Shepard, & Verdone, 2019, minute 8:00) has been designed, implemented, and tested within large watershed basins including the Mississippi watershed in the U.S.A and the Danube watershed in Europe (Schmidt K. , 2001). Healthy connected floodplains can reduce nutrient and sediment

loading at a basin level. For example, in the Mississippi watershed, healthy connected floodplains led to a reduction in nitrate loading which helped to reduce the size of the dead zone in the Gulf of Mexico (Johnson, Shepard, & Verdone, 2019). Other benefits of healthy connected floodplains include local water quality benefits such as improvements to drinking water quality and recreational areas and habitat benefits, such as increases in fish populations and migratory bird populations (Freeman, Pringle, & Jackson, 2007). Johnson et al (2019) also describe a floodplain as "… a unique interface between terrestrial and aquatic [ecology]that does not occur otherwise on the landscape" (min 8.35). These regions act as an unapparelled node in which to implement restoration ecology (Mohan, Saritha, Rameshan, Chacko, & Gopikrishna, 2020).

In social infrastructure planning terminology, floodplains are referred to as "hazard lands." Floodplains are often demarcated by the wetted width of a river valley during a one-in-one-hundred-year storm. As climate change advances however, the storms that were defined as having a 1:100 year return rate or a 1% risk scenario are now coming at decreasing intervals, thereby increasing risk to people and infrastructure within these riparian hazard zones. Inter-basin watershed models project that within the U.S.A. inland flooding would affect 41 million people in a 1:100 year storm event (Johnson, Shepard, & Verdone, 2019) and that these 1:100 year storm events are increasing in frequency (Pachauri & Meyer, 2014). Several studies have shown that restoring ecological and lateral hydrological connectivity in floodplains can significantly reduce these hazards (Schmidt & Gordon, 2019; Association of State Flood Plain Managers, 2008). Moreover, a working group based on the Tizsa River in Hungary, a sub-watershed of the Danube, has mapped a process for shifting complex socio-ecological systems towards increased lateral connectivity in their floodplains to increase watershed resilience (Sendzimir, et al., 2007).

Another working group, called Rain for Climate, has established several water forests, which have been defined as "renewal of vegetation and hydrological stabilization of a territory through the conservation of water on land" (Kravčík, Pokorný, Toth, Kovac, & Kohutiar, 2007, p. 91). These water forest restoration projects are proof-of-concept sites, and one is based in the high Tatras mountains in Slovakia. The method used in this 'water forest' was to increase the potential for water storage through hand-built water retention structures (Rain for Climate, 2018). The resulting increase in lateral connectivity supported the associated soil communities that support forest growth and biodiversity, in turn thereby supporting the resiliency of the local

socio-ecological communities. The Rain for Climate group's approach of saturating the small water cycle in sub-basin or watershed units can be viewed as a mitigation and adaptation solution that holds a potential for impacting the resilience of the large Earth system water balance (Kravčík, Pokorný, Toth, Kovac, & Kohutiar, 2007, pg. 7). Additional evidence is derived from research on Russia's boreal forests. These represent the largest expanse of trees on Earth and regulate the climate of northern Asia, altering local atmospheric conditions with the possibility of contributing to larger climatic patterns (Gorshkov & Makarieva, 2008; Makarieva, 2010).

2.6 Beaver Wetland Complexes

The beaver (*Castor canadensis* in North America, *C. fiber* in Eurasia) is probably the most well-known ecosystem engineer, referring to its ability to create or significantly modify aquatic habitat in relation to hydrology, geomorphology or and other ecosystem functions (Larsen, Larsen, & Lane, 2021). Scholars and practitioners interested in helping impaired ecosystems have studied and utilized the behaviour of beavers in a range of ecosystems that historically would have supported robust beaver populations. Beaver activity is known to increase the volume of water storage on a landscape with accompanying increases in baseflow during drought conditions (Dittbrenner, et al., 2018; Puttock, 2020) decreases in peak flows during flood events (Grudzinski, Cummins, & Vang, 2020), and enhanced storage of sediment and macronutrients in the floodplain (Andison, Burgess, & Elliot, 2011; McCullough, Harper, Eisenhauer, & Dosskey, 2004). So capable are beavers at transforming a landscape that where such modifications are desirable, yet natural conditions are not favourable for beavers to survive, river management has employed simulated beaver dams (Fairfax, 2021). These human-built structures, called beaver dam analogues (BDAs), are purposed to reproduce the form and function of a natural beaver dam. Efforts to actively reintroduce beavers have accelerated during the 21st century under climate response (Puttock, 2020) with accompanying interest in natural BDAs built to boost the success of translocated beavers as the BDAs provide deep water habitat for them to enter and escape from predators (Fairfax, 2021)

Beavers play a complex role in floodplain dynamics. Their instinctual behaviour of dam building has shaped the dynamic riparian landscapes of North America where, prior to European settlement, an estimated 400 million beavers inhabited the continent (Fairfax, 2021). They build dams of wood and sediment across small channels (typically at gradients less than 6%),

secondary or abandoned channels on floodplains, and hillside seeps or springs (Grudzinski, Cummins, & Vang, 2020). They may also dig narrow canals across the floodplain. Their dams create wetlands by trapping sediment and slowing down water. Multiple colonies of beavers can give rise to a beaver wetland complex characterized by a river corridor that is spatially heterogeneous, with numerous channels, dams, and ponds in varying stages of being filled with sediment (Grudzinski et al., 2020, p 191).

Allowing beavers to inhabit riparian zones has been found to lead to the provision of broad ecosystem services such as carbon storage, stormwater management, nutrient cycling, and water filtration (Thompson, Vehkaoja, Pelikka, & Nummi, 2020). To gain a sense of the monetary value of these services, a modified benefit transfer approach to ecosystem services valuation, has estimated the water storage capacity gain brought by beaver activity in the US at close to $75 USD per hectare for provision of water supply for use by society (Thompson, Vehkaoja, Pelikka, & Nummi, 2020).

The ecosystem services accruing through beaver wetland complexes have also been shown to increase landscape level resiliency to climate change (Fairfax, 2021; Wohl & Bouwes, 2020). One of the ways by which functional resilience in riparian systems is increased is through reconnecting streams with the surrounding floodplains. Lateral and vertical connectivity commonly increase in river corridors with beaver dams (Andison, Burgess, & Elliot, 2011). Their dams enhance overbank flows and groundwater recharge (Fairfax & Small, 2018). Subsurface water storage has also been reported to improve downstream base flows (Larsen, Larsen, & Lane, 2021). By attenuating peak flows and adding surface and sub-surface water storage within a river corridor, beaver “ecosystem engineering” supports a river corridor’s resilience to floods, drought, and wildfire (Fairfax & Whittle, 2020; Fairfax & Small, 2018)

A series of 13 beaver dams on a tributary in rural southwest England increased the water storage capacity of the watershed system by one million litres (Puttock, 2020). They found that beaver activity across the study site had also resulted in reduced peak flows (even during saturated conditions) of 30% on average along with supporting a constant baseflow leaving the site even under drought conditions.

The trend towards increased beaver preservation/ reintroduction efforts and accelerated BDA construction taken together with the multiple well-established benefits that can accrue through improved water storage brought by beaver dams offered a rich area for an additional

case study exploration (Chapter 4). Beaver wetland complexes have a direct link to the context for the message that *restoring capacity and connectivity can increase watershed system resiliency* that emerged as central to the ecological art exhibit that will be presented. Moreover, observing a beaver wetland complex firsthand offered a place where my knowledge of ecological restoration, artistic approaches, and efforts to communicate a watershed restoration message intersected.

2.7 Connectivity and Capacity

"Connectivity" and "capacity" emerged as important keywords and organizing concepts during the literature review. Connectivity has been applied in ecological, hydrological, and geomorphological studies as landscape or corridor connectivity, hydrological connectivity (lateral, or longitudinal), and sedimentological connectivity, respectively. It also appears in the lexicon of climate change and climate response research and is used by ecological and environmental artists as well. Yet, as Bracken and Croke (2007, p.1749) observed, "Unlike other disciplines, notably ecology, published studies show no consensus on a standard definition."

Ecological connectivity often refers to habitat corridors that allow for the movement of species across a landscape, considered an essential component for the sustainability of wildlife populations (Bracken & Croke, 2007). Increased connectivity within ecosystems is thus envisaged as a supporting requirement for many aspects of biodiversity that sets into motion a positive feedback loop for resilience of a system (Timpane-Padgham, Beechie, & Klinger, 2017). The more connections within a biodiverse community, the more resilient that socio-ecological system becomes (Ogden, et al., 2013). In the field of ecological restoration, the definition of connectivity can depend on specific context, discipline, and background. Within ecological systems theory, as part of a Holling's Loop, connectedness may be looked upon as a range of external and internal relationships affecting an element's behaviour (Gunderson & Holling, 2013). From a hydro-geological perspective, various definitions of connectivity exist such as hydrological connectivity, which describes how water moves within a watershed, and sedimentological connectivity, which describes the movement of sediment and attached pollutants through a watershed (Bracken & Croke, 2007).

The connectivity of a socio-ecological system can be framed in two important ways for the purpose of evolving the message that will be central to the thesis ecological art exhibit. First,

is hydro-ecological connectivity, which through riparian habitat corridors forms desirable linear hydrological connectivity facilitating the transport mechanisms of soil, energy, and organisms from the headwaters to the outlet of a watershed system to support biota (Freeman, Pringle, & Jackson, 2007; Jalava, et al., 2001). This process is supported by strong lateral hydrological connectivity in the floodplain, which allows the potential for volumetric water storage capacity, including in the hydric soils of the riparian zone (Runkel, 2002). An example of water storage capacity in the floodplain is shown in figure 2. a riparian wetland constructed in the Pine River Watershed. Second, is the social connectivity found in the relationships and communications between and among individuals in our socio-hydrological communities. This seeks to centre the human in the watershed restoration/climate response dialogue (FAO, IUCN CEM & SER, 2021); it is where my work towards messaging through art is situated.

In Southern Bruce County, Ontario Nature mapped potential pathways of ecological connectivity between the major ecosystem complexes which are the Greenock Swamp and the Huron Fringe Forest. The Pine River was chosen as a corridor with potential to provide a physical pathway for species movement between these remnant ecosystem complexes, which also provide important functional hydrological buffering. Specifically, the early mappings developed under a team from Natural Heritage Information Centre, Nature Conservancy of Canada, and Ontario Parks sought "…to identify a potential natural heritage area network consisting of buffered core protected areas and corridors that would increase landscape functionality, ensure ecological integrity, and help to focus biodiversity conservation activity within the region" (Jalava, et al., 2001, pp. 25).

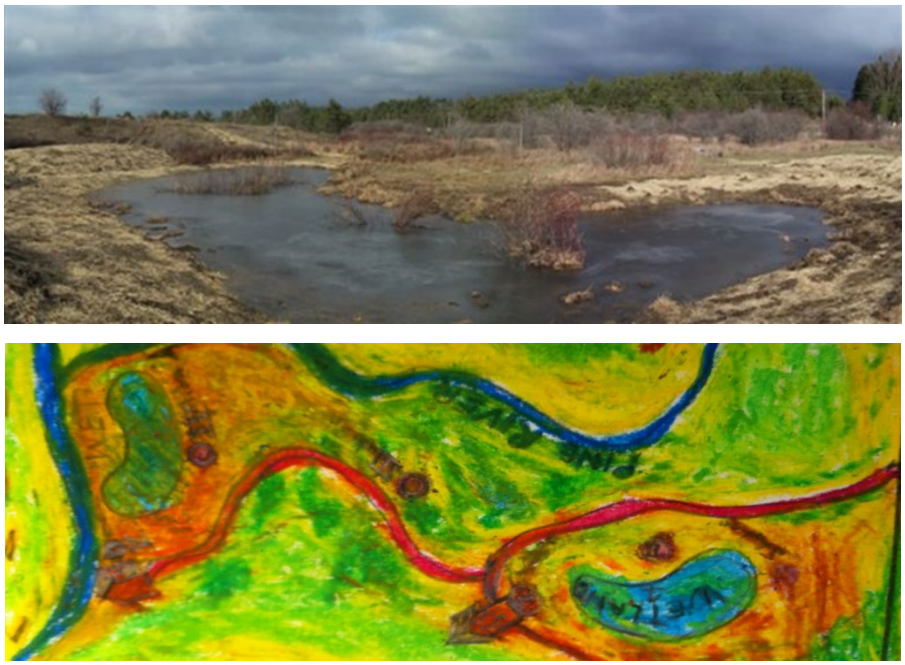

Figure 2. Constructed Wetland Riparian Zone, PRW (Mason, A.)

Shown above is a wetland constructed by the PRWIN in the Pine River Watershed within the riparian zone, part of a roughly 10 km reforested corridor that has been designed to provide habitat connectivity and an environmental study area for local students. Wetlands in the riparian zone also provide the additional role of increasing lateral hydrologic connectivity and water storage capacity. Below is a hand drawn map in oil pastels of the property that students used for navigating the property. In the winter of 2024 a beaver has been seen building a dam in this section of floodplain.

Like connectivity, capacity can be viewed through hydrological and socio-ecological lenses. For example, a standard definition of capacity includes “the total amount that can be contained or produced” and/or “someone's ability to do a particular thing” (Cambridge Dictionary, 2023). When experts from particular disciplines join the conversation, capacity may become a concept and/or carry embedded measuring methods. In this way, suddenly introduced into the narrative may be discipline specific ideas or understandings about volume, size, magnitude, scope, space, retention, proficiency, educational background, or other socio-economic resources. This point that communication of capacity (and potential), and discipline specific language in general, can be messy, impressed itself heavily on me as I reviewed the relevant literatures.

As practicable examples, first, a hydrological approach may focus on capacity as the transient storage zones, such as the pools, eddies and the hyporheic zone, where the hydric

saturated soil indicative of the water table surface, intermixes with the flowing waters of a stream system (Runkel, 2002). In contrast, social capacity studies may be considering “capacity” in terms of community members with training or education in fields representing the four pillars of sustainability (social, economic, environmental, and cultural skillsets) (Hawkes, 2001). Third, ecological capacity could be expressly viewed as elevated levels of forest and wetland habitat on the landscape and subsequent levels of biodiversity ((IPBES) Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2018). The following figure 3. showing restored connectivity and capacity on the landscape, is intended to portray the understanding of both capacity and connectivity most relevant to communicating the thesis message chosen for the ecological art exhibit to convey, namely a functional restoration approach for increasing socio-ecological watershed system resiliency.

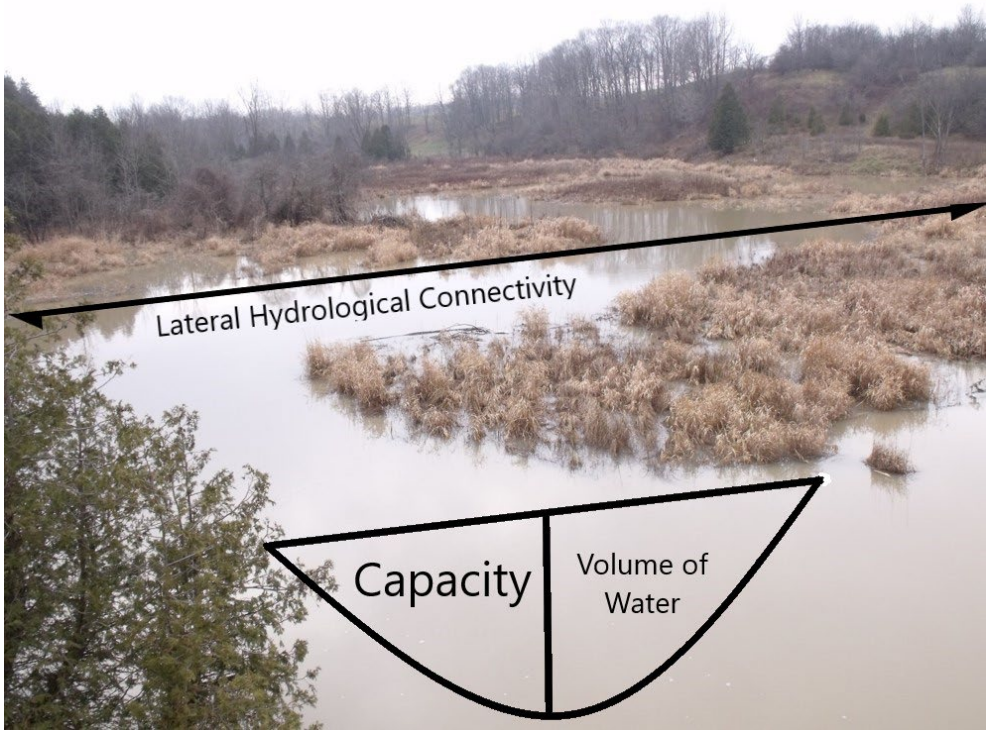

Figure 3. Connectivity and Capacity on the landscape (Mason, A.)

This image shows the Beaver Wetland Complex on Willow Creek, near Paisley, Ontario explored further in Chapter 4. The image depicts lateral hydrological connectivity as the wetted region across this section of floodplain and capacity as the volume of water held back on the landscape.

The links between capacity and water storage potential and socio- eco-hydrological relationships and connectedness made it apparent that there is sustenance in the idea that *restoring capacity and connectivity in a watershed system can increase its resilience*. How we communicate this type of knowledge, may be found in many alternative communications pathways including ecological art, which can offset a reliance on terminology that may be confounding in a multidisciplinary setting. As a researcher-artist-communicator I tried to keep this discipline specific language in mind during the design and output phases of the ecological art created for this thesis.

2.8 Resiliency

Resilience in a watershed system can be imagined as a system in a functional and dynamic equilibrium state. A socio-ecological watershed system in a dynamic equilibrium state can exhibit predictable seasonal patterns that can support various economic and social activities at the local level (Gunderson, et al., 2017). At a global level, these local watershed systems can be viewed as feedback loops (Kravčík, Pokorný, Toth, Kovac, & Kohutiar, 2007) that relate to the larger state of the Earth System (Steffen, et al., 2018). A system that is managed for water quality and quantity is likely to exhibit positive attributes (Hayes, 2018) in support of the triple bottom line often outlined in sustainability theories relating to economic, ecological and social wellbeing (Waite, 2013). Enhancing resilience is therefore a key goal of restoration projects with the aim to return an impaired ecological system to a state of self-sustaining dynamic equilibrium. A resilient system can maintain its functional state in response to external stressors or pressures (Walker & Salt, Resilience Thinking, sustaining Ecosystems and People in a Changing World, 2006). Higher resiliency presumably represents a more robust system in terms of being able to withstand external or detrimental pressure.

The foundational adaptive four-phase cycle is the Holling's loop. This offers an example of a theoretical metaphor for how a resilient system might behave (Gotts, 2007). The Holling's loop is a three-dimensional lemniscate (∞) with four quadrants. The loop object shown below in figure 4. is an ecological art production that I created expressly to capture the mechanics derived from the theory. Named the *Holling's Hand-held Hydrology Loop*, the object also represents an early technical trial or small-scale pilot that, through subsequent iterations, became centrally integrated in the final ecological art installation produced. (Chapter 4).

Figure 4. Holling's Hydrology Loop (Mason, A.)

This loop combines Holling's theory of a resilient system, as one that has high connectivity and capacity with applications of watershed restoration, by placing water inside a model of Holling's loop. In watershed system restoration, where the river discharge rate of a system is too high during storm events, and too low during drought events, increasing water storage capacity and lateral hydrological connectivity, can increase the resiliency in small watershed systems.

In Figure 4, the r phase represents growth; the K phase represents conservation; the Ω phase represents release; and the α phase represents reorganization (Walker & Salt, 2006). Holling's loop integrates attention to three main variables: potential, connectivity, and resilience (Gunderson & Holling, 2013) which operate in three spatial planes. Capacity represents the accumulation of social capital, or biomass (Gotts, 2007), or as is proposed in this thesis, potential water storage capacity. Connectivity is an expression of the interrelationships among elements in a system, the limit of this segment of the lemniscate curve symbolizes a state of rigidity that can lead to fragility in a system (Gotts, 2007). The third plane is that of resilience and it is related to the interaction of the capacity and connectivity variables in the system (Hobbs & Allison, 2004). For me, this relationship evolved to hold a centrality in articulating, as artist and science communicator, how, as capacity and connectivity increase in a watershed system, so too will the

system's resiliency. This, then, became one of the science communication takeaways my ecological art has been crafted to convey.

2.8.1 Critique of Resiliency and Systems Thinking

The processes of resilience thinking most often have their foundations in social-ecological systems (SES) framework, which can have several intrinsic biases, such as defining individual and social interests in relation to the environment, while missing other underlying motivations and institutional drivers of social behaviour (Fabinyi, Evans, & Foale, 2014). When formal institutions and established social units are considered under SES framework, they can fall short of including power dynamics and social diversity within the analysis (Fabinyi, Evans, & Foale, 2014). Systems Thinking can develop impressive webs of interacting feedback loops within a given socio-ecological system consisting of desired outcomes and process based strategies to drive change towards resiliency. However these system maps don't necessarily lead to clear pathways for action that can be defined by "scope, priority, timing, time delay, unintended consequences, and sustainability of proposed improvements" (Stroh, 2015)p. 187).

Further critique and concerns were gathered during a convening of Capacity Builders of Systems Change organized by Illuminate Network and the Academy for Change in Santa Fe, New Mexico in 2019 and are paraphrased as such. The timescale that is required of funding agencies that often support Ecological Restoration work is often short in relation to the time successional processes can occur in an ecosystem or the time it takes to build meaningful, shared understanding and language amongst project partners and the local community (Membrillo, Riddell, Berman, Ceroni, & Gaskin, 2019). The spatial scale of Ecological Restoration is hard to increase within the context of current socio-ecological management regimes and without largescale restoration it is hard to produce a transformation from degradation to resilience (Membrillo, Riddell, Berman, Ceroni, & Gaskin, 2019).

The focus of many systems change practitioners might not be on the most critical leverage points to shift decision making under current social conditions, which could lie in the hands of those who control online or financial algorithms (Membrillo, Riddell, Berman, Ceroni, & Gaskin, 2019). The focus on complexity or large scale systems change may be distracting and shallow in the context of some small site specific ecological restoration projects (Membrillo, Riddell, Berman, Ceroni, & Gaskin, 2019).

The specialized language developed in modern systems change dialogue may be considered elitist and could reinforce divisions across social groups that are already disenfranchised by processes such as environmental or systemic racism (Membrillo, Riddell, Berman, Ceroni, & Gaskin, 2019). Also, community outsiders who can utilize specialized systems change language could out compete local practitioners of restoration work and further reinforce the colonial practices of outsourced governance and management of natural resources (Membrillo, Riddell, Berman, Ceroni, & Gaskin, 2019).

From an individual perspective working towards improving sustainability and transformation can require an uncomfortable reflexivity on the behalf of the practitioner in order to examine the bias we can carry into the work and our own interactions and relationships within the socio-ecological system (Membrillo, Riddell, Berman, Ceroni, & Gaskin, 2019). Working on systems change can be isolating for individuals trying to do this work, as often there is little opportunity to interface with peers or colleagues focused on the same type of work . It can be very difficult to find opportunities to work in this field in a meaningful and personally sustainable way (Membrillo, Riddell, Berman, Ceroni, & Gaskin, 2019).

2.9 Complexity in Watershed Adaptive Management

Current dominant North American water management regimes can be appreciated in the context of their origins. In North America, most of the current approaches originated with European settlers, and many parallel methods continue to be used in these landscapes (Eden & Haigh, 1994). The general practice has been to clear forested landscapes, drain wetlands and straighten and narrow waterways to prepare agricultural and societal infrastructure (Water and Agriculture Information Center, 2019). These practices have been shown to induce specific environmental problems such as erosion, nutrient pollution, and loss of biodiversity. Numerous social, political, and economic influences, added to hydrological responses to climate change, make problem solving for these environmental problems associated with water management complex or wicked. The timeline of European water management practices; subsequent environmental problems and restoration techniques runs ahead of the North American timeline. For this reason, I found it useful to contrast and compare watershed restoration work between the Pine River watershed in Ontario (34km in length/ 160 km^2) and a European watershed, the Tisza

in Hungary (966km in length/56 087 km^2 watershed) which share some of the same socio-ecological features.

Of interest is how two paradigms for water management employed in the Tisza watershed mirror the historic and the current water management practices widely in use in southern Ontario. In both places, management methods have sought at one time or another to isolate civil and agricultural systems from the saturated soils of floodplains or swamp forests. The two paradigms can be viewed as "Protect the Landscape from the River" (protect-from paradigm) in comparison to a "Live with the River" (live-with paradigm). In the Tisza River context, the 'protect-from paradigm' has involved isolating the river from its floodplain through a series of dikes and hard-engineered channels. In contrast, the 'live-with paradigm' has involved restoration of the river's floodplain through lateral connectivity that allows portions of the nutrient-rich flood pulse to revive the riparian ecosystem (Sendzimir, et al., 2007).

The complexity inherent in managing integrated socio-ecological watershed systems for resilience at a local level (Gunderson, et al., 2017) can be very challenging for many reasons. In the Tisza watershed, the system map below (Figure 5) depicts the layers of social and ecological feedback loops that affected water management of this basin under the 2007 Hungarian governance regime (Sendzimir, et al., 2007). Demonstrated also are the comparative positions of the 'protect-from' and the 'live-with the river' paradigms.

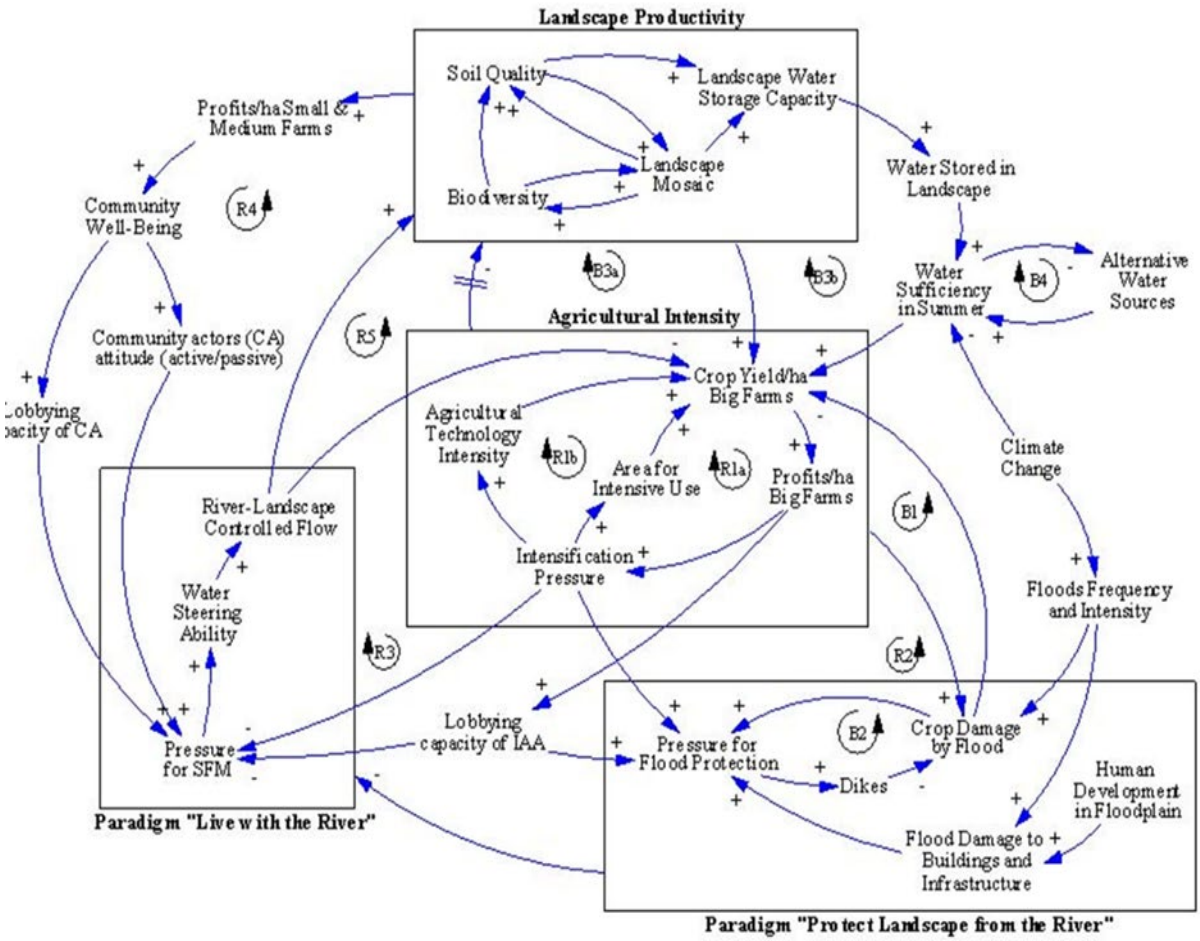

Figure 5. Feedback Loops in the Tisza River Basin, Hungary (Sendzimir et al., 2007)

This diagram of feedback loops observed in the Tisza River Basin, Hungary depicts conventional (protect-from) and alternative (live-with) paradigms to river management. The boxes and arrows demonstrate the inherent complexity of a socio-ecological watershed system and how adaptive management, hydrology and society can interact on the on the landscape (**used with permission**).

These social and ecological relationships are already complex in a contemporary time scale, but when socio-ecological watershed management is extrapolated to the scale of a century or more, system complexity only grows. A great deal of complexity was also discovered through the process of creating an integrated watershed management plan for the Pine River, in Southern Bruce County, with factors ranging from legislated policy and market driven crop prices to invasive species and drainage practices affecting the uptake of ecosystem restoration (LaPorte, et al., 2012).

Under the protect-from-the river paradigm, grey infrastructure, such as dike systems, are engineered often with the aim to protect recreational and residential areas from the rivers in flood stage. The threshold that most dikes are designed to withstand is a 1:100 year (or 1%) storm. Problematic, of course, is that climate change has been resulting in an increase in high-intensity rainfall events during the spring season (Pachauri & Meyer, 2014) This increased spring precipitation also coincides with the snowmelt in many regions and is a time when crop cover is devoid from the agricultural landscape, which has been shown to increase the volume and rate of water leaving the landscape (LaPorte, et al., 2012). Built societal infrastructure is threatened by these large flood events that are occurring at much higher frequencies and intensities. Many efforts to respond to these risks have taken the form of isolating existing societal infrastructure, by building hard-engineered structures such as dikes and 'protecting' stream banks with stone rip-rap.

This "end-of-pipe" approach accelerates channelization and isolation of rivers from their floodplains, exacerbates high flow conditions linked with climate change scenarios, and does not offer any mitigation opportunities for nutrient or sediment removal. Furthermore, these large-scale grey infrastructure projects tend to carry a steep economic price tag and will be increasingly under stress during storm events fueled by the changing climate (Schmidt & Gordon, 2019). The alternative "live-with the river paradigm" of water management often involves the building of green infrastructure for water storage in floodplains and headwater reaches of watershed systems (Johnson, Shepard, & Verdone, 2019; Sendzimir, et al., 2007). This latter approach has been shown to have multiple benefits to socioecological communities (Schmidt & Gordon, 2019). However natural systems can have a greater variance regarding predictability of the location of channels which can make land use planning difficult. A compromise between these two water management paradigms are structures such as Water and Sediment Control Basins (WASCoBs) that use some elements of grey infrastructure to provide predictability and functional aspects from green or blue infrastructure (Schmidt K. , 2001) to mimic natural floodplains.

2.10 Summary: Evolving a Watershed System Resiliency Message

Through an examination of relevant studies, literature review has established the feasibility and scientific merits of the message proposed (*restoring water storage capacity and*

lateral hydrological connectivity can increase watershed system resiliency). This message will form the central theme for the ecological art exhibit presented in CHAPTER 4 to explore use of art as an interface for communicating ecological restoration messaging as a climate change response. This concept can be applied across various scales from the local to larger regional scales and evidence has been provided that volumetric water storage on the landscape may have positive effects on small water cycles and help to stabilize aspects of the Global Water Balance (Gleeson, et al., 2020; Kravcik & Lambert, 2015). However, current water management regimes are often entrenched within society and communication barriers may impede transformation of watershed systems towards resiliency.

2.11 Grounding the Art-Science-Communication Intersectionality

This section explores how ecological art, whether virtual, visual, auditory, or kinetic, can be used as an effective interface for communicating complex messages regarding watershed resiliency. The exhibit of ecological art created for this thesis aims to effectively communicate a message for restoring capacity and connectivity in order to increase watershed system resiliency. Art can be an effective medium for addressing the complex issues involved in socio-ecological restoration (Ahn, 2016; Guy, 2015). Art is a means of skirting certain language barriers (Riberio, 2007) that can limit clear communication in the multi-disciplinary work required for integrated watershed management.

2.12 Art as Metaphor

Art often provides visual metaphors or analogies for issues through symbolic representations of reality (Roosen, Klockner, & Swim, 2017). This use of visual symbolism to express complex ideas has long-reaching roots in human history. Dating back to 7000-5000 Years Before Present, is the symbol of the Ouroboros, the image of a snake eating or biting its own tail (Van der Sluijs & Peratt, 2009). Ouroboros has been used to represent multiple ideas including self-destruction, renewal, and cyclical patterns in nature. Comparative literature suggests that this symbol represents the idea of "circular continuity" (Santiago, 1971), which I propose can be extended to the ecological concept of dynamic equilibrium and resilience theory as depicted in Holling's Loop. The Ouroboros has been illustrated in many forms. The two most

common are pictured below in Figure 6: a self-destroying and renewing serpent, in a circular or lemniscate (∞) shape (Bos, 1970; Santiago, 1971).

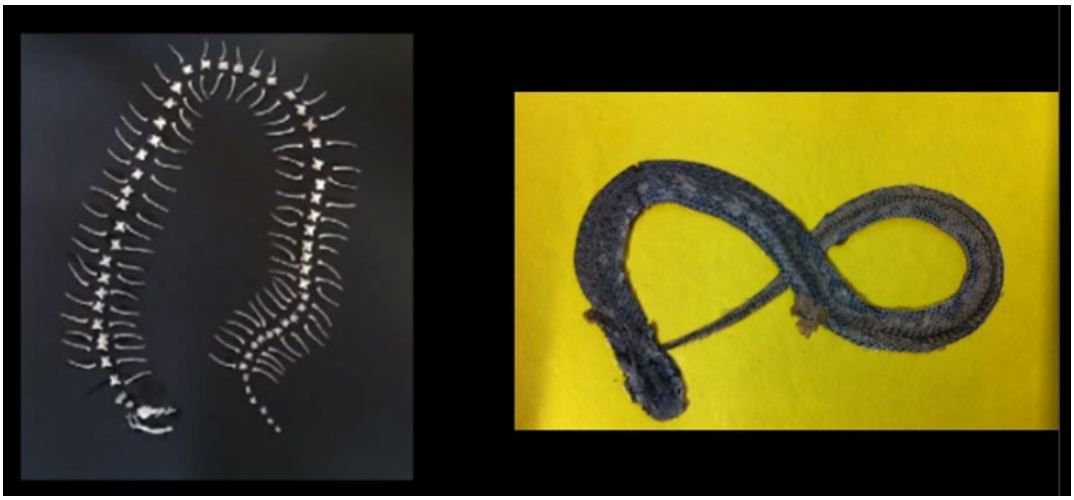

Figure 6. Milk snake skeleton and Northern Brown Snake: Ouroboros (Mason, A.)

Left: Milk snake skeleton I preserved and mounted after specimen was found deceased with rigor mortis biting its own tail. Right: Northern Brown Snake found crushed in a lemniscate shape.

Metaphors often enable ideas or knowledge to be communicated to an audience more effectively than a purely factual account could (Sopory & Dillard, 2002). This supports my proposition that art can be used as a metaphor and a type of visual symbolism to facilitate the communication of a specific watershed restoration message. Through embodied narrative and metaphor, art has been shown to facilitate audience members' willingness and capacity to shift towards adopting an increased pro-environmental stance (Roosen, Klockner, & Swim, 2018). The flexibility of artistic symbolism has also allowed it to carry social capital embedded in a culture or sub-culture's ideology and accompanying narratives across time and geographies. For instance, in Norse mythology, Jörmungandr (or the world serpent) represents Norse culture's particular vision of the Ouroboros. Jörmungandr, too, is a serpent that encircles the world biting his own tail; and, in a world-ending scenario, Jörmungandr releases his tail and poisonous gases fill the atmosphere. This symbolic representation of Jörmungandr could act as a metaphor for human responses under climate change: either we proceed on a trajectory towards a current Earth System collapse (*destruction*) or, through a philosophy of *renewal,* driven by pro-environmental action (Steffen, 2011), Jörmungandr will not devour the world. In many ways, when people,

whether restorationists, politicians, professors, stakeholders, or artists talk about climate change, it is already essentially metaphorical. This is because it is difficult for most people to even begin to imagine what 2.5 degrees Celsius of warming would do to the planet, leading to climate change being perceived as an abstract issue, carrying no direct threat; art used as a metaphor has been shown to counteract this level of abstraction, which allows an audience personal engagement with the subject matter (Roosen, Klockner, & Swim, 2018). As E.O. Wilson expresses in his book*, The Origins of Creativity,* a metaphor can be used "to cross boundaries, deliver little shocks of aesthetic surprise and humor and thereby achieve nuance and novel perspective" (Wilson, 2017, p. 163).

2.13 Communication and Narrative

Communication is a form of social connectivity wherein ideas can be exchanged, learned, evolved, and understood. It is multisensory, although we are most familiar with receiving communications through our senses of hearing and vision. Yet smell, taste, and touch can also be used. In a general way, communication with others typically involves both vision (eye contact or body language) and sound (speech or other sounds like laughter, sighing, or crying) and depends on some sort of narrative (Castro & Peres, 2019). A narrative is, of course, simply a story. Narrative art, then, can easily be understood as art that tells a story. The broad category of environmental art I will be exploring in deeper detail under Objective 2–Grounding the art-science-communication intersectionality, involves using narrative using a diverse range of mediums. According to the Tate, "[m]uch of Western art until the twentieth century has been narrative, depicting stories from religion, myth and legend, history and literature" (Tate, London, 2021). Contemporary, or modern art, tends to make use of more elusive symbolism such as coded references to political or social issues. This approach offers "modern allegories," and messaging from the artist often emphasizes their connection to these broader social issues (Tate, London, 2021). This attention to connection emerged strongly for me under Objective 1–Evolving a watershed system resiliency message and is integral to the message selected, namely that *restoring connectivity and capacity can increase watershed system resiliency*.

2.14 Ecological Art: Definition and Principles

Ecological art is art with an ecological purpose, created by artists who are concerned with the state of both local and global environmental situations. Ecological-art addresses aesthetics, ethics, politics, culture, and economics, and the impact these have on the world's ecosystems (Weintraub, 2012). Many artists use the terms eco-art, ecological art, environmental art, earthworks, and land art interchangeably, yet some distinctions are recognized (Carruthers, 2006). "Environmental art" is most often used as an umbrella term encompassing any art that is about the environment or situated in the environment but does not explicitly pertain to restoration messaging (Carruthers, 2006). In this way, paintings, sculpture, photography, audio narratives, music, dance, or interactive exhibits that are site-specific and rely on the natural landscape can be considered to belong to environmental artworks. Earthworks and land art are similar and tend to be less about activism than other forms of ecological-art and use the environment itself as the medium.

Ecological art, Eco Art or EcoART may be defined as "a broad field of interdisciplinary arts practice, distinguished from Land Art and Environmental Art by its specific focus on world sensitive ideologies and methodologies. EcoART practice seeks to Restore, Protect and Preserve the world for its own sake, and to mediate human/world relations to this end." (Carruthers, 2006, p. 3). Ecologcial Art or Eco Art can occur in many varieties of medium, form, material, size, and modality (which sense(s) are being engaged) it can even encompass restoration processes and projects or include functioning mechanicals (as does some of my work, for instance) (Weintraub, 2012).

Ecological Art as a distinct style took shape in the hands of artists such as Robert Smithson in the 1960's (Nay, 2011). In his work *Spiral Jetty* Robert Smithson used artistic earthworks to connect economic and sociological patterns to the findings from fields of conservation science and ecology (Graziani, 2004). The term ecological art should be considered as a starting point in terms of exploration of this genre of art rather than a complete and all-encompassing description. Whatever the definitions, with climate change currently occurring at an alarming rate, the field of ecological art has also been expanding in response (Nay, 2011; Cape Farewell, 2007).

The main principles of ecological art as uncovered through literature review, then, would include the following: First, the artist wants their art to inform the viewer of environmental

issues and the historical and ecological dynamics of eco-systems, and this is often in reference to current politics and culture. Next, the artist hopes their art will assist viewers to reframe their interactions with nature and put forward new ways to co-exist with the environment (Brookner, 1992). Many ecological artists, as well as art educators and gallery owners, are also hoping that ecological art pieces or installations will creatively support and even propose new ways for sustainability, healing, and coexistence with the natural world (Weintraub, 2012). Finally, in terms of materials used, because these artists are concerned with environmental materials and forces, they may create art that works with natural forces such as: water, precipitation, ice, wind, and even lightning; or that include natural materials.

2.14.1 Shortcomings of Ecological Art

There can be a conflict within ecological art between aesthetics and ethical considerations (Ouellet, 2020). An example of this type of conflict can be seen in ecological artist Olafur Eliasson's installation of twelve ten-ton blocks of Greenland glacial ice displayed during the 2015 COP21 summit in Paris (Shapshay, Tenen, & Nannicelli, 2018). This melting glacial ice installation was meant to bring urgency to the issue of rapid climate change at a moment when considerable attention was focused on this issue. However, the carbon footprint of obtaining the material for the installation from Greenland poses an ethical dilemma; raising the question of whether the ends justify the means regarding whether this carbon expensive art making process negates the message that the aesthetic art piece is meant to convey (Shapshay, Tenen, & Nannicelli, 2018).

Within much of established art history, the choice of material is essential to an artistic process, yet the role of the artist is to transform the materials into an art object. However, within Ecological Art the materials themselves could be the focus of the final art object, being of nature, the final product could be an earthworks, such as the Spiral Jetty by Robert Smithson, and this focus on the material as the subject of the art puts, ecological art at odds with more traditional art forms (Stoltz, 2023).

One of the underpinnings of Ecological Art is that it often carries an environmental message, which can take an anti-establishment angle regarding dominant structures of fossil fuel driven economics for example (Lippard, 2021). This oppositional stance of Ecological Art can be extremely provocative and has resulted in the destruction of artworks such as Chris Drury's

Cabon Sink: What Goes Around Comes Around, in Wyoming and James Tyler's *Brickface Hope* by funders and governing bodies that have ties to the fossil fuel industry (Lippard, 2021). This controversial aspect of Ecological Art could further division within communities and could perhaps delay potential constructive solution pathways.

2.15 Shortcomings of Environmental Communications

There are a series of known communication barriers and opportunities that can impede the uptake of environmental messaging (Wortley, Hero, & Howes, 2018). A recent comprehensive review of the possible impacts of climate change–related visual art conducted by Roosen et al. (2018) identified several gaps in current non-art-based environmental communication practices that art and other visuals like multimedia have potential to bridge. These investigators adopted a psychological perspective and sought to determine potential effects of confrontation with ecological messaging. They also derived a "preliminary conceptual framework that identifies special features of art that go beyond other means of communication" (Roosen et al, 2018, p. 85). The list below provides a summary of identified gaps (Roosen, Klockner, & Swim, 2018, p. 87) that have specific relevance to the watershed restoration science message that the thesis ecological artworks will seek to communicate:

- lacks the kind of narratives and metaphors that engage people in climate action and relate climate change to their personal lives
- does not challenge social norms or actively stimulate the redefinition of norms and values
- lacks the dimension of personal, direct experience of the problem
- fails to overcome the psycho-emotional barriers to behavioural change/message uptake

The weaknesses presented in the above list can be summarized as inadequacies of narrative, engagement, personal connection, and message-to-understanding-to action sequencing. And, while the intent of this exploratory work has been centred on communication via art as an alternative to non-art-based, more traditional communication forms, it is evident that the provision of science-based climate data may not be enough to persuade people to change behaviours that influence watershed system management (Gabrys & Yusof, 2012). The use of personal narrative has been reported to provide an audience with a chance to overcome difficult

emotions related to aspects of a sensitive topic such as the climate crisis (Roosen, Klockner, & Swim, 2018). This can be accomplished by presenting an interface that encourages behavioural reflexivity using both cognitive and emotional cues expressed through artistic means (Green M. , 2006).

2.16 Discipline-Specific Language and Positioning

The complexity of climate change requires experts from a myriad of disciplines to come to the same table and brainstorm solutions for managing 'water in a changing world' (Jackson, et al., 2001, p. 1027). However, the complexity involved in managing socio-ecological watershed systems has been reported to create a 'technocratic elite' (Peterson St-Laurent, Hagerman, & Hoberg, 2017, p. 210) who can struggle to communicate with stakeholders in different disciplines. An often-reported barrier to communication, discipline-specific language can intensify feelings of division among these potential stakeholders (Riberio, 2007). These language barriers can be rooted in the literacy practices, conventions, and discourse patterns of individuals or schools of thought (Rex, et al., 2010). The discipline or sub-discipline expertise and role that individual experts or teams are assigned can also exacerbate communication problems. Environmentalists, for example, have an ethical duty to communicate information related to the severity of global climate and water crises (Roosen, Klockner, & Swim, 2018). Restorationists, in turn, need to help people understand how to restore the function of socio-ecological watershed systems.

In contrast, hydrological scientists, while not unaligned with socio-hydrological theories, may be more focussed on the measurement of specific ground or surface water parameters as their contribution to a project. From a broader environmental science communication perspective, finding ways to connect these methods to outcomes that will represent a solution pathway for maintaining Earth system state resilience (Ogden, et al., 2013) remains difficult. Broadly speaking, the public comprise diverse backgrounds in terms of knowledge and their own interests, and thus may need to be persuaded that the proposed solutions make sense. In specific relationship to executing restoration work, these differing starting points brought into the communication and decision-making processes involved are not infrequently reported as posing a significant obstacle (Wortley, Hero, & Howes, 2018).

The group carrying out restoration work along the Tisza River (the largest tributary of the Danube River) in Hungary (mentioned previously under Objective 1) reported meeting several communication barriers. Througout their work to increase lateral connectivity and the floodplain's potential for water storage, they encountered difficulty communicating the scientific merits of these ideas. Moreover, stakeholder and public resistance made securing subsequent project commitments a struggle at times. Sendzimir, et al. (2007) attributed some of these barriers to the diversity of community experience, beliefs, and training of rural Hungarian society. They also pointed to barriers of problem complexity, peer pressure, and shifting political climates[1] (Sendzimir, et al., 2007). Their experiences align with those of broad-scale restoration efforts aimed at improving the socio-ecological system health of the Danube watershed (Schmidt K., 2001).

Language and an inbility to agiley communicate science were similary identified as barriers during the Pine River watershed restoration in Southern Bruce County, Ontario. In this region, water management has primarily involved the drainage of swamp forest to isolate civil and agricultural systems from their saturated soils as well as, to a lesser degree, from river floodplains. The practices largely reflect a 'protect-from-the-river paradigm' introduced by Sendzmir et al. This approach has been in effect since the arrival of European Settlers to this Ontario watershed in the mid-1830s and is quite entrenched in current agricultural practices (LaPorte, et al., 2012). The idea of deliberately increasing the amount of water stored on the landscape was initially experienced as counter-cultural. The agricultural community were in fact actively involved in on-going installation of large amounts of drainage infrastructure. However, through communication between agricultural and conservation practitioners within the Healthy Lake Huron working group, the installation of Water and Sediment Control Basins (WASCoBs) was ultimately agreed as a compromise. Education, persistent communication efforts, and external funding played a role in the progression of these projects, but changing a water management paradigm will require a great deal of work across many disciplines. Perhaps a communication technique that is 'outside the box', such as using ecological art, could help to envision a new and different water management paradigm.

[1] political cycles are a major barrier to climate change responses and ecological restoration work but that work lies outside the scope of this thesis

2.17 Eco Anxiety Considerations

Often stakeholders will come to a discussion related to water management with a set of preconceived ideas and behaviours associated with water and subsequent land use. These differing perspectives can be inflamed when looking at a scenario such as division of water use during a period of water scarcity (Roosen, Klockner, & Swim, 2018). Furthermore, fear can be elicited or accompany consideration of climate change communication, especially where decision-making or the urgency of action are forefront. More than a decade ago, Randall (2009) recognized that "loss" had become inextricably attached to climate change communications and that the transition through climate change loss would be increasingly encountered by layers of people within our societies. These losses brought by climatic constraints will include the loss of ways of life, employment sectors, countless species and habitat types that are culturally and emotionally significant—as well as the loss of potential children when, for financial, emotional, or other reasons related to climate change in particular, people feel they must take the decision to not become parents. All are scenarios that can trigger a sense of mourning associated with climate change (Randall, 2009). A great deal of climate change and environmental communication has also been found to elicit feelings of shame and guilt in response to the collective inaction of humanity and the consequences of our behaviour on the planet which can also lead to fear and anxiety about the future (Vinocour, 2011).

Academic and ecological artist Emily Apter's concept of planetary dysphoria offers a unique term for the potentially paralyzing depression that people can experience when contemplating how human actions have become a dire threat to the underlying ecological systems that support all of humanity's basic needs. More precisely, planetary dysphoria (a term linked with ecological anxiety) has been used to describe a negative human emotional response to thinking about "the real and imagined processes of the Earth's destruction and the end of life as we know it" (Apter, 2013, p 131).

For example, this adverse response has been observed when certain individuals contemplate the predicted outcomes of the current trajectory of the Earth System state (Steffen, et al., 2018; Barnosky, Matzke, Mindell, Revilla, & Smith, 2012; Burtensky, Baichwal, & De Pencier, 2018). The seriousness of this despair and distress became evident when the American Psychological Association added ecological anxiety to their Diagnostic and Statistical Manual of

Mental Disorders in 2017 (Clayton, Manning, Krygsman, & Speiser, 2017). Indeed, ecological anxiety has been increasingly experienced among people displaced and directly affected by extreme storms, rising sea levels, and extended drought and flood conditions as well as among researchers who specialize in climate change mitigation (Swim, et al., 2011).

Figure 7 *HEARTH: Planetary dysphoria* is an example of an artwork that expresses this dysphoria which has been observed across social, economic, and cultural spheres. I created this symbolic representation of masked individual reacting with heart clenching saddness to a dying planet. The mask is meant to provide an anonymity implying that it could be any human witnessing these events.

Figure 7. HEARTH: Planetary dysphoria (Mason, A)

This image depicts a mask carved of thuja occidentalis (eastern white cedar) weeping a turquoise tear for the accelerating planetary ecocide. The background image is mixed oil pastel and acrylic paint on cardboard with LED lights. The mixed media piece can be viewed moving at https://youtu.be/63oY94YaMp8 (38 Views).

Using works of art as a communication interface shows some potential to help people to navigate some of these barriers associated with eco- anxiety (Guy, 2015; Bentz & O'Brien, 2019). At the same time, for the many people who still perceive climate change as an abstract issue carrying no direct threat; art has been demonstrated to counteract this level of abstraction, thereby inviting the audience into personal engagement with the subject matter (Roosen, Klockner, & Swim, 2018).

2.18 Ecological Art Examples and Links to Resiliency Message

Ecological art has been recognized as a medium through which methods and motivations for ecological action can be communicated (Weintraub, 2012) in a time when this call-to-action message has never been more urgent. Researchers from a broad array of disciplines and sub-disciplines have compiled an amazing amount of data pointing towards alarming global trends and what the future outcomes for our planet and humanity may be if mitigation and adaptation efforts are insufficient. Yet, public, practitioner, and decision maker uptake of these ideas is still not great enough to affect a large-scale shift towards resiliency in socio-ecological systems (Gabrys & Yusof, 2012; Voicescu, et al., 2022). Through their art creation, ecological artists strive to offer an alternative (and likely complementary) means of emphasizing the environmental issues of climate change and the impending possible collapse of the Earth System state (Bentz, 2020). In their review, *Climate change, adaptation, and Eco-Art in Singapore* (Journal of Environmental Planning and Management), Guy et al (2015) acknowledged ecological art as a method to move the public's practices towards more sustainable behaviour.

A strong example is Zai Tang's *Escape Velocity V* and is shown below in figure 8 as presented by the Singapore Art Museum. Tang (1984-present) is a London-born artist who now practices in Singapore and has shown internationally. *Escape Velocity V helps* explore a question he poses on his studio website: "What does it mean to listen to the voices of nature in a time of ecological crisis?" (Tang, 2021). This art exhibit comprises a sectioned series of screens of organic-material arranged as a small amphitheater within which is presented, in two-spaces (walls and floor), an immersive audiovisual experience based on field recordings from areas in Singapore that are rich in biodiversity but threatened by urban development (Bukit Brown Cemetery, MacRitchie Reservoir, the Rail Corridor, and forests near the Mandai Project) (Singapore Art Museum, 2021).

Figure 8 Escape Velocity V by Zai Tang at the Singapore Art Museum 2021

The sound and visual exhibit Escape Velocity V by Zai Tang is shown above with a 2021 Installation view including two people enjoying the work. Image courtesy of Singapore Art Museum (used with permission)

Tang's *Escape Velocity V* challenges the audience to immerse themselves in a soundscape featuring elements of the human and threatened non-human world that provides the foundation for this installation. The multimodal exhibition incorporates drawing, animation, and soundscapes to draw out the audience members connectivity to the natural world (Singapore Art Museum, 2021). Considering the role of Tang's exhibit as an interface for an accessible communication of science, I imagine his *Escape Velocity V* as a place of connection between the natural and human world. By offering field sounds (not words or texts), the artist seems to have expressly sought to encourage us listen in a different context. To me, this exhibit is symbolic of efforts to connect the human, who is too often outside the climate change narrative (Abbott, et al., 2019), to the ecosystems that may not be easily seen or heard for the participant-viewers of the exhibit.

Tang's aims align well with those of the ecological art exhibit that I have purposely built for this thesis. I have contemplated communication through ecological art as a form of social connectivity, wherein the functional restoration message proposed in this thesis for increasing socio-ecological watershed system resiliency can be exchanged, learned, and understood. I have

chosen to make the art kinetic to require and evoke this connectivity through "movement and interaction" (see, CHAPTER 3-METHODOLOGY). In respect to the intersection of the thesis message (*restoring connectivity and capacity can increase watershed system resiliency*) and medium (an ecological art exhibit), then, although no artwork, installation or exhibit in and of itself can provide the "solution" to freshwater scarcity, or other climate-change impacts, ecological art does provide a means to potentially increase connectivity and capacity within communities—and that can strengthen social resiliency. A resilient social community is much more likely to be able to protect and conserve their environment. Their doing so would in turn provide ecological and hydrological functions back to the community, setting up positive feedback loops for resiliency and sustainability.

Art can be an expression of both emotion or empathy and afford reflection on intense and complex experiences or issues. Indeed, it inclines to be a goal of an ecological artist to see if one's art can resonate or trigger an understanding in the audience, to see if one's ideas can be communicated and received clearly, if connections have been made. Roosen, Klockner and Swim (2018) propose that "art has the ability to articulate social and emotional trends through individual passions; personal stories and narratives that may change people's perceptions, inspire, and create visions for the future" (p. 86). Ecological art can be positioned to act as a tangible expression of ecological theories related to climate change (Bentz, 2020). The art producers often seek through the narratives represented in their works, to capture the public's interest and put forward new ways to co-exist with the environment at multiple scales from the personal to the regional to the global (Guy, 2015).

Notwithstanding Jerrold Levinson's (2015) observes that while there are "demonstrably better and worse artworks…" there is also "the undeniable importance of personal taste as regards preferences among works of art" (Levinson, 2010, p. 225). Regarding the aim to communicate specific ecological messages to broad audiences this may highlight a limitation of art being a universal communication tool. However, provided below is a sampling of some influential ecological artworks that include a range of environmental art in regard to medium, modality (which sense(s) are being engaged), method, form, material, size, or scale, which shows a range of ways art can be presented to audiences, who will all have unique viewing or experiential preferences. These works all have a connection to climate-change and climate-response, and in particular water scarcity, ecological restoration, and on-going degradation and

consumption of the earth's resources. They are, therefore, exemplars linked to the exhibit of ecological art constructed to communicate a message for increasing socio-ecological watershed system resiliency central to this thesis.

Waterlicht (water light) by Dan Roosegaarde is a huge outdoor light and art installation that premiered in the Netherlands. It offers a streetscape with water being depicted as light. Figure 9. shows *Waterlicht's* 'virtual flood' which is created (largely through the medium of light via a combination of LEDs and lenses). This installation offers audiences a vivid experience of where the water table would lie if the sea walls (grey infrastructure), that protect the populus from being inundated by water caused by sea level rise, were to fail. *Waterlicht* is also a unique example of transient or ephemeral ecological art in that the art modality itself is light. Created as site-specific artwork for the Dutch District Water Board in Amsterdam, and sixteen other international installations, it has had audiences of more than 60 000 people and has gone on to achieve global reach. From a communication perspective, this art production evidences the enormous potential of ecological art to meet multiple audiences in a place-based context.

Figure 9. Waterlicht by Dan Roosegaarde (Roosgaarde, 2021)

Roosegaarde's *Waterlicht* uses light to show audience members the height water would reach in the exhibit space if predicted sea level rise continued to progress. Source: www.studioroosegaarde.net (**used with permission**)

Another influential artist and author in both environmental art practice and research is Lislotte Roosen. The contribution to the academic literature, studies, and critiques she and her colleagues have published, have provided me with insight into how to articulate the potential of environmental art, especially within an academic space. A significant piece showcased in their comprehensive review is Yolanda Roosen's ceramic artwork depicting a human head inside a Venus fly trap, titled Friend, or Foe, which represents the "interconnectedness of humans and nature to the effect that if we kill the plant (nature), we also kill the human (ourselves)" (Roosen, Klockner & Swim, 2017, p. 99). The message of Friend or Foe is not unlike that represented in *Unbearable* by Jens Galschiot. *Unbearable* presents a stylized polar bear carcass speared by a symbolic depiction of the exponential global temperature rise that is being caused by the burning of fossil fuels (Roosen, Klockner, & Swim, 2018.

Similarly, Ludmila Kalmaeva's drawing of a deer with a human face and a hunting target on its head puts the viewer face-to-face with the destructive aspect of human nature. Roosen, Klockner, & Swim (2017) have suggested that Kalmaeva's piece is intended to encourage viewers to consider the ways in which we distance the Self from this destructiveness. "Shedding light on this darker side of humanity can increase empathy for the victims of our lack of awareness and connection (nature and other species) as well as for humanity itself-our own nature" (Roosen, Klockner, & Swim, 2017, p. 102). Using a different medium, the work *Drowning World* by Gideon Mendel presents a series of photographs showing people in increasingly deep water, portraying the personal effects of large stormwater events (Roosen, Klockner, & Swim, 2017, p. 85). This artist's collection provides a visceral experience of the dangerous shift in the global water balance by positioning people within these rising waters.

Beverly Naidus has created artworks that offer narrative around the problems of energy-dependence and nuclear legacy issues. As importantly, she wrote *Arts for Change: Teaching Outside the Frame* (Naidus & Brandt, 2009) which has become a significant text in many post-secondary art courses. She is credited for the interdisciplinary studio *Arts in Community* curriculum which incorporates art and pedagogy practices with ecology and social engagement (Naidus & Brandt, 2009). Included in her substantial portfolio are *Art in a Time of War, Cultural Identity, Eco-art, Globalization and Art, and the Artist as Visionary and Dreamer*. Her well-known *Eden Reframed,* is a community-based permaculture project where degraded soil using

phytoremediation and mushrooms provides a public place to grow and harvest medicinal plants and edible plants (Naidus & Brandt, 2009).

Sharing Naidus's interest in pedagogy and wanting to further an ecology meets art experience for his students' is Changwoo Ahn. A proponent of the potential of the art-science intersectionality, Ahn challenged his students at the George Mason University, from a range of disciplines such as engineering, biology, chemistry, and fine arts, to design a floating wetland that would be self-propelled and would help to filter the water of a small, polluted lake as can be seen in Figure 10 (Ahn, 2016).

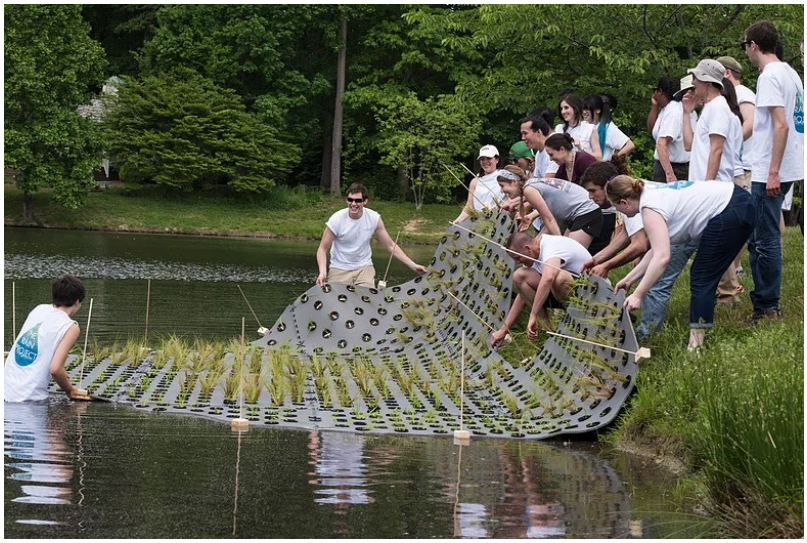

Figure 10. Multidisciplinary Floating Wetland Launch (Ahn, 2016)

Students launching a Floating Wetland designed using art and ecology amoung other disciplines (Ahn, 2016) Source: https://www.changwooahn.com/gallery (**used with permission**)

This multidisciplinary collaboration resulted in a viable and effective floating wetland called 'the Rain Project' (Ahn, 2016 p. 291). Given that discipline-specific language and multiple and competing perspectives, expertise, and methods have been found to impede ecological restoration practice, it is especially interesting how Ahn's student-teams found ways to communicate effectively across their disciplines to complete this multi-pronged solution focused on ecological restoration.

What becomes evident is that there is, undoubtedly, an important role for merging art with the technical details of restoration ecology in order to reach a broad audience and foster the kinds of communications relevant to climate change action and a shift towards sustainability

(Ahn, 2016). The works that I have introduced above have been in keeping the broader definition of Art in the sense that the Ecological artists have embedded a level of sensory interest in their creations that surpass those of average and utilitarian objects; have situated their pieces in such a way as to engage the interest of an audience to engage with these works; and have elucidated upon the process behind their 'making' (Thomas, 2018). Each of these Ecological Art (EcoArt) examples also expresses an environmental message that is pertinent to either climate change response, or human connection to our environment. To showcase these large installations or land-based art, digitization, and other technical capabilities, combined with the power of the Internet, have been enthusiastically taken up by a number of contemporary ecological artists to help communicate their works (Cape Farewell, 2007).

2.19 Climate Change Response and EcoArt as a Resiliency Message

Despite it being clear that human behaviour has put us on a trajectory towards several compounding and catastrophic climate change scenarios (Ripple, Wolf, Newsome, Galetti, & Alamgir, 2017) or even a global mass extinction event (Ceballos, et al., 2015), public and political uptake to ecological restoration or Climate Change response has lagged dangerously. A truly terrible response brought by this line of thought is the suicide by self-immolation of 60-year-old lawyer and environmental activist David Buckel in April of 2018. The New York Times (Associated Press*;* Sun 15 Apr 2018*)* reported that Buckel used fossil fuel to set himself on fire in protest against ecological destruction. David wrote: *"*Most humans on the planet now breathe air made unhealthy by fossil fuels, and many die early deaths as a result—my early death by fossil fuel reflects what we are doing to ourselves."

The painting *Anthropocene* (Mason, 2002), is an art piece I produced that presents humanity as an asteroid, symbolizing a catastrophic threat to the current Earth System state if we continue on our present trajectory. This symbolism is also present in more current cultural commentary, in the film "Don't Look Up", where climate change is symbolized as a comet speeding towards Earth (McKay, 2021). The central expression of this symbolism is of society willingly pushing the panarchy of the Earth's ecosystems towards a tipping point, flirting with the possibility of a global mass extinction event or, in Diamond's (2011) words, an ecocide: "an unintentional ecological suicide" (p. 6). This grim picture is consistent with the stark predictions of Ripple, Wolf, Newsome, Galetti, & Alamgir (2017); Elizabeth Kolbert, in her book *The Sixth*

Extinction; James Lovelock in *The Revenge of Gaia* (2006); Jared Diamond in *Collapse* (2005), and the reports of the International Panel on Climate Change (Pachauri & Meyer, 2014; IPCC, 2023)and the IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2018)—all of which suggest a frightening trend for the Earth's ecosystems. These large biofeedback loops linking our planet's atmospheric, biotic, and hydrological systems can be viewed in their role of maintaining an epoch- the Anthropocene. The trajectory of the Anthropocene epoch is unlike many earlier epoch regime shifts which were driven by a non-human dominant cause, for instance the K-T comet or asteroid strike that caused a mass extinction event at the end of the Cretaceous period, altered the atmosphere and influenced climate patterns (Kolbert, 2015). Referring to figure 11. *Anthropocene*, we are behaving like a metaphorical asteroid, with the collective actions of our species at a planetary level echoing the actions of past human cultures who committed "ecocide" at a local level "by destroying the ecological services and functions that supported their societies" (Diamond, 2011, p. 6).

Figure 11. *Anthropocene* (Mason, A., 2002)

The mixed media painting, done in oil pastel and acrylic paint, *Anthropocene* presents humanity as a catastrophic threat (in the form of a metaphoric asteroid hurtling towards the planet) to the current Earth System state if we continue our present trajectory.

This theme of self-destruction is also consistent with aspects of work produced by Robert Smithson (American, 1938–1973) whose exhibit *Spiral Jetty* (1970) brought a great deal of

attention to ecological art. In a review of Smithson's ecological artwork, critic Eric Nay identified a specific trope of "self destruction as reparation" (Nay, 2011) that has kinship with my *Anthropocene* painting figure 11. The quandary of self destruction or an alternate restorative pathway, regarding humanity's relationship to nature, was discussed earlier in regard to ouroboros as symbol and metaphor. An examination of this destructive aspect of the human self in the world, is eloquently communicated by ecological artist Jackie Brookner (1945-2015) in the following quote, and furthermore challenges the reader to rethink the stark human *vs* nature viewpoint:

> *"Amidst the epic scale of our self destructiveness and the acuteness with which we refine our deadly powers, is it trivial to point to the unintentional fallout of the daily round of our lives, of the extinction of fish and birds, plants and land animals, and the burdens of pollution we excrete into the world's waters and air? I think not. It's all part of the same scenario of self destruction, depending, of course, on what we mean by self. Reasonable beings, we use our reason as reason enough to separate ourselves from other animals. But the root of the word "animal" tells a different story. The Latin "animus" means soul, air and breath, life principle. Rather than separating us, it is about what <u>connects</u> us to the rest of breathing creatures and to air, life's breath itself. How can we rediscover this sense of connectedness? Can we find our way out of our destructive and atavistic patterns to imagine a more accurate sense of ourselves, where we can recognize and even celebrate our necessary immersion in the rest of creation?"*
> *– Brookner, The Gift of Water, 2002, p.1*

Brookner's narrative invites both reflection and tentative answers. Perhaps people and nature can be self-supporting under an alternate water management paradigm as the message for the thesis ecological art exhibit proposes, namely *that restoring lateral hydrological connectivity and potential for water storage capacity will increase watershed system resiliency*, thereby supplying multiple opportunities across hydrological, ecological, and social dimensions. In this way, the innate connection of the human to nature and the landscape could become a leverage point for shifting societal views on managing our natural environment and the ecosystem services it provides us. Independent of this, Brookner's words and art pictured below in figure

12. seek to evoke our imagination as a platform for accelerating a shift away from an ecologically destructive path towards a restorative one instead.

Figure 12. *The Gift of Water.* (Brookner, 2001)

Jackie Brookner's EcoART installation in Grossenhain Germany symbolises renewal and interconnectedness, as two cupped hands that support a community of mosses are misted by a fountain emerging between the palms of hands. The growing mosses are part of a wetland community that filters water in a public swimming complex. (**used with permission**)

As Diamond has offered, "[a] remaining cause for hope is another consequence of the globalized modern world's interconnectedness" (2011, p. 525). Namely, we now have the ever-growing ability through technology, to learn from the threads of each other's experiences and findings—at near real-time speeds and across the planet. This, taken together with the work of many scholars, artists, scientists, restoration practitioners, community groups, and government could be harnessed for collectively transmitting and translating methods and motivations for restoring and adaptively managing the planet's ecological systems in time to preserve sufficient ecological services that are supportive of the Earth System state that has supported humanity for millennia.

2.20 Summary: Grounding the Art-Science-Communication Interface

Given that ecological art (the medium) will be used in this thesis as an interface for communicating a functional restoration message aimed at increasing socio-ecological watershed system resiliency -as a climate change response-to both lay and expert audiences, the literature review under Objective 2 has had a number of goals. The first was to establish art as metaphor for environmental science as a long-standing and effective method of communication. Secondly exploration of how methods of communication and narrative have been employed to further environmental messaging. Some fundamental aspects of Ecological Art were explored to better lay out established components and principles within this discipline, along with examples from influential Ecological Artists. Critiques of contemporary and historic environmental communication strategies were offered in order to further define the research gap this thesis is exploring. Two barriers that inhibit environmental communication were outlined as discipline-specific language and eco anxiety, which were proposed to be barriers that ecological art could circumnavigate in some instances.

CHAPTER 3- METHODOLOGY

3.1 Introduction

This exploratory study took a primarily qualitative approach (Knowles & Cole, 2008) to investigate whether art (specifically, ecological, interactive, sculpture-based art) can offer an alternate medium to text-based and/or oral methods for ecological restoration (ER) communication relevant to climate resiliency strategies.

As with many exploratory studies, conclusive answers were not really anticipated (Zukauskas, Vveinhardt, & Andriukaitiene, 2018). Rather, the aim was to explore connections that, if fruitful, could lead to a closer understanding of the role art can take in ER communication as well as useful directions for future studies. According to Creswell (2018), exploratory research is appropriate for research conducted to obtain insight into little-understood issues in order to provide some groundwork for future research. It is typically employed for studies like mine, where the researcher is unsure of specific hypotheses, the research topic is fresh or uses literatures from different disciplines, and little prior work is available to draw on (Creswell & Creswell, 2018; Zukauskas, Vveinhardt, & Andriukaitiene, 2018).

Exploratory research can include both primary and secondary research. A secondary research strategy was used to gather information from published academic literatures and then interpret and synthesize this towards addressing the research question. This secondary research strategy also informed and supported the artmaking that was undertaken for the thesis. The Arts Based Research methodology, which involved the iterative creation of the ecological thesis art, takes on elements of exploratory primary research, although this part of the research did not include a formal data analysis stage.

An art-based research (ABR) methodology was adopted to develop the ecological art created in this thesis, which drew on interpretative phenomenology (IP) and auto-ethnography. Under this methodology, the choices I made for collecting, evaluating, and synthesizing relevant literatures, and thereafter creating the thesis' artworks, were informed by the five-step ABR design process that Hervey (2000) recommends (see sub-section 3.4.3). Within the ABR methodology the three thesis research objectives were explored. Recalling from Chapter 1, these were, first, to evolve a science-based ecological restoration (ER) watershed system resiliency

message (Obj 1) that could be communicated via art. Next, Obj 2 involved exploring how art, especially ecological art, has been used for communicating climate change and ecology narratives and concepts. Last, custom artworks were created (Obj 3) to communicate the chosen ER message, based on synthesis of the literatures reviewed under the first two objectives.

The process for data collection and analyses involved three broad stages that I have loosely identified as literature review, consolidation, and interpretation (analysis), and artmaking. The phases in practice were iterative with interpretation, synthesis, and artmaking often co-occurring. The stages were structured to roughly correspond to the five steps that Hervey (2000) considers essential to the process of artistic inquiry; namely initial awareness; decontextualization and intentional re-creation; appreciation and discrimination; refinement and transformation; and, last, recontextualization (Hervey, 2000, p. 58).

The following main sections cover my epistemological and conceptual framework, the methodological strategies I used for the thesis enquiry, the data collection and analysis procedures and methods employed. A researcher's positionality section is also included.

3.2 Epistemological and conceptual framework

Many scholars advocate for flexibility in a qualitative research design. However, the research design still must be crafted under an approach that, while flexible, remains comprehensive in justifying the methods selected (Reiter, 2017). The plasticity of qualitative methodologies can be a strength that lets the researcher adjust methods and strategies for interpretation to the characteristics of the phenomenon under study (Creswell & Creswell, 2018; Popper, 2002). These malleable characteristics are particularly important given that the researcher will be instrumental to the collection, analysis and interpretation of the data when working in an auto-ethnographic lens and as an artist researcher under an ABR lens (Finley, 2002). For this reason, Moon and Blackburn (2014) stress the need for the researcher to spend time thinking about how their own philosophical perspective or 'philosophical worldview' (Zukauskas, Vveinhardt, & Andriukaitiene, 2018) can influence the methodology choices made and, thereby, also the research outcomes. My worldview aligns best with that of (social) constructivism.

3.2.1 Social constructivism philosophical perspective / worldview

Creswell (2018) identifies four worldviews or philosophical perspectives. These are positivist/post-positivist; constructivist/social constructivist/constructionist; transformative; and pragmatic. My worldview aligns best with that of constructivism/social constructivism/constructionism, based on a belief that realities are "constructed socially by individuals" (Creswell, 2018, p.4). In terms of epistemology, or how humans acquire knowledge, constructivism/social constructivism holds "that meaning is created from the interplay between subject and object…. the subject constructs the reality of the object" (Moon & Blackman, 2014, p 1168). A distinction is sometimes made that suggests that constructivism's focus is on how each individual mentally constructs the world of experience through cognitive processes whereas *social* constructionism's focus is societal in scope rather than individual (Moon & Blackburn, 2017). However, more commonly the terms constructivism, social constructivism, and social constructionism tend to be used interchangeably under the generic term 'constructivism' (Creswell & Creswell, 2018)

In the thesis context, a (social) constructivist worldview at its most basic suggests that by piecing together truths from various siloed perspectives, a broader understanding of larger socio-ecological systems could be arrived at (Swartout & Tate, 1999), and that such a perspective can be facilitated by interaction with both art objects and other people. Constructivist epistemology does not adhere to the idea that objective 'truth' exists and is able to be revealed by scientific reductionism. Instead, 'truth' or meaning emerges from people's involvement with the realities of their environment (Zukauskas, Vveinhardt, & Andriukaitiene, 2018). This could not be more important than in climate change science, given its complexity and interaction of multi scale socio-ecological systems. Climate change effects various individuals and regions differently and its true impact is more that just the sum of these perspectives.

That social constructivism places emphasis on everyday interactions between people and how language and objects are used to construct reality corresponds well with the art-based research methodology adopted. Art-based research well accommodates the complexity of climate science and its inherent communication elements (Goldstein, Murray, Beard et al., 2020). Climate science research can take diverse strategies at multiple geographical, social and temporal scales. When a thesis aims to examine art as a communication medium to broaden ecological

restoration understanding, then "[t]he value of constructionist research is in generating contextual understandings of a defined topic or problem" (Moon & Blackman, 2014, p. 1172).

3.2.2 Socio-ecological systems conceptual framework

The contextual understandings and analytical work of the thesis occurred within a socio-ecological systems (SES) framework. According to Partelow (2018), one core aspect of an SES framework is its anthropocentric view of natural resource management that seeks out elements of societal co-operation that can support resilient systems. Two main goals within the SES framework supported the literature review and artmaking phases of my study. First is the SES framework's emphasis on understanding how SE systems function; second is the framework's interest in understanding how to develop, implement, and transform SE systems to meet sustainability and resilience goals (Partelow, 2018). The inherent multi-disciplinarity represented by the SES concept (Guba & Lincoln, 1994) aligns well with my epistemological perspective of social constructivism. Specifically, discipline specific knowledge (research) is needed from many societal sectors in order to achieve solutions to resiliency in SES. Although classic SES methodology prescribes analysis based on interactions of resource systems, resource units, actors and governance systems, the SES framework affords the flexibility to incorporate other methodologies of analysis (Partelow, 2018).

There is a certain epistemological discrepancy within Social Ecological Systems framework in relation to the empirical and traditionally positivist sciences that underlie the fields of ecology, biology and geochemistry among other natural sciences in comparison to the social sciences which can pull from alternate epistemological perspectives such as social constructivism (Cumming, 2014). Resolving these differences in how knowledge can be acquired within an SES framework can create tension between qualitative and quantitative data for example and can call into question methodological approaches used within this growing framework. By choosing a social constructivist perspective to define the knowledge acquisition in this thesis, I have focused more acutely on the social perspectives of SES framework, but I feel that this additive epistemology does allow for data driven evidence obtained from ecological restoration literature to be considered on equal footing to more artistic and interpretive ways of knowing.

3.3 Methodological strategies

The art-based research, interpretative phenomenology, and auto-ethnography methodologies used for this study are described in the following sub-sections.

3.3.1 Art-based research (ABR)

Art-based research (ABR) was the main methodology guiding the study. Developed as methodological genre between the 1970s and 1990s (Gioia & Leavy, 2020), ABR offers a connective link between the arts and sciences (Gioia & Leavy, 2020). Art-based research can include "any social research or human inquiry that adapts the tenets of the creative arts as a part of the methodology… the arts may be used during data collection, analysis, interpretation and/or dissemination" (Jones & Leavy, 2014, p.1). As a mode of qualitative inquiry, ABR has grown in both legitimacy and recognition within academia (Snowber, 2019) and can be used to gain insight into the subjectivity of human experience (Pentassuglia, 2017). It employs a variety of practices and governing theories to reflect the diverse range of literary, performative, and visual modes of artistry (Knowles & Cole, 2008). These modes encompass a large variety of art types. A type of art loosely refers to a domain such as performance, writing, painting, sculpture, dance, or photography. The types of art used within ABR methodology, can be inter-mixed, as a communication tool or aesthetic element within an artistic inquiry or as part of the inquiry process itself. Within ABR the artistic process can be a mode used by the researcher, the researched (i.e., participants), or a combination (Hervey, 2000).

As the thesis aim was to investigate art as a medium to compliment text- or oral-based methods for communicating ecological restoration (ER) messaging, ABR was a natural fit. Artistic processes are presented as a form of investigation and as a way of knowing within an ABR methodological design (McNiff, 1998; Pentassuglia, 2017). The contribution of art is increasingly considered to be a powerful way of developing meaningful connection with climate change response and communication (Gabrys & Yusof, 2012). ABR allows for inclusion of aesthetics and embodied ways of knowing (Snowber, 2019) that can add depth and even transformational experiences to the pedagogy of climate change (Bentz & O'Brien, 2019). Art's embodied ways of knowing involve sensory experience and reaction to experience through movement, as a legitimate form of knowledge gathering (Kontra, Lyons, Fischer, & Beilock, 2015). This characteristic was an essential methodological consideration for making artistic

decisions during the creation of the interactive ecological art installation. Considerations of what participant-viewers of the art might find interesting to look at and interact with, influenced the final form that the thesis artworks took (Goldstein, Murray, Beard, Schnoes, & Wang, 2020). This appeal to multiple senses in the artworks, by using multiple art types, was an effort to make the key ER message, that the artworks were designed to portray, readily available to the participant-viewers.

ABR can facilitate "the evocative force of aesthetics in order to reject and refuse the modern dualism of art-science" (Pentassuglia, 2017, p. 2). She argues further that ABR provides art as a communication medium to foster a multisensory form of connectivity for ideas to be exchanged, learned, evolved, and understood. ABR has also been found to facilitate the making of connections between stakeholders in a manner that traditional text-based communication cannot, which was a critical consideration in my study (Chow, et al., 2019). When participant-viewers engaged the artworks prepared for the thesis, for example, their senses of hearing, vision, and touch were elicited. Given the identified communication barriers the thesis attempted to consider, namely discipline-specific language and the challenges posed by ecological anxiety, ABR enabled attention to be put on the possible different learning and communication needs of the audience receiving the ER information.

Therefore, in using ABR, art and art practice had multiple functions, i.e., they were part of the ER message studied, part of the framework for interpretation and synthesis of this message, part of the artwork product produced, and central to the thesis purpose. This use is consistent with acknowledgement that ABR can be used at all stages of research “including data generation, analysis, interpretation, and representation” (Leavy, 2020, p. ix). The creation of the installation of ecological art also addressed the presented research gap regarding the lack of people represented as central in visuals of watershed systems and hydrological processes.

3.3.2 Interpretive phenomenology

As a complementary approach, I used elements of interpretative phenomenology (IP) within the broader ABR methodology. Interpretative phenomenology enables how individuals make sense of their everyday experiences to be considered in the domain of academic discourse and professional practice (Tuffour, 2017). IP originated with the philosophy of Husserl and Heidegger with their exploration of how the individual experiences a phenomenon, referred to as

Dasein (Eatough & Smith, 2017). IP has a long history of use in health sciences, and psychology in particular, but it is currently being used in more diverse fields of academia (Larkin, Watts, & Clifton, 2006). As a methodology, IP "aims to explore the lived experience of a phenomenon, representing an individual level of analysis with an understanding that social contexts are embedded within an individual's being" (Frechette, Bitzas, Aubry, Kilpatrick, & Lavoie-Tremblay, 2020 p.6). Because IP can be used to examine experiential meanings through the interpretive work of the researcher, in contrast to following a theory-driven examination (Tuffour, 2017), it was helpful for identifying emergent themes in the literature and real world examples of the relevant elements of connectivity in the ER / resiliency message, art uses, and communication practices. This reflexive analysis under IP methodology allows for the personal experience of a practioner to bring a depth and an enlivening aspect to academic research (Finlay, 2002).

With academics and practitioners reporting communication barriers among scientists, the public, and decision makers as part of the problem under study (Elsawah, Filatova, Jakeman, & Kettner, 2020), IP's guidelines for flexibly seeking connections among emerging themes and grouping them together according to conceptual similarities helped me to explore relationships and make my own connections for guiding the artmaking. While typically utilizing an interview approach (Eatough & Smith, 2017) the interpretative IP work in this thesis occurred between the researcher and experience of observing the Beaver Wetland Complex on Willow Creek in the context of processing literature review findings, conducting field work and beginning ABR techniques. IP does allow for a first-person approach to incorporate narrative descriptions and journals or diaries which offer interpretation by the researcher, participants, or both (Eatough & Smith, 2017). I was thus able to consider my own interpretations of a watershed system where the ER message, derived from literature review, of increased water storage capacity and lateral hydrological connectivity demonstrating aspects of resilience was functioning in the real world. This process of interpretation also provided inspiration for what might yield the most interesting and relevant outcomes for producing the artworks using ABR.

Interpretive Phenomenology is frequently used in a case study approach within health sciences, where a clinical protocol is known and an inefficiency in care or continuance of poor patient outcomes has been identified (Tuohy, Cooney, Dowling, Murphy, & Sixsmith, 2013).

Under the IP methodology the personal observations of (health care) practitioners are gathered and used towards finding creative solutions or insights. In an analogy to the restoration ecology field, my perspective is that under climate change there are known environmental pathologies, such as degraded socio-ecological watershed systems, and known ecological restoration solutions being conducted by ecological restoration practitioners. Yet, a marked lack of improvement persists among these increasingly disturbed SES, so using the personal perspectives of restoration practitioners could provide similar value in the ER field, and to promote the adoption of ER messaging for a broader audience.

3.3.3 Auto-ethnography

The thesis also leaned on auto-ethnography, a sub-approach within the discipline of ethnography (which itself is attributed to Anthropology) (Williamson, 2018). Ethnographical methodologies are concerned with the study of people in their environments and involve the researcher directly in the process of observation (Bell, 2005). Auto-ethnographical research design can include both participant observation and non-participant observation; participant observation was included in this thesis. Such approaches can draw in the lived experiences of participants, allowing them a voice in research discourse (Bernard, 2006) which corresponds well with a social constructivism perspective.

Given the interpretation of literatures, examination of art and other artists' works for communicating ER knowledge in particular, and the artmaking as a main element of the study, auto-ethnography provided for an academically informed narrative that embeds my personal experiences in the context of the enquiry. This process intends to be both evocative and provide an analytical lens (Besio, 2020). Inspiration to utilize auto-ethnography in relation to art was sparked by the narrative writings of Thoreau's *Walden.* For instance, when Thoreau describes the particular colour of Walden's pond, how it reflects and distorts the image of a person swimming in it, he evokes the work of master painter Michaelangelo to create imagery of the human connection to this particular ecosystem (Thoreau, Walden, 1982).

As Williamson (2018) points out, as a methodology auto-ethnography emphasizes the role of the researcher within the social and natural system being studied. As an artist, my personal experience of watershed restoration communication was represented in the artistic process and also shaped the literature review choices and overarching thesis narrative. Moreover,

auto-ethnography supports qualitative research from field experience, whether formal or informal, and documentation by field notes or journaling methods (Bernard, 2006), which I used during the Willow Creek Beaver Dam wetland complex mini-case study.

3.4 Data collection and analysis procedures

The gathering and synthesizing of various literatures to conduct the enquiry and inform the artmaking comprised three broad phases, each with accompanying methods. The phases were loosely categorized as literature review, interpretation (analyses), and artmaking. In practice, these phases were iterative and co-occurring although each had particular outcomes or deliverables associated with it. This flexibility to interweave practice and process is foundational to ABR methodologies wherein art, whether as object or process of study are part of the principal mode of research inquiry (McNiff, 1998).

3.4.1 Literature review phase

The literature review phase served to identify the research gap, scope the context and scientific soundness of the ER message the artworks would portray, and, importantly, uncover the contributions art has made for communication. As a method, the literature review involved searching for and reading across a fairly diverse range of topics. I was reading to uncover possible connections between restoration ecology, resiliency, and watershed literatures and the literatures addressing art as a communication medium in environmental fields.

Findings from this phase were interpreted and reinterpreted. The aim was to gain insight into how to employ the artworks to not only communicate the selected “message” but also to navigate the challenges to environmental messaging that emerged. The two communication barriers included in this study were: discipline-specific language that can cause a disconnect in the siloed disciplines often involved in watershed restoration; and ecological anxiety. The purposeful inspection of human connection to watersheds and larger orders of socio-ecological systems has been found to be a means of addressing adaptive ecological management (Walter-Toews & Kay, 2005).

3.4.2 Consolidation and interpretation (analysis) phase

This consolidation phase involved finalizing the ER message and deciding how to leverage the possibilities that I learned art can offer as a communication medium. I expressly

wanted guidance for the artmaking phase. The artworks needed to capture, embody, and "communicate" the resiliency message chosen. I needed to myself make sense of the intersecting challenges involved in the thesis enquiry—namely how to reach a diversified audience, what aspects of the ER message to highlight, what were the precise areas where art offers promise over text-based approaches, and, finally, how to have any sense of rigour around the decision making?

Evidence was gathered indicating that art-science work is increasingly used to develop meaningful connection between climate change and environmental messaging (Roosen, Klockner, & Swim, 2017). Art visuals, objects, and performances that image the scientific and social dimensions of climate change were recognized in literatures as useful addressing the research gap which was to situate people more directly into the visualizations of watershed systems (Abbott, et al., 2019). Moreover, art, as a medium for creatively addressing complex problems associated with resiliency in the face of climate change (Shrivastava, Ivanaj, & Ivanaj, 2012) was shown to have considerable promise for smoothing some of the challenges of siloed knowledge and exchange, discipline-specific language, and ecological anxiety that can impede ecological communication (Roosen, Klockner, & Swim, 2017). I decided to include a small case study of a beaver wetland complex.

Case study method

The case study method is often used when focus is needed on "a contemporary phenomenon within some real-life context" (Yin, 2003, p. 1). Case studies are extremely common for SES research and for ecological restoration and conservation research. A case study often provides historical background for a defined site within a given ecosystem and then follows the restoration project from planning, through implementation, to monitoring the project for success (FAO, IUCN CEM & SER, 2021). For instance, "wetland restoration case studies are presented to outline the historical reasons for the degradation, the setting of goals, and the process of significant wetland restoration efforts across different sites" (Zhu, Jiang, Yuan, & Verhoeven, 2019, p.220) The multiple case studies approach has been used to describe resilience within various SES (Walker & Salt, 2006) and compare SES and ER practices across the globe.

I employed a single case study approach to provide a real-world example of what increased capacity and connectivity look like in a small watershed system, in the Willow Creek

Beaver Wetland Complex. The case study informs and complements the artistic representations portrayed by the thesis artworks. This case study began with a nod to quantitative methodology in the Standard Operating Procedure conducted for measuring total suspended sediment (TSS) in the water column within the beaver wetland complex in relation to rainfall (attached in appendix). This field work method of gathering TSS data in the beaver wetland complex provided a bridge to connect the findings from the literature review regarding the ER message with the ABR methods used to create the thesis artworks aimed at communicating this message.

3.4.3 Methods for the Willow Creek Beaver Wetland Complex Case Study

Purpose: An informal yet valuable observational study was then carried out at a beaver wetland complex on Willow Creek in Paisley, Ontario. The aim was to ascertain whether there was a reduction in sediment from the water column as an indicator of increased resilience in response to the increased water storage capacity and lateral hydrological connectivity observed at the site. Specifically, beavers have the ability to increase the storage of surface water and the lateral hydrological connectivity in the wetland complexes created upstream of their dams (Puttock, 2020). This three-acre site had been allowed to naturalize by the current and previous landowner for a period of approximately 20 years, and beavers have been allowed to construct their dams without interference. The landowner allowed me access to the site to observe the effect of the beavers' behaviours on the hydrology, water quality and local biodiversity. To this end, following observation and journaling, four dam sites were identified (shown in figure 13.). Total Suspended Sediment analysis was conducted during 2013.

Figure 13. Map showing location of four beaver dam sites on Willow Creek

Method: The technique set out in the University of Waterloo Ecology Lab was used to collect and analyze Total Suspended Sediment (TSS) samples taken from the Willow Creek Beaver Wetland Complex. Namely, I used 'sterile' sample jars to collect 500 ml of water upstream of each of the four Beaver Dam Sites. A standardized filter paper was dried in a kiln at 100 degrees C for 40 minutes. The filter paper was then weighed on a scale to the nearest µg and recorded. The filter paper was placed on top of an Erlenmeyer flask attached to a vacuum pump. 100 ml of the water sample were poured through the filter paper, while the vacuum pump was activated capturing the sediment. The filter was dried again for 1 hour at 100 degrees C in the same kiln and re-weighed. A total of 23 of samples were gathered. The difference in mass was recorded as TSS and then graphed against cumulative precipitation amounts for the region, obtained from Environment Canada, during the 5 days preceding the TSS sampling date.

Multimedia Ecological Art Journaling Methods: Over a period of seven years, I made many observational forays to the Willow Creek Beaver wetland to document the presence of flora and fauna and to observe the hydrological function within the site in response to various seasonal and meteorological changes, in specific relation to the presence and activity of the resident beavers. My observations took place on walks through the riparian forest upstream of the beaver dam wetland complex, noting, photographing and filming the changing forest as the beaver felled primarily poplar trees and shunted them down from a moraine bluff into the area of their dam building. I was fortunate to have use of a small cabin, cantilevered over the edge of the Dam site 1 where I could observe the beaver and wildlife activity relatively unobserved. Some of the notable wildlife sightings included: a circling golden eagle; a coyote that sat on the opposite bank of the wetland and observed me; a mink that used the ice to slide on its belly between dives into the wetland during a winter thaw; and a muskellunge that I released from being caught in a hockey net that melted through the ice in a sudden spring thaw. This cabin also allowed me space to draw and sketch the flow patterns of the beaver wetland complex as it changed with the building up of the dams, forming two oxbow like pools at the outside edges of the wetland complex. The beauty and connection to the natural world that I felt in this space allowed me to contemplate and bridge together the elements that I later present in my ecological art exhibit. Observing and mapping with body movement, the path the main current took through the beaver wetland complex became the basis for the use of dance in this thesis.

Summary: This case study provided an understanding of what r*estoring lateral hydrological connectivity and water storage capacity* can look like on a landscape. These observations provided the "initial awareness" (Hervey, 2000, p. 46) phase for the development of of the ecological art installation produced during this thesis, including the use of dance.

3.4.4 Artmaking phase

Another decision taken was to create ecological artworks, and two methods emerged as especially fruitful for guiding the artmaking process. First, dance was chosen to be incorporated in the artworks for its possibilities in helping to increase the message uptake. This choice allowed for sculpture-based, interactive art pieces to be created. Second, Hervey's (2000) five-step method for artistic inquiry was selected. Both methods and their merits are described in the artmaking phase. The artmaking phase corresponded specifically with the third thesis objective (creating custom artworks to communicate the chosen ER message). However, from the perspective of doing the artmaking, the process relied on implicit and explicit findings from the literature review and interpretation phases.

Role of ecological art in the thesis

The ecological artworks created for the thesis presented the audience with symbolic representations of a dynamic, resilient watershed, which was the ER message chosen. One ecological restoration pathway, *increasing lateral hydrological connectivity and the storage of water on a landscape*, was highlighted in several art pieces with the focus being on connectivity, tipping points, thresholds, and the drive to enhance resiliency of socio-ecological systems.

The thesis artworks fall under the umbrella 'genre' of ecological art. As a contemporary movement, ecological art represents an ecologically friendly method with emphasis on environmental issues. There are numerous and diverse approaches involved in ecological art. These are created to energize, inform, engage, and activate change in public policy or behaviors (Roosen, Klockner, & Swim, 2017). The thesis artwork also took inspiration from ten ecological artists and one art collective whose work was detailed in (Chapter 2.18 and 2.19). Each of the included ten artists is concerned with the state of the environment and all share a collective aim

of wanting to extend communication and evoke some reflectiveness in the part of their audience for their artworks (Weintraub, 2012).

Dance and applied theatre method

Dance was chosen as a method and form of communication in the thesis artworks. The use of performance art pieces “can more effectively motivate interest and action, and they can enhance dialogues on important societal issues” (Gergen & Gergen, 2010, p. 4). Dance specifically provides opportunities to create shared experiences among artists and participant-viewers regarding an unveiling of research data or content (Hervey, 2000). Moreover, as a practice, dance and movement has been shown to help foster processes that may enhance learning (Kontra, Lyons, Fischer, & Beilock, 2015). Dance helps move the arts away from the traditional conceptualization as an entity to be passively absorbed by encouraging artist/researchers to take part in actively building the knowledge that most pertains to and represents them (Snowber, 2019).

The thesis ecological artworks are interactive and kinesthetic engagement with them calls on some dance-like movements. This design choice invites the audience “to take part in the process of making meaning, allowing for a more dynamic interchange of various types of knowledge and 'expertise' " (Clover & Craig, 2009, p.7). Teixeira-Machado, Arida, & Mari (2019) carried out a study that showed that dance can increase aspects of the dancer's functional resiliency. Specifically, dancing supported increases in structural volume and connectivity in the brain, which resulted in improvements in the parameters they measured to gauge their participants' resilience. These were "memory, attention, body balance, psychosocial parameters and peripheral neurotrophic factor" (pp 232). The peripheral neurotrophic factor is known to support the growth and plasticity of neurons that allow learning to occur (Wang, et al., 2019). This benefit of dance was important for my study because “perceiving art demands attention, and processing art requires parts of the brain that are not normally accessed by typical communications about climate change” (Roosen, Klockner, & Swim, 2018, pp 85). Significantly, the process of kinetic learning has been shown to increase learning of scientific concepts when sensorimotor regions of the brain are linked with reasoning (Kontra, Lyons, Fischer, & Beilock, 2015).

Furthermore, another study involving a meta-analysis of dance movement therapy found dance to have potential to decrease clinical symptoms of depression and anxiety (Koch, Kunz, Lykou, & Cruz, 2014), both of which can be triggered by ecological anxiety (Swim, et al., 2011), which was one of the barriers to communication that the thesis considered.

"The mind is like an ecosystem- a self-corrective network of circuits"
(Bateson, 1979 p.8)

Hervey's (2000, p. 58) five-step method for artistic inquiry

ABR is often a process-based rather than product-based form of enquiry. For process guidance, I drew on the work of Lenore Hervey (2000). In her book, titled *Artistic Inquiry in Dance/Movement therapy: creative research alternatives,* Hervey lays out five steps that she considers essential to an artistic inquiry. These following sub-sections briefly describe each design step and how I connected the step's initiatives or directives not only for the thesis artmaking but also for some overall decisions about what content to include.

Initial Awareness – This step of the artistic inquiry results from an image or idea being selected to address the research question because it strikes the artist/researcher in some unique, possibly aesthetic way. During the literature review phase of the thesis, aspects of the Holling's Loop and a number of watershed restoration strategies emerged and were connected with observations made at the Beaver Wetland Complex (namely the ideas of restoring connectivity and capacity).

Decontextualization and Intentional Re-creation – This step involves removing images or ideas from their original context and re-creating the concept as an artistic composition. Considering my aim to create art that embedded the ER watershed resiliency message chosen, I needed to emphasize artworks that could encourage knowledge exchange and stimulate dialog. Here I integrated a pattern from the movement of water through the beaver wetland complex on Willow Creek with the SES resiliency and watershed restoration approaches from the literature review. I arrived at the idea of having Holling's *hydrology loop* as central to the knowledge component of the ER message. I then explored how, through a type of stylized dance, the patterns of water movement, the adaptive cycle, and nested cycles could be presented. These ideas resulted in

early compositions of the *Handheld Holling's Hydrology Loop* art piece. This model allowed the concepts to be operationalized in an art object.

Appreciation and discrimination – This step of Hervey's artistic inquiry process involves an aesthetic evaluation of the artworks produced to judge how well they address the research question or task. With the *Holling's Hydrology Loops* piece, I reflected on the prompts, discoveries, and example practices of from other ecological artists that had relevance to art's possibilities for communication and knowledge transfer in particular.

Refinement and Transformation – This step involves adjustment, transformation, and manipulation of the artworks in response to continued critique and assessment. For me, this was largely completed alone, although having the opportunity to exhibit the installation allowed for external informal feedback on the artworks to be considered. Hervey indicates that this step is a cyclical and iterative process that can be ongoing until some level of aesthetic or ideological satisfaction is achieved. Refinements to the ecological artworks included making the *Handheld Holling's Hydrology Loop* more three dimensional for ease of use and to better connect a participant-viewer to hydrology, both literally and figuratively. I also scaled up the handheld loop concept (initially meant to embody small local watersheds) by creating the *Bio-Regional Holling's Hydrology Loop* and through designing and creating the complete *Earth System state Water Balanc*e sculpture. This step also involved building iterations of the *WaterShed, the installation* structure that displays the ecological art pieces in a cohesive manner.

Recontextualization -The final step of Hervey's artistic inquiry process involves placing the art in a context relative to its proposed value, where it can be viewed and assessed by others. For me, this step meant exhibiting the thesis artworks at conferences, workshops, and art shows, where audiences were able to interact with and provide casual informal feedback about the art pieces. While no formal participant-viewer observations were collected, informal anonymous comments were offered that reflected experiences or perceptions that participant-viewers had regarding the ER message as well as how some interpreted the artworks.

Under the ABR methodology I adopted, art was the medium under study, a component of the methods employed, and the artworks created were central to the thesis enquiry. With such a research design, art allowed for a neutral or novel canvas (Bentz,2020) upon which to place the

knowledge components of the restoration ecology message on watershed resiliency. Artmaking involves a process of creative transformation, taking an idea and developing it into a tangible artifact/object. Artmaking itself necessitates that the audience, participant, or viewer enter into some kind of relationship or connection with either the artist and/or the art object (Chow, et al., 2019). Whether an artwork or exhibit is successful in communicating the message or experience the artist sought will depend on how accessible it is, to and for whom, among other factors. According to Sinner, Leggo, Irwin, Gouzouasis & Grauer (2006), "[i]nterpretations emerge from inquiry, as a researcher explores, assesses, or develops relationships between theories, concepts, and lived experiences" (p. 1235). The guiding questions for me in adopting the methodology I did were: Will it help embrace the multi-disciplinary nature of SES watershed systems (Guba & Lincoln, 1994) and, in particular, will it allow for the useful inclusion of an exploratory ecological art exhibit?

3.5 My positionality as a researcher-practitioner

Popper (2002) notes that as a researcher, while one may struggle to be truly objective, one remains compelled to situate the research agenda, necessarily, from a specific (subjective) angle. Reiter (2017) argues, "[t]he social sciences have reached a moment of strong self-reflexivity" (p. 130) that calls researchers to reflect deeply on our own positionality in the research process. Because the methodological decisions and perspectives adopted are informed by where the researcher stands (Reiter, 2017), I have included an Artist Statement and Materials Choices sub-sections. Through sharing my own strengths and biases as artist, restoration practitioner, and climate change advocate, I hope to be critically reflexive and transparent with the reader regarding my subjective position within the research methodology.

3.5.1 Ecological Artist Statement

Research interests and practices often emerge from professional, educational, and/or personal lives of the researcher (Sinner, Leggo, Irwin, Gouzouasis, & Grauer, 2006). The thesis exploration brought me to reflect on my own biases, preferences, and the ways in which the role I have played in shaping the study have roots in my lived experience.

My training and performance background include drawing and painting from a young age in multiple mediums—oil, water colour, charcoal, pencil. I have also presented performance art

in various locations, for example, at the Emergency festival in Peterborough, Ontario, and at the Artists on the River festival in Paisley, Ontario. In dance, I have taken over 10 years of formal and informal training in a range of styles. I have also studied trapeze, aerial silks, and the flying ladder (forms of circus art) at various locations such as the Banff Centre for the Arts and in Budapest, Hungary. Another area of circus arts that I have practiced are called flow arts, which include creative skill based techniques to manipulate objects while incorporating dance. Both dance and circus arts draw upon focus on the present moment tied to the skill based task, which relates to Mihaly Csikszentmihalyi's theory of Flow (Csikszentmihalyi, Abuhamdeh, & Nakamura, 2014). Explorations of metaphor using discipline-specific language such as "flow," "connectivity" and "capacity" of water at multiple levels were conceptualized in my ecological art exhibit by combining my visual and movement-based art experience.

My discipline-specific knowledge foundation includes university education, BSc in environmental science from Trent University and I am presently a candidate for an MES in Environment Resources and Sustainability at the University of Waterloo. It also includes nine years of professional practice in restoration ecology. For example, restoring native dune grass ecosystems on the Lake Huron shoreline; working to develop a restoration plan and socio-ecological system study of inland lake in the Lake Huron fringe ecoregion; helping to plant over 200 000 tree seedlings in riparian and buffer strip tree planting and co-creating the Integrated Watershed Management plan for the Pine River Watershed as part of the Healthy Lake Huron initiative PRWIN Integrated Watershed Management Plan (lakehuroncommunityaction.ca). This education and work experience prompted me to associate watershed restoration with a fluidity and dimensionality I conceive as supportive for engaging diverse audiences with aspects of watershed resiliency and climate change narratives.

The act of artmaking to portray a particular ecological and environmental narrative is, in and of itself, an act of interpretation and re-representation. I have worked as a professional interpreter of local socio-ecological heritage of Bruce County for general audiences, for Ontario Parks, and for the Bruce County Museum & Cultural Centre over eleven summer seasons. Each of these roles has allowed exploration of how three-dimensional objects and visual aids can capture an audience's interest, drawing them closer to a scientific narrative (Tilden, 2008). The act of interpreting also helped me to acquire a sensitivity to how words, the vocabulary chosen,

and the elements of 'a story' can privilege one or another discourse. Finally, by incorporating movement into my sculptures, I was acknowledging that kinetic learning has been found in the literatures to offer an effective way to learn new concepts (Teixeira-Machado, Arida, & Mari, 2019).

3.5.2 Materials choice for the artmaking

I worked with a variety of materials to create the thesis artworks but focused on re-using discarded materials. My penchant for scraps of wood, discarded cardboard, broken bike frames and so on corresponds to my belief that the use of recycled materials or "rubbish" helps emphasize the nature of my ecological art. For the thesis artmaking, I also incorporated new materials such as the PVC tubing. Neon acrylic paints and a black light were chosen for their vibrancy, as a means to counter the bleak and dark undertones of environmental dysphoria and to entice feelings of hopefulness.

One of the main contributions that a multimodal ABR-centric methodology can offer is provision of a new lens through which SES watershed systems and the need for climate resiliency can be viewed and, perhaps, an artistic interpretation of what words or images alone cannot express (Snowber, 2019; Kubinowski, 2013).

3.6 Summary

The exploratory qualitative research that was conducted during this thesis was framed by the processes of literature review, consolidation /interpretation and artmaking. These processes were informed by Socio-Ecological Systems framework and the philosophical perspective of social constructivism. These lenses provided a foundation for a research design to be developed from a combination of art-based research, interpretive phenomenology and auto-ethnography, which was grounded with a case study and . The art-based research methods drew from Lenore Hervey's five-step method for artistic inquiry consisting of: initial awareness; decontextualization and recreation; appreciation and discrimination; refinement and transformation; and recontextualization.

CHAPTER 4 - ECOLOGICAL ART EXHIBIT and CASE STUDY

This Chapter presents the artworks created under the objective 3 **Using purpose-crafted ecological art to communicate a watershed resiliency message**. This represents the culmination of the research process. Images of the major art pieces are provided individually with accompanying meta-narrative and commentary. One supporting case study follows in the Willow Creek Beaver Wetland Complex. This case study contributed to the process of creating the context of the message, the central exhibit and to capture some of the synergies, questions, challenges, and decisions that motivated the final installation.

One intention of this thesis has been to create an interactive ecological art exhibit towards exploring whether art, in this form, can provide an alternative means for visually communicating a message of watershed resiliency in relation to climate change (Roosen, Klockner, & Swim, 2017). Drawing from perspectives of hydrology, restoration ecology, and systems theory, the exhibit's central communication is that watershed system resiliency can be increased through restoration of lateral hydrological connectivity and improved water storage capacity. This message is an example of "what ecologists actually know about the causes and pace of environmental and climatic changes" (Ellison & Borden, 2019, pg. 10), and the artwork is an attempt to extend the reach of the communication of this message to broader audiences . The artworks appearing in this chapter also represent an effort to help address a reported lack of visual depictions of water cycles that situate people and our collective influence on hydrological processes as integral to climate change - climate adaptation conversations (Gleeson, et al., 2020)

Water, the watershed (its cycles and functioning), and increasing watershed system resiliency form a conceptual nexus for the interactive ecological artworks that have been created. From the local to the global – in theory and practice – increasing the storage of freshwater on the landscape is one solution pathway to mitigating and adapting to a changing climate (Kravčík, Pokorný, Toth, Kovac, & Kohutiar, 2007; Gleeson, et al., 2020). The research journey through the thesis literatures has shown the potential, past and into the future, of artwork as an alternative medium for environmental messaging to both expert and lay audiences. However, these literatures have also shown that complex barriers remain to communicating climate change. climate response data and messaging (Roosen, Klockner, & Swim, 2017). This finding is consistent with my lived experience as a watershed restoration practitioner. That ecological art has shown promise as a method for helping with some of these communication barriers (Roosen,

Klockner, & Swim, 2017). Dr. Lance Gunderson encouraged the creation of the art pieces presented in this chapter to explore the concept of the Holling's loop that he and C.S. Holling created to explore transformation and resilience in socio ecological systems (Gunderson & Holling, 2013). These artworks were exhibited informally to general audiences ten times in various, primarily academic, settings in Ontario. Some of the feedback received during these showings appears under "Audience Responses to the Ecological Art Exhibit"(section 4.2) representing preliminary effort to gauge the exhibit's effectiveness as an alternative mechanism for communicating an ecological restoration message.

4.1 Using Ecological Art to Communicate a Watershed Resiliency Message

Using original art to present a series of scientific concepts provides a novel entry point for members of a multi-disciplinary audience, whether experts or non-experts on the subject matter at hand. The aesthetics of the included art pieces and their interactive components were designed to entice people to engage with concepts that might be intimidating or disturbing to contemplate in other formats such as: hydrological systems theory; textual articles or books warning of global system collapse (Diamond, 2011; (IPBES) Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2018). The central message chosen for the ecological art pieces was explored further after the presentation of the main exhibit with the case-study-styled examination of a Beaver Wetland Complex located on Willow Creek in Paisley, Ontario. An ecological art journal was kept to record observations at the Willow Creek site. This exploratory work helped me to place some of the science underlying the watershed system resiliency message into tangible and interactive art pieces with potential for communicating the selected message's ecological concepts to diverse audiences. The ecological art pieces are next presented with images and commentary.

I. The WaterShed

The WaterShed (presented in figure 14.) houses the interactive exhibit created for this thesis. Built from recycled lumber measuring some 2m x 2m x by 6m, the *WaterShed,* is not an easily moved installation and was built to showcase the art in a primarily digital space. This *WaterShed* exhibit houses the pieces: *Hand-held Holling's Hydrology Loops (HhHH Loops)*,

larger suspended *Bioregional Hollings Hydrology loop*s, and the *Earth System State Water Balance* sculpture. An additional art piece – the *Watershed as Functional System* – is presented as a stand-alone piece within the *Watershed*[2]. The complete ecological exhibit seeks to embed, communicate, and demonstrate experientially how increasing lateral connectivity and potential for water storage capacity on the landscape can lead to increased watershed system resiliency. For example, the hand-held art pieces (HhHH Loops) in the *WaterShed*, seen on the left side and centre of the photo, which represent local watershed systems and the small water cycle. The suspended larger *Bioregional Holling's Hydrology Loop* (blue), visible in the left center of the photo, represents the larger water cycles that are linked through the interaction of precipitation and the global climate. Collectively, the artwork seeks to evoke a meta-narrative that embodies the ecological message, evolved under Objective 1, in exploration of the utility of art for communicating messaging that relates to watershed restoration, ecology, and climate change and climate adaption.

[2] There were other art pieces created and occasionally presented but these have themes that are beyond the scope of the thesis.

Figure 14. *WaterShed* (Mason, A. 2021)

This figure represents the *WaterShed* (2m x 2m x 2.5m) as the complete exhibit of interactive ecological art built to convey the message that restoring lateral hydrological connectivity and potential for water storage capacity can increase watershed system resiliency. The *WaterShed* is made of recycled lumber and consists of a platform on which the *Earth System State Water Balance* sculpture is placed and a beam from which the larger Holling's Hydrology loop is suspended and connected to the artist with aircraft cable. This larger *Holling's Hydrology Loop* is attached to a hip harness that translates the movement of the artist moving on the *Earth System State Water Balance* to the large *Holling's Hydrology loop*, representing the large water cycle. The small *Handheld Holling's loops* are held in the artist's hands and represent the movement of the small water cycle and the dynamics within the local watershed systems. The piece *Watershed as Functional System* is placed over the artist's face. An early iteration of the Holling's Loop in two dimensions, which outlines the four quadrants of a resilient system, is shown on the right of the image.

II. Holling's Hydrology Loops

Early in the thesis research Holling's Loop (Holling, 1973) caught my interest as a well-known visual representation to describe patterns of complex resilient systems. This loop is represented by a lemniscate shape that lies in a cartesian plane where the x-axis represents connectivity, and the y-axis represents potential energy in a system (Gunderson, 2013). Resilience is a concept used to interpret socio ecological system processes and as a framework it is now being used to help understand global systems (Ellison & Borden, 2019). (Gunderson & Holling, 2013; Resilience Alliance and Santa Fe Institute, 2018) are among researchers who have extended the original Loop model to relating to nested social-ecological systems to better capture the inter-connectedness of earth and human systems. Figure 15. is a photograph of a Holling's Loop I created on a plywood platform. Holling's loop represents a system that can fluctuate across four phases and maintain its socio-ecological function. The purpose of the platform was to initiate kinesthetic and visual learning, where a stationary stylized walking movement on the platform formed a movement pattern representing a stable or resilient system or pattern of movement.

Figure 15. Holling's Loop Plywood platform (Mason, A. 2013)

My interpretation of a Holling's loop constructed from plywood and cedar posts to act as an actual platform for further artistic iterations of the resilient watershed system (2 ft x 3 ft). The quadrants are colour coded and include: a quadrant in green for growth(r); a quadrant with red for conservation (k); a quadrant with purple for chaos or release (Ω); a quadrant with yellow for reorganization (α).

A subsequent exploration of Holling's loop and resiliency theory was inspired by the illustration in Holling and Gunderson's *Panarchy: Understanding Transformations in Human and Natural Systems* (2013) that maps Holling's and Gunderson's adaptive systems management theory in three dimensions. Holling and Gunderson's (2013) exploration stretches the X-axis *connectivity*, Y-axis *capacity* dimensions of Holling's loop into three dimensions, through an added z-axis representing *Resiliency*. This 3D representation of a resilient system also allowed Holling and Gunderson to explore transformations of human and natural systems using analysis that included what causes systems to shift into alternate states. Furthermore, this adapted Holling's loop extrapolates to the concept of Panarchy and the idea of interacting socio ecological systems, that are linked in both space and time, through nesting hierarchies (Gunderson & Holling, 2013). This led me to wonder what the theoretical model would look like were it to be physically constructed in three dimensions, and how capable such a physical structure or sculpture might be for articulating some of the underlying watershed system resiliency messages the thesis ecological artworks would be required to communicate. I constructed the Wire Shadow Box shown in Figure 16. (below) as an initial response to these considerations.

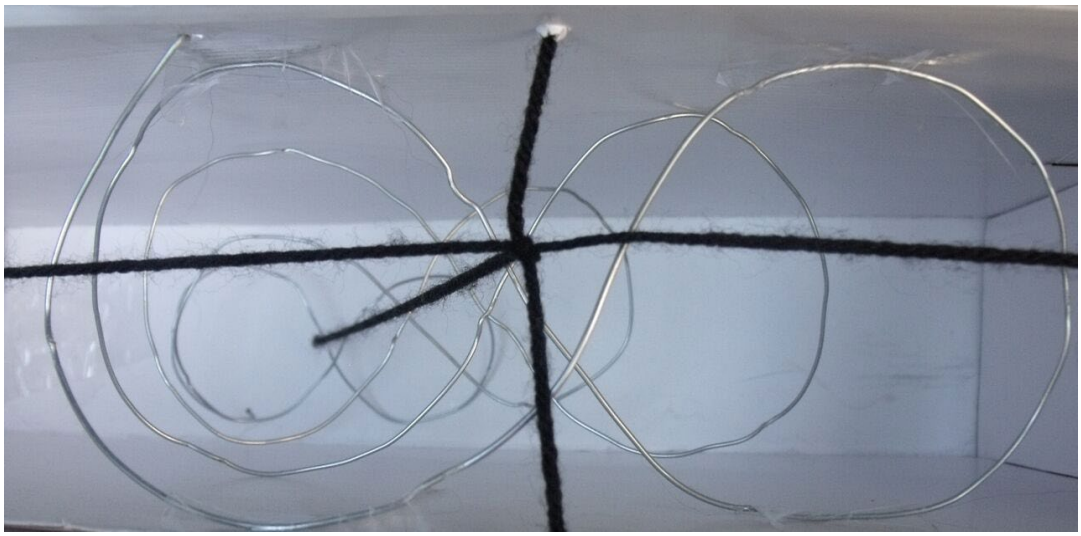

Figure 16. Wire Shadow Box of three-dimensional Holling's loops (Mason, A. 2013)

Three-dimensional iteration of nested adaptive cycles inspired by Gunderson and Holling's presentation of resiliency as a z-axis and the y- axis representing potential and the x-axis representing connectivity. The shadow box is constructed from 22-gauge wire to represent the adaptive loops and black acrylic yarn to represent the three-dimensional axis which is secured within a cardboard box lined with white paper (8.5" x 11" x 4").

The early art pieces (or pilot pieces) I built provided the fundamentals for inspiring kinetic and interactive components for the ecological artworks. The *Hand held Holling's Hydrology Loop (HhHH Loop)* art pieces represent this idea of Holling's adaptive and resilient systems in relation to watershed function. Shown in Figure 17., the plastic tubing was crafted into a functional loop into which water was inserted. The *HhHH Loops* were designed to act as an ecological art symbol for local watersheds treated as functional hydrological systems that, when stacked in a panarchy, might help to maintain the resiliency of the Earth System.

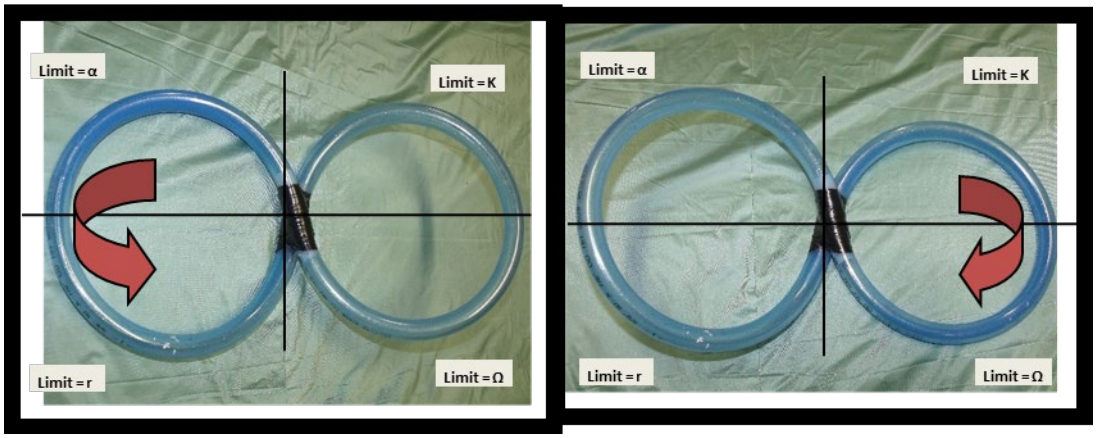

Figure 17. First Iteration of *Hand held Holling's Hydrology* Loops (Mason, A. 2013)

The first version of the *Hand held Holling's Loops* (HhHH Loop) is shown above, symbolizing a resilient watershed system. The HhHH Loop (52 x 20 cm) is constructed of PVC tubing and connector filled ¼ full with a mixture of water and blue glue. During the initial iteration of the HhHH Loop, movement by the artist did not give the water inside the tubing sufficient kinetic energy to overcome the gravitational potential between the quadrants of the shape.

When the *HhHH Loop* is manipulated, a dynamic equilibrium begins to emerge as the person holding the art piece starts to track the pattern of the water moving through the art object. This pattern of hand movement is enhanced by the movement of water in the structure, symbolizing the interface of people and nature that takes place in a socio-ecological system. These *Loops* also embody an analogy for a watershed system with adequate connectivity and potential that exhibits resiliency and a dynamic equilibrium. The initial iteration of the *HhHH Loop* did not provide a smooth flow of water throughout the symbolic system, so the shape was modified in the next iteration to be more three dimensional and accommodate the artist's movements more easily. This three-dimensional iteration shown in figure 18 more closely

resembles the work of Holling and Gunderson who introduce the z axis to the Holling's Loop as a function of resiliency in relation to the connectivity and capacity of a system (Gunderson & Holling, 2013).

The three-dimensional aspects of the *HhHH loops* also incorporate the idea that resilience is linked to increased connectivity and potential in a hydrological system. These three-dimensional *Hand held Holling's Hydrology loops (HhHH loops)* are symbolic of small socio-ecological watershed systems oscillating in dynamic equilibrium states. It was easier to cause the water to flow smoothly between the quadrants representing the phases of growth, conservation, release, and reorganization to depict a resilient and dynamic watershed system state. The purpose of this *HhHH loop* was to take these concepts of a resilient watershed system and make them tangible. Combining theory and my practitioner's understanding of watershed restoration to merge in an artistic piece capable of communicating visually and kinetically to various audiences.

Creating this physical art piece of *HhHH loop* helps to visualize dynamic equilibrium in a system, which I sought as an artist to share with an audience. These *HhHH Loops* also act as symbolic representation of how humans are currently a driving force affecting the functioning of all ecosystems on Earth and, in turn, how the functional state of these ecosystems supports our behaviours. This reciprocal relationship has been integral to the thesis study. The intrinsic connectedness between humans and our environment was inspired by eco-artist Brookner's work and has been delved into at a conceptual and emotional level in relation to ecological anxiety (Aptner, 2013) and climate action in relation to restoration ecology (Lake Huron Framework, 2021). I have used my own experience as a thermostat along with exploring reactions of peers, practitioners, academics, and lay public as a soft metric for gauging the effectiveness of ecological art as a communication medium.

Figure 18. 3D Holling's Hydrology Loop showing resiliency (Mason, A. 2019)

The second iteration of the HhHH Loops (40 x 24x 14 cm) was inspired by (Gunderson & Holling, 2013) *in Panarchy Synopsis: Understanding Transformations in Human and Natural Systems* and symbolize resilient small watershed systems. A video (42 views) of the *Hand held Holling's Hydrology Loop can be viewed at https://youtu.be/2fd7ADZMtks?si=7npitaEM77dQJtHE* and attached as appendix 2.1

III. Watershed as a Functional System

The next piece of ecological art, titled *Watershed as a Functional System,* and shown in figure 19, represents an exploration of the intersection between watershed systems, thresholds or tipping points, and the cup and ball diagram as a metaphor for resiliency. The geometrical shape of the egg carton evokes the cup and ball theory often used to describe stable system states and the basin of attraction, which defines an ecosystem functioning in one of these stable states (Beisner, Haydon, & Cuddington, 2003). The surface of the depression in this theory represents the landscape or conditions the ecosystem is bound by and the ball represents the community of life within these bounds, when the ball is within a single basin of attraction is said to be in a stable state and as conditions push it up towards the limits or edge of this basin it can tip into another basin, causing the system to move rapidly into a different regime (Walker & Salt, Resilience Thinking, sustaining Ecosystems and People in a Changing World, 2006). One side of the egg carton is shown in green and blue, symbolizing the peaks and valleys of various

intersecting watershed basins, this was done to provide an analogy towards visualizing a watershed as a system. On the opposite side of this same egg carton, an adaptive system is represented in four separate colours (red, green, purple, and yellow) which brings elements of the four quadrant Holling's loop into the piece as well. The egg carton was selected as it contained distinct basin shapes and it also mimicked a sine wave or half of a lemniscate shape, pulled into a plane, using this form as the basis of this piece was an attempt to link the concept of stable systems within basins of attraction, and apply it to watershed basins as well as the concept of Hollings loop, in a 3D perspective.

The 28 x 14 x 36 cm piece is mounted with a rotating bearing so the artwork can spin to show the various sides of the work. The bearing is secured to a wooden frame, which allows it to be attached to the WaterShed. The surface of the piece is a mirror which was chosen to extend the shape of the painted egg carton. The result is a visual metaphor using a play on reflection and perspective to show the merging of the concepts of watershed basin; basin of attraction and Holling's adaptive Loop. The movement of the piece also alludes to the title Watershed as Functional System, with the idea that watershed systems are dynamic moving and fluctuating things that may exhibit patterns and stages of flow for example but are not static.

Figure 19. Watershed as Functional System (Mason, A. 2018)

This piece (28 x 14 x 36 cm) is meant to show how a watershed could be thought of as a functional system. A threshold or tipping point for a system is often imagined as a basin and ball diagram, where a stable system state is represented by a ball being in the lower part of a basin and when the ball reaches the lip of the basin it can tip over into a different system state. In this sculpture I compared this symbolic basin to watershed boundaries, the high point of land where a drop of water would flow either into one basin or another. I used an egg carton as the focal point of the sculpture as it already contained a series of basins and/or peaks and valleys. The colours I chose on the functional system side of the piece allude to the four quadrants of the adaptive cycle in Holling's Loop, which is another way of symbolizing a resilient system. The movement of the piece is to showcase a melding of two conceptual paradigms. A video (3 views) of the piece moving can be viewed here: https://youtu.be/GT5Rw5Sgf7I also attached as appendix 2.2.

IV. Bioregional Holling's Hydrology Loops

The *Bioregional Holling's Hydrology Loop* shown in figure 20. is a kinetic sculpture that is driven by the artist's walking motion, as an example of human behavior that impacts larger bioregional scale socio-hydrological systems symbolized by this larger suspended Holling's Hydrology Loop. The Bioregional Holling's Hydrology loop is a larger iteration of the *Handheld Holling's Hydrology Loops*. The implied variables on the x, y, and z axis, which the sculpture

moves through as it is manipulated by the artist's movement are still connectivity, capacity, and resiliency, when looked at from the perspective of Holling's adaptive cycle. The perimeter of the loop, which is made of a recycled and reshaped hula hoop, is filled with water, to approximately 1/4 of its volume. The Holling's Hydrology Loop is a representation of an adaptive and resilient watershed system that is functioning in a dynamic equilibrium state. The human interface with this sculpture is a motif for the *interconnectivity* of human behaviour with the functioning of the earth's hydrological systems at the bioregional scale. This interconnectivity is literally symbolized via ropes that connects the artist's movement to the sculpture.

The *Bioregional Holling's Hydrology Loop* functions as an intermediate piece within the entire *WaterShed* exhibit. From an execution standpoint, the artist manipulates this piece while standing on the *Earth System State Water Balance* whilst moving the *Hand held Holling's Hydrology Loops (HhHH loops).* This multitasking and sequential movement of the various kinetic sculptures is meant to symbolize the dynamics of various scales of watersheds that our human behaviour influences. The *Bioregional Holling's Hydrology Loop* represents a socio-hydrological system such as the Great Lakes Watershed that is a significant and distinct bioregion that is defined not only by its geography but also by its related human uses. The placement of the *Bioregional Holling's Hydrology Loop* within the *WaterShed* exhibit is between the smaller *HhHH loops,* which act as syntax for small/local watershed systems and the *Earth System State Water Balance* which represents the larger climate parameters that are shaped by the ebb and flow of these interacting bioregional watershed systems. This configuration is meant to show that we are connected to and have influence on hydrological systems at multiple scales. We have the most control over smaller local interactions *(HhHH loops)*, but these interactions influence larger bioregions (*Bioregional Holling's Hydrology Loop)* and in turn our entire *Earth System State Water Balance* which also has a direct influence back on us.

The additive nature of restoring local watershed systems towards resilience has a long history within the management regimes of Southern Ontario and its network of Conservation Authorities -based on major river watershed drainage areas (Lake Huron Framework, 2021). The health of headwaters that feed into major river systems and in turn the Great Lakes is part of bi-national approach to restoring and conserving Great Lakes Water Quality (United States Environmental Protection Agency, 2021). Additionally, the restoration of the local small water cycle, achieved through increased connectivity and capacity in local watersheds, can lead to

more reliable precipitation on the landscape based on increased evapotranspiration (Kravčík, Pokorný, Toth, Kovac, & Kohutiar, 2007). This reliable or predictable precipitation may help to preserve agricultural productivity, forest health and the assurance of drinking water and water needed for industrial production. Furthermore, contributions to bioregional resiliency can also provide positive feedback to help preserve larger Earth System State processes such as helping to stabilize the patterns necessary for maintaining the Atlantic meridional overturning circulation (Jackson, et al., 2015).

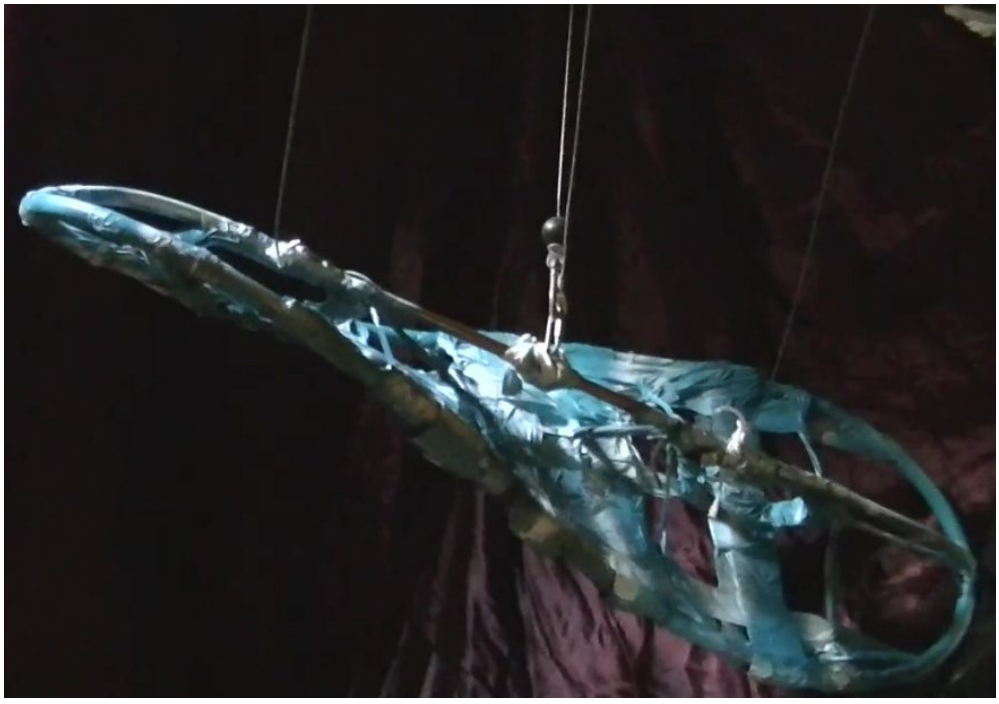

Figure 20. *Bioregional Holling's Hydrology Loop* (Mason, A. 2018)

The *Bioregional Holling's Hydrology Loop* (130 x 27 x 43cm) is a kinetic sculpture that is driven by a walking motion, as an example of human behavior that impacts a watershed socio-hydrological system symbolized by a larger suspended Holling's Hydrology Loop. A video (10 views) of the *Bioregional Holling's Hydrology loop* being moved by an artist's walking gait can be found at: https://youtu.be/RrIRjhiiucM and also attached as appendix 2.3. This sculpture is an intermediate piece in the entire *WaterShed* installation and represents a bioregional watershed system such as the Great Lakes Watershed.

V. Earth System State Water Balance

The kinetic sculpture created as part of the thesis, called the *Earth System State Water Balance*, is shown in an early iteration in Figures 21/22. The final *Earth System State Water*

Balance, shown in figure 23, represents how the cumulative actions people take at the local watershed level become amplified through bioregional water cycles and at the level of the global water balance. We can choose to act in ways that maintain and support the dynamic equilibrium of these cascading water systems, or we can act in ways that threaten to tip us out of this Earth system state. The physical action of manipulating the sculpture is meant to embody this idea of meaningful climate action through watershed restoration.

The following diagrams depict the physical and conceptual process of the sculptures creation, with early prototypes and finally the uncovered inner workings of the final *Earth System State Water Balance*. The early platform was constructed of plywood and mapped the Holling's loop into four quadrants where the artists feet would map out a dance representative of movement in a resilient system. The second iteration was based on earlier work with the Holling's Hydrology Loops controlled by the artist's hands, where water was placed in a PVC tube to showcase the movement of water within a resilient system. The concept was then shifted so that the movement of the water could be controlled by the artist's feet. The final frame for this sculpture is made of two partial bicycle frames that support two plywood platforms, one for each foot of the participant. The body of the sculpture is constructed of various scrap wood 2x4's. The frame of the sculpture was then covered with second-hand fabric, this use of reused materials was important to the subject of the art piece which deals with climate action. PVC tube was used to form the lemniscate shape of the Holling's loop. The tube and frame were also painted to correspond with the four phases of a Holling's loop and L.E.D.s were added for effect.

Figure 21. Prototype for Earth System State Water Balance (Mason, A. 2017)

This is an intermediate step in the water balance sculpture development, where a *Holling's hydrology loop* was attached to a fulcrum to function as a prototype for the finished kinetic sculpture *Earth System state Water Balance*, which follows. The idea was to adapt the pattern of movement developed in the use of the *HhHH loop* for the lower body on the Holling's loop plywood platform.

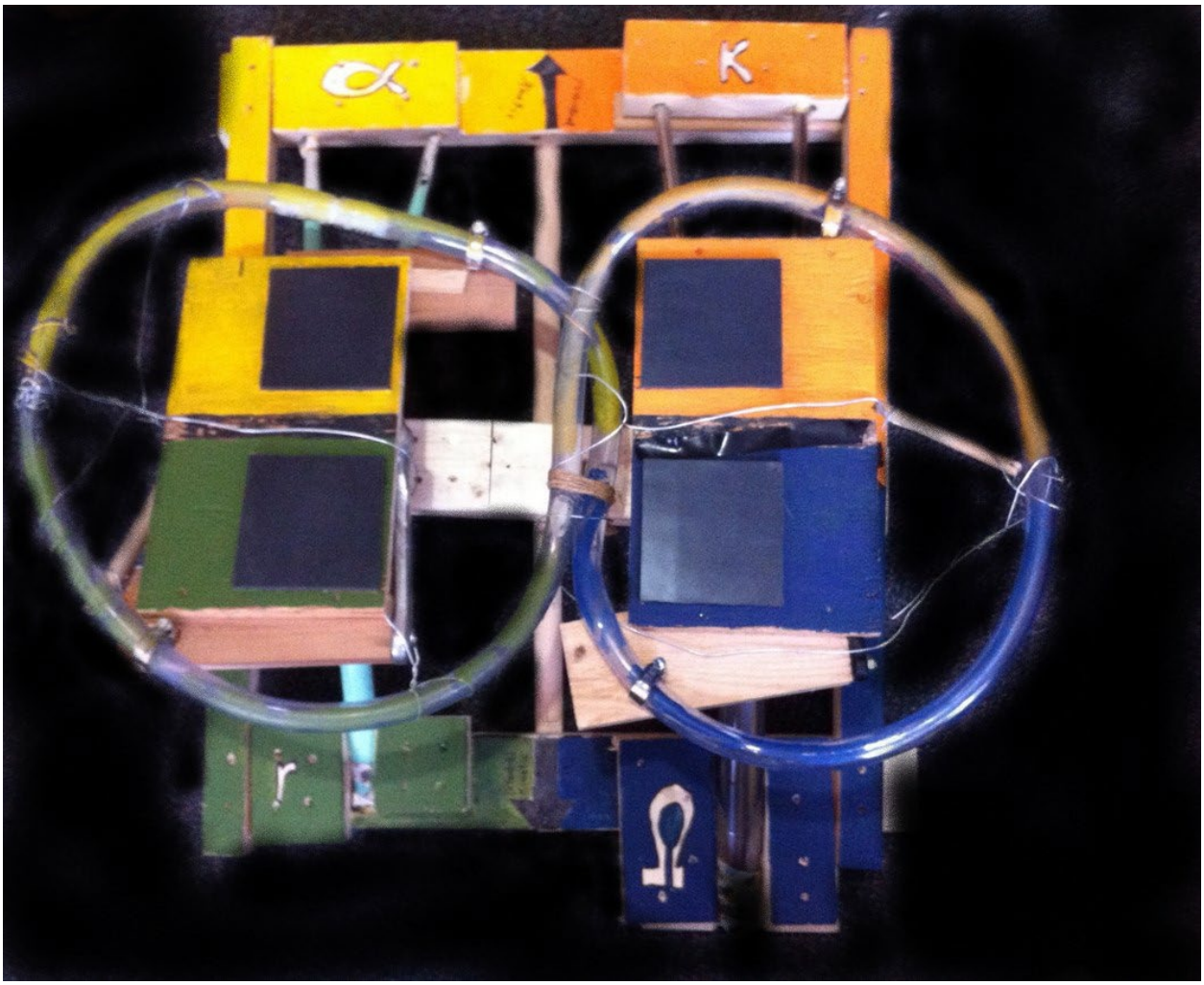

Figure 22. Early version of *Earth System State Water Balance* (Mason, A. 2018)

This is the working structure of the *Earth System State Water Balance* kinetic sculpture that was created with two partial bicycle frames with the hub and cranks intact and plywood platforms attached. These platforms allow a human to interface with a hydrologic Holling's loop and attempt to create a dynamic equilibrium state, with a rhythmic pattern of body movement. This movement is symbolic of human actions affecting watershed health, and in this context acting to stabilize a system that is nearing a tipping point.

The finished *Water Balance Sculpture* is shown in Figure 23. on the next page. Evolved through several stages of construction, its message content and working mechanicals allow the piece to provide an interactive, kinetic experience. The sculpture embodies a resilient watershed, existing in a functional dynamic equilibrium state or what can be considered an adaptive management regime. This ecological art piece is intended to evoke relationship linkages between

adaptive systems theory (Holling's Loop) for improved watershed system resiliency, and the restoration potentials inherent in improving connectedness and water storage capacity on a landscape.

Figure 23. *The Earth System State Water Balance* kinetic Sculpture. (Mason, A. 2018)

The kinetic sculpture *Earth System State Water Balance (40 x 83 x83 cm)* symbolizes the Earth System which is made of up a panarchy of interacting socio ecological watershed systems. The human interface in this art piece represents how humans are the driving force of socio ecological systems and we can decide the direction we push these systems that support us. The PVC tubing is filled with water, and it contains four pads (labeled for each quadrant of the Holling's Loop) to place the heel and toe area of each of the artist's feet when they are standing on the sculpture.

The *Earth System State Water Balance* provides the artist a physical interface with the sculpture by allowing the artist to stand on two platforms, which have a quadrant for the balls and heels of the feet. The three fulcrums allow for movement between the heel and ball of each foot and the third fulcrum allows for movement between the left and right sides of the sculpture.

That is, the artist stands on these four foot pads which represent the four quadrants of the Holling's loop and moves their weight from toe to heel on alternating feet. The balancing act required for demonstrating this sculpture's messaging is intentional, meant to convey the proximity to a system tipping point that could push us out of the Anthropocene and into another global system regime state or Epoch. When the component parts of the sculpture are in motion, the multitasking demanded symbolizes a panarchy of resilient watershed systems, stacking and influencing larger scales of systems that influence climactic conditions.

This video (28 views) shows me interacting with the Water Balance Sculpture and the HhHHs https://youtu.be/zLrL6jkPnoo and is also attached as appendix 2.4. As the Holling's Hydrology Loops interact across spatial and temporal scales they provide some influence on the function of the kinetic sculpture 'Earth System state Water Balance' which itself symbolizes an aspect of the Earth System State. This interacting of socio-ecological watershed systems symbolizes a panarchy of systems working within the greater Earth System State. The human interface in this art piece represents how humans are the driving force with socio-ecological watershed systems and we can decide the direction we push these systems that support us. However, the complex panarchy of our total Earth system is balancing within a specific equilibrium state and if we are not careful, we could tip this system into another less favorable regime.

The multitasking involved in operating this ecological art exhibit is also a nod to highlight the inherent complexity and feedback loops that make up socioecological systems and are involved in interdisciplinary work such as watershed restoration. Kinetically and visually, the *Earth System State Water Balance* portrays a resilient Earth System state Water Balance—one that would be made up of many resilient local watersheds exhibiting traits of lateral connectivity and water storage capacity in their floodplains. This additional water storage capacity would create a reduction in kinetic energy during large precipitation and flood events and would also provide a source for baseflow during droughts (Abbott, et al., 2019); both flood and drought events are occurring with greater frequency in association with anthropogenic climate change (Pachauri, et al 2014). In a bioregion, the larger watershed systems that are fed by resilient smaller systems could be affected by having a source of more reliable land-based precipitation based on evapotranspiration of hydrated and vegetated watersheds, which relates the restoration of the small water cycle (Kravčík, Pokorný, Toth, Kovac, & Kohutiar, 2007). Preserving these

elements of the small water cycle could have positive feedback mechanisms that help mitigate aspects of climate change at the Earth System state level (Abbott, et al., 2019).

4.2 Audience Responses to the Ecological Art Exhibit

Ten presentations of the ecological art pieces in various stages have been made to various audiences[3]. More in-person exhibiting had been anticipated, but the Covid-19 pandemic prevented this. The presentations that took place include showings at six different multidisciplinary Waterloo Institute for Complexity and Innovation (WICI) workshops/symposiums between 2017 and 2023. The *Earth System State Water Balance* and the *HhHH Loops* were also presented at the *Artists on the River* art show and sale in Paisley, Ontario and at the Bruce County Museum & Cultural Centre in Southampton, Ontario in 2018, for the director.

Recently in June of 2023, the pieces *Watershed as a Functional System, the HhHH loops, the Bioregional Holling's Hydrology Loops* and the *Earth System State Water Balance* was shown at the WICI and Fields Institute ***Math for Complex Climate Challenges Workshop*** held at St. Jerome's College, University of Waterloo and at a follow up workshop at the Perimeter Institute called the ***Hammers and Nails, a curiosity based approach to climate research***. The qualitative, informal feedback provided by viewers following these showings suggests that the ecological art has promise as an effective medium of delivery of a complex restoration ecology message. Recognition by the artistic and academic community also lends some support to the use of art as an alternative form of communication. What follows are brief descriptions of the venue, audience, and some responses gathered across the 10 showings:

At the Waterloo Institute of Complexity and Innovation (WICI) workshop ***Leveraging Systems Approaches to Improve Planetary and Human Health,*** April 25th, 2018, I presented several ecological art pieces at the Lyle S. Hallman Institute for Health Promotion – the Earth System state *Water Balance* sculpture (pg. 84), *Hand-held Holling's Hydrology Loops* (pg. 74), the *Watershed as Functional System* sculpture (pg. 78). One audience member mentioned, during our conversation, being intrigued by how much science information had been captured in the

[3] Again, other art pieces were presented but are not within scope of this thesis.

ecological art. This was a rewarding remark that somewhat supports the notion of art as a mechanism for experiential learning and communication.

At the WICI conference ***Modelling Complex Urban Environments*** June 21, 2018, held at St. Jerome's College, I entered a print of the painting *Anthropocene* and the art piece *Watershed as Functional System*. I was awarded a small prize ($25) after members of the conference had viewed, judged, and voted on their effectiveness as a medium for depicting complex systems.

An early, more mobile iteration of the *Watershed* and its housed art pieces was presented at the ***WICI Science Communication Poster Competition*** held in the Science Learning Complex at the University of Waterloo on April 4, 2019. The works were viewed by approximately 50 students and faculty who were participating in the event and many students passing by who were travelling between lectures and classes. I received/heard general informal comments of appreciation about the incorporation of art in science communication from judges and audience members. This feedback was offered as discussion primarily while I was attending my exhibit and following the short presentation of my work that I provided.

At WICI's ***Synergies: a Cross-disciplinary Colloquium on Design*** held at University of Waterloo Architecture School in Cambridge on Thursday November 21st, 2019, I presented a four-minute PowerPoint presentation on my ecological artwork and my thesis message. The audience was mainly composed of architecture students and professors. I emphasized the possible role of ecological art in mobilizing community members in restoration work. This was followed by discussion of the challenges of incorporating social science and art as a student with a science background. I was also able to display one of the larger Hollings Hydrology Loops suspended from the ceiling in a gallery within the Architecture school which received some interest and generated conversation among audience members.

On July 14, 2018, at the ***Artists on the River*** art show and sale in Paisley, Ontario, I exhibited the *Hand-held Holling's Loops* and the *Water Balance* sculpture. This opportunity brought the artworks to a broader and non-academic audience and was also a chance for me as artist-creator to talk with some other artists about their work and mine. Other artists and artisans that displayed their work at this venue were painters, potters, and fabric artists, primarily based in Bruce County, Ontario.

Participant viewers of the ecological art installation offered generally positive feedback regarding the ecological artworks and expressed an understanding of the embedded concepts. Some viewers elected to provide anonymous written feedback, in response to the exhibit. Selected comments included:

"Very interesting and very clear"

"I actually understood this. My brain was able to process this."

"A very interesting and innovative look at resiliency of our most precious commodities. I hope to see these ideas expanded for practicality reasons and including art aspects make it even more spectacular. Great Work!"

"I do like the attempt to link [the art pieces] to the implementation of WASCoBs, and to do this in a way that people can experience in different formats. It really does follow McLuhan's dictum that the medium is the message. If it is okay with you, I would like to show your video to some other people who are studying complexity, although not necessarily ecology to see what they get out of it."

In connection with my at-the-time employment as Program Coordinator at **the Bruce County Museum & Cultural Centre** in Southampton, I presented several pieces - including the relevant *The Water Balance* sculpture and the *HhHH Loops* - to the Director, the Exhibits Designer, and the Business Manager as a potential interactive exhibit. The pieces were well received, and I went on to create a plan that included construction of a robust version of these ecological art pieces for education of the public on matters of watershed resiliency during the Anthropocene. The plan was discontinued in its second year, when I left my position.

In the digital space, I presented a one-minute video for the University of Waterloo 2020 Gradflix competition. GRADflix is a research communication opportunity for knowledge translation, a way to connect the research world to the practice world. My video narrated my core research objective and showcased the ecological art pieces. My submission was chosen as one of 23 finalists. The audience comprised University of Waterloo students, professors, staff, and a

panel of judges. Judging was based on communication, creativity / visual impact, and technical quality criteria. My submission was not one of the final top-four selected by the judges. The video (103 views) was created and shown during the University of Waterloo (2018) Gradflix competition and continues to be available for viewing online on my YouTube channel https://youtu.be/Gfh09csZAXI and is also attached as appendix 2.5. I host a YouTube where the videos I created to communicate the ecological art in this thesis have been posted. A number of the videos are visible as links within this thesis document. As of June 07, 2023, the channel has had 828 total unique views.

A boost to my work as an ecological artist occurred, when in May of 2022, I responded to call for climate change artists, and was accepted to display my thesis ecological art exhibit on the Climate Art Web. The art exhibit, the meta-narrative, and some insight into my positionality as an interdisciplinary artist are available at https://caw-wac.com/2022/05/04/adrienne-mason/. The Climate Art Web (CAW-WAC) is a grassroots network that brings together climate artists living in northern Turtle Island (Canada). The partners include Canada Council for the Arts, Calgary Arts Production, and Traction: Art for Climate Justice.

Summary and reflections on the scope of the presentations. My intent was to have the art presentations serve as an interface for members of a general audience to learn about systems theory, hydrology, and watershed restoration. This art was created to foster discussion across disciplines about managing watershed resiliency using systems theory and recommendations in watersheds in Southern Bruce County, Ontario. Although the ecological art exhibit did have some positive traction and feedback in communicating a specific watershed restoration message, the findings were subjective and insufficient data was gathered to contrast and compare the difference between traditional scientific findings being used to communicate this message and these artistic methods. The feedback received was encouraging in the sense that audience members were able to grasp some of the complex watershed resiliency concepts and were also drawn to the interactive artwork. In order to more fully understand whether this ecological art was effective in delivering this watershed resiliency message a more formalized social study involving a focus group, survey and interviews could be conducted.

4.3 Willow Creek Beaver Dam Wetland Complex Case Study

The message *restoring lateral hydrological connectivity and water storage capacity will increase watershed system resiliency* was explored within an observational study of the Willow Creek Beaver Wetland Complex. An ecological art journal was kept to record observations and reflections made at the Willow Creek Beaver Dam Wetland Complex. This supporting case study was done to place the theories underlying the watershed system resiliency message into a real life setting and it also offered inspiration to create the tangible and interactive art pieces that would help to communicate these resiliency concepts to a general audience.

Purpose: to examine in deeper detail the benefits of beaver activity on a landscape motivated the inclusion of this case study. The literature has established that beaver wetland complexes can increase lateral hydrological connectivity, and water storage capacity on the landscape, that in turn can add resiliency to an ecosystem (Andison, Burgess, & Elliot, 2011). Beaver activity has been associated with increased baseflow during drought conditions (Dittbrenner, et al., 2018; Puttock, 2020), decreased peak flows during flood events (Grudzinski, Cummins, & Vang, Beaver Canals and Their Environmental Effects, 2020), and enhanced storage of sediment and macronutrients in the floodplain (Andison, Burgess, & Elliot, 2011; McCullough, Harper, Eisenhauer, & Dosskey, 2004). Of equal importance, the case study allowed for elaboration of some of the insights gained from the Literature Review completed under Objective 2–Grounding the art-science-communication intersectionality. In making and reflecting on extended field observations (2011-2018), I arrived at a better consideration of the underlying science and its relationship to the thesis *message* (restoring connectivity and capacity can increase watershed system resiliency) that the purpose-crafted art exhibit would convey. Moreover, such an exploration offered what I have called a "nature node," that is a natural space where my field knowledge (ecological restoration), artistic endeavours, and experience-in-nature intersected, in ways pertinent to the thesis aim.

Site: My observations were carried out at a beaver wetland complex in a riparian zone of Willow Creek near Paisley, Ontario as shown in Figure 24. The beaver wetland complex on Willow Creek covers just over one hectare and lies within the jurisdiction of the Saugeen Valley Conservation Authority (SVCA). Willow Creek is one of the smaller tributaries that is managed

as part of the Lower Main Saugeen Watershed by the SVCA. The lower main Saugeen watershed, where the beaver wetland site is situated, is predominantly agricultural; with estimates of land use being described at 76% agricultural, 19-20% forested, and 1.2% urban/rural (Saugeen Valley Conservation Authority (SVCA), 2018). The remnant forests are small and fragmented (3.3% meet criteria for forest interior features) are often limited to the back of farm lots, which at times follows the path of the Saugeen River and tributaries such as Willow Creek, leaving 29% forested riparian zones in this region(SVCA, 2018). Between 2011-2018 I observed the development and function of four beaver dams at the Willow Creek site. The forested riparian zones surrounding the Willow Creek case study supported the beavers' ability to create the dams, primarily from poplar trees, resulting in a beaver wetland complex that allowed for a restoration of water storage capacity at this site and an increase in lateral hydrological connectivity of this floodplain.

Figure 24. Willow Creek Beaver Wetland Complex, near Paisley, Ontario.

The beaver wetland complex was observed from 2011-2018 and covers roughly 3 acres. Dam site 1 is indicated by the red oval. Source: (Corporation of the County of Bruce, 2021) https://maps.brucecounty.on.ca/Geocortex/Html5Viewer/index.html?viewer=BruceMaps

The extended period of study resulted in multiple qualitative observations and there was also the opportunity to undertake some quantitative field work. Specifically, I measured Total Suspended Sediment (TSS) up and downstream of the beaver dams within the study area to reflect on the success of beaver engineered wetlands to reduce sediment loads leaving agricultural watersheds. This also provided an example of discipline-specific language as a barrier in environmental messaging. One reflection was whether there may be any shortcomings of presenting unit measures like TSS which, while well-known for many discipline specialists, is not without limitations and may not convey the same, or even much, meaning to the general public.

Beaver wetland complexes are an alternative method of storing water on the landscape at no up-front cost, in comparison to the expensive construction costs of grey infrastructure such as Water And Sediment Control Basins (WASCoBs) or built treatment wetlands. This is one reason for the increased popularity of beaver dam analogues (BDAs) and reintroduction of beavers (Larsen, Larsen, & Lane, 2021). I was reflecting on the natural roles of beaver wetland complexes in comparison to using engineered structures like WASCoBs, for instance, as a method of storing water on the landscape. At the site I was able to observe the how water was stored in the beaver wetland complex in response to extreme precipitation events, as well as other changes related to the interconnectedness of the changing stream system and ecology (Goldfarb, 2021). Likewise, I observed changes the beavers made to the surrounding riparian forest by removing specific trees like *Populus tremuloides* to build their dams. By increasing the amount of water stored on the landscape beavers also change the types of plants that can grow in the riparian zone by extending the area of wetland habitat around a stream, which favours their dietary needs and can also increase nutrient (Grudzinski, Cummins, & Vang, 2020). In the video called Lateral Hydrologic connectivity in the floodplain (one minute three seconds) https://youtu.be/NQYU9jAleZQ and also attached as appendix 2.6, I present views of this beaver wetland complex to help familiarize readers with the site; the video includes narration of some hydrological and ecological observations.

Figure 25. Willow Creek Beaver Wetland Complex: Infographic and Beaver Dam

Photo on left spring freshet showing this wetland complex in flood where there is increased lateral connectivity and capacity for water storage. Photo on right showing one iteration of Beaver Dam 1 which had influence on the hydrological function of this wetland complex. (Mason, A. 2017).

Another set of observations took on a quantitative nature via a series of TSS samples collected downstream of each dam in an effort to ascertain whether there was any reduction in suspended sediment as the water slowed down and was stored behind these dams. (Method details have been provided in chapter 3). Through conducting the TSS sampling, I was seeking to cross-check the credibility of the thesis message (i.e., *restoring lateral hydrological connectivity and potential water storage capacity on the landscape will increase watershed system resiliency).* Results of the TSS testing are presented in Figure 25. As can be seen, the TSS did not reveal any trends to indicate that the beaver wetland complex on Willow Creek was able to slow stormwater runoff to allow sediment to drop out of the water column (Graph on Left). There was, however, a clear relationship between precipitation and TSS in Willow Creek. The average of all TSS samples from the complex and cumulative 5-day precipitation, as measured at the Environment Canada Gauge in Kincardine, showed a relationship between increasing TSS in Willow Creek and precipitation events. Specifically, a spike in topsoil erosion and resultant in-stream TSS can be observed when storms occur. This relationship is well-known and expected and highlights the problem of high rates of runoff over predominantly cleared agricultural land. The filter paper used to measure the TSS samples is displayed between these two graphs.

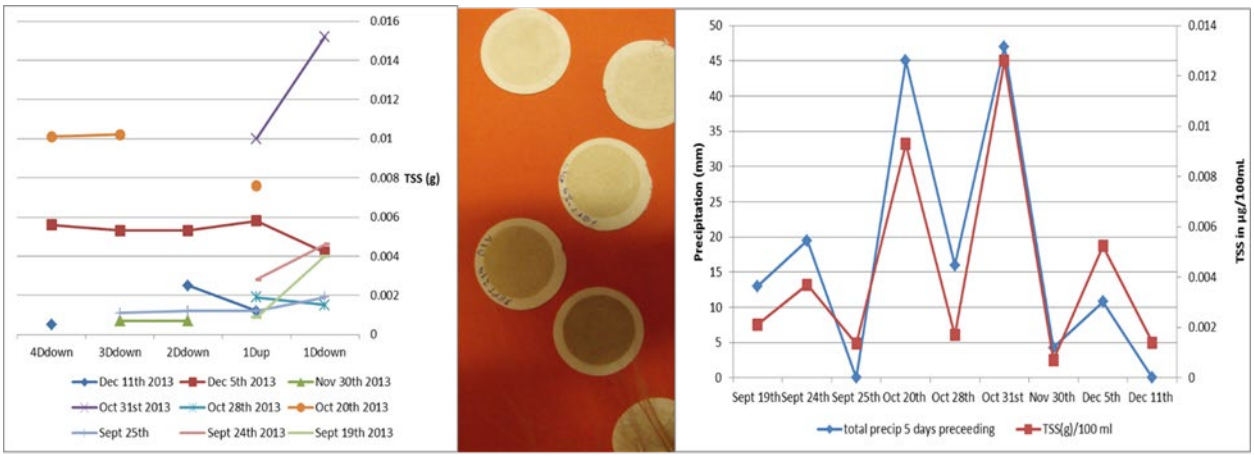

Figure 25. TSS & Precipitation in relation to Willow Creek Beaver Dams (Mason, A.)

Graph on left showing TSS samples taken at Dam sites 1 through 4 with colours referring to same day sample moving left to right downstream through the beaver wetland complex. No significant trends were observed. Centre panel shows filter paper used for TSS samples. Graph on left shows blue 5-day precipitation totals in mm with average TSS samples taken on each day of sampling at the Willow Creek beaver wetland complex. This shows a visual correlation that highlights the well-known problem of high rates of topsoil erosion following large precipitation events.

In reflecting on how ecological art as an alternative communication medium might be able to help people engage in climate-change or climate-response conversations, as part of my study of the Willow creek beaver dam complex, I kept an ecological art journal, inspired by Thoreau's *Walden* (Thoreau, 1982). A sample of some of the journal work is presented below in Figure 26. entries took the form of written texts, sketches, coloured drawings, completed paintings, and short videos.

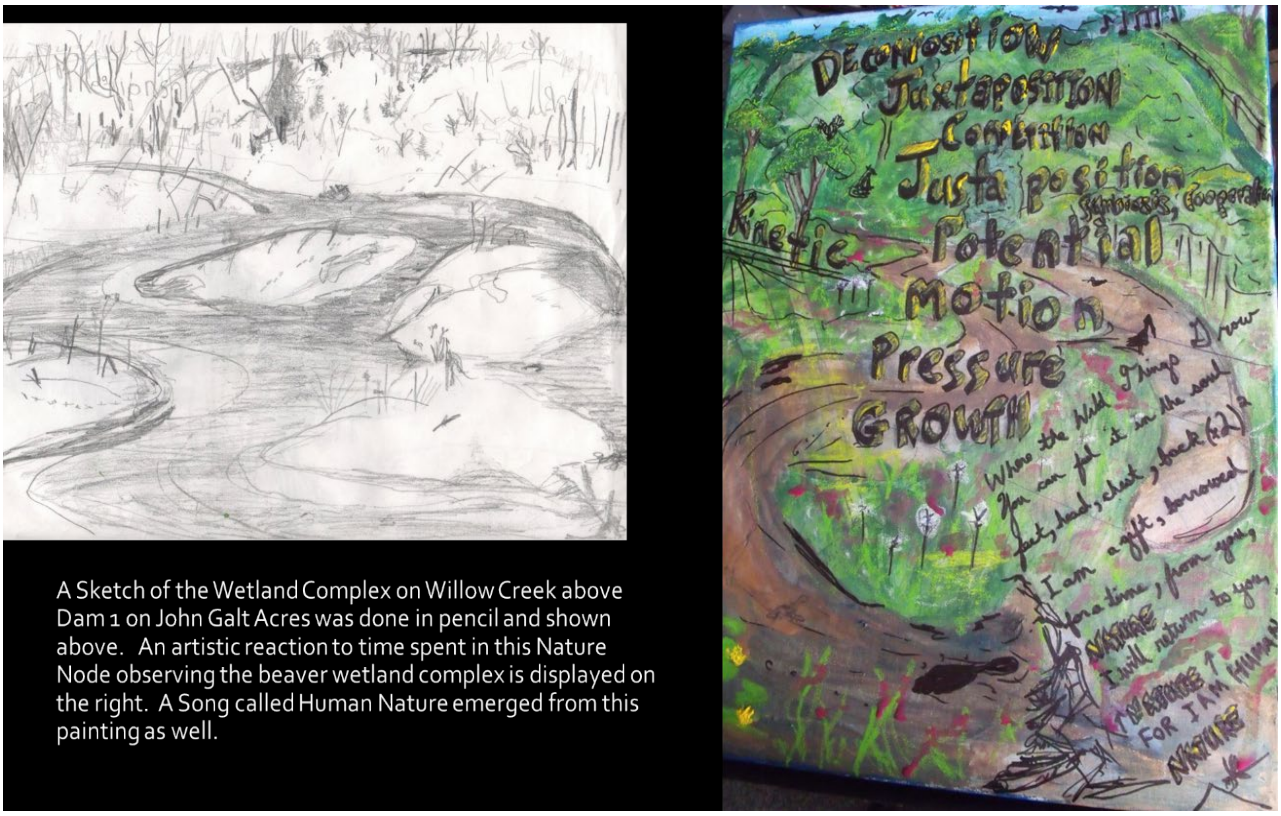

Figure 26. Willow Creek Beaver Dam EcoArt journal excerpts (Mason, A. 2016)

I sought to record an evolution of my thinking about the links between the role of beaver wetlands and the associated activity of beavers as ecological engineers and the resilience in socio-ecological watershed systems (Goldfarb, 2021). At another level I was looking to extrapolate interconnections among beaver wetlands and restoration efforts concerned with the global water balance and a resilient climate. The eco-Art journal entries produced a tracking of thoughts as I witnessed the comings and goings of wildlife and changes in the hydrology of the site. I called my observation platform a "nature node" in the sense that the landscape was a place of intersectionality where I was able to experience the beaver wetland complex as a researcher, observer, artist, and so on. The "Nature-node" also provided respite from ecological anxiety and hence has relevance to the addressing of planetary dysphoria, which was found to be a barrier to communicating environmental messaging (Aptner, 2013). Furthermore, watching the beavers and observing changes in the site's landscape inspired my practice as artist and ecological restorationist.

During the eco-art journaling I deliberatively strove to push myself beyond observations into a realm of reflexivity in so far as researcher self- awareness is an important consideration in

ethnographical studies (Reiter, 2017). Reflexivity can be described as a process in qualitative research that is "affected by whether the researcher is part of the researched and shares the participants' experience" (Berger, 2015, p.219). Reflexivity can create space within research methodology to allow researcher reflection on current management paradigms in order to influence adaptive actions (Frechette, Bitzas, Aubry, Kilpatrick, & Lavoie-Tremblay, 2020). I was interested in this aspect of reflexivity in so far as it can connect landscape observations with a message of ecological restoration action.

This position aligns well with the claim that it is through interaction with literature; phenomena, such as the beaver wetland complex; and other people, that learning comes to exist (Blockley & Hems, 2006). The flow of water through the beaver wetland complex inspired how I would share my observations through ecological art and what benefit it might have in the context of communicating an ecological restoration message more broadly. I was inspired to situate this interpretive observation-based knowledge and knowledge gained through literature review within an exhibit of ecological art to facilitate an interesting interface for knowledge exchange, that could potentially transfer to mobilizing climate actions (Wilson, Lavis, Travers, & Rourke, 2010). The thesis ecological art installation uses the kinetic action of the interactive sculptures as a metaphor for communicating the message that "action" in the form of ecological restoration is a prudent and engaging response to the pending climate-change crisis.

Frequent visits to the beaver wetland complex also meant keeping uppermost in mind that a socio ecological watershed is a dynamic and complex system. Whatever we measure as scientists or seek to understand through predictive modelling, for instance, the hydrological, geomorphological, and other ecological systems processes, may be all but hidden to the casual or non-specialist observer. I thought considerably on what role nature might play in creating an emotional connection to the watershed resiliency concept I would be employing ecological art as an interface to communicate. Practically speaking, for example, a number of the farmer-stakeholders I encountered during the case study investigation were quite adamant that beavers and beaver dams are undesirable whereas others, like the previous and present landowner of the site, were convinced of the ecosystem value accrued through allowing a large area of land to naturalize over time. There is a high amount of uncertainty involved in this type of water storage because of the unpredictability of beavers, which can contribute to highly charged conversations about water storage on the landscape. Using novel ecological art to approach this controversial

subject seemed to be a soft approach that might encourage shifts to current water management paradigms.

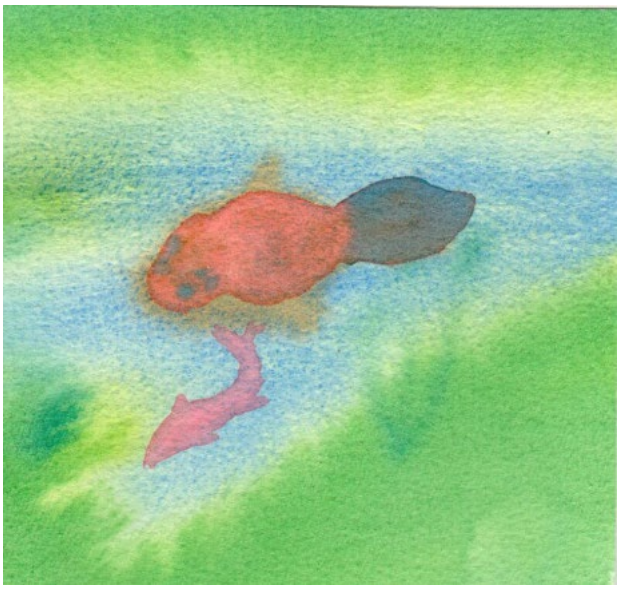

Figure 27. Beaver and Trout watercolour (Mason, A. 2011)

A small watercolour painting I completed, reflecting on the relationships among beaver, fish, and the wetland complex. Dams can act as barriers, especially to non-native species, such as the rainbow trout, introduced by fishing clubs. However, native freshwater fish co-evolved with beaver wetland complexes in much of North America (Larsen, Larsen, & Lane, 2021).

Throughout the years of observation, the beaver wetland complex had many iterations, with the lodge changing position twice, and two years with offspring resulting and two years where the beavers were absent. The beavers were observed using stones and mud underwater to create Dam 1, proving very effective in modifying the capacity for water storage at this site. Extremely hot dry summer conditions, winter flood events, and cold winter temperatures with high amounts of ice cover were some of the stressors this ecosystem faced during the observation period. A great deal of biodiversity was also observed, and although completely qualitative, this suggests a resilient system. The watercolour (*Beaver and Trout*) is one I made during the case study period. *Beaver and Trout* shows an American beaver, one of many I witnessed during my site visits. What we cannot "see" in the painting, and is thus hidden below the surface, are aspects like the millennia that followed the receding glaciers, in what is now Southern Bruce County, where the ecosystem evolved from tundra like plains into climax Great Lakes St. Lawrence forest ecosystems, where beavers acted as a keystone species in socio-ecological

watershed systems into the 1800's (Riley, 2013). These forest and wetland mosaics evolved with and supported the native fish community (Riley, 2013). Even considering something as simple as how animals like beavers use communication reminds us that there is a lot more to socio-ecological systems than just human actions (Hood & Bayley, 2008; Gabrys & Yusof, 2012).

Summary: The Willow Creek Beaver Wetland Complex acted as a 'nature node', a space where my knowledge gained though literature review, and as a restoration practitioner, natural and cultural heritage interpreter and as an artist interfaced with a changing and dynamic ecosystem. The activity of the beavers stored water on the landscape during times of drought and flood and provided lateral aquatic habitat connectivity in this riparian zone, which supported an abundance of wildlife. Seeing these beavers enacting principles found in literature review was incredibly exciting and something that inspired me to share and communicate this watershed resiliency message more broadly. The very fact that I interacted with this ecosystem through observational forays and gathering water samples inspired the interactive nature of my ecological art exhibit described in the preceding section 4.1.

CHAPTER 5 - DISCUSSION

With climate change increasingly disturbing watershed systems and 2 billion people lacking access to safe drinking water (United Nations, 2023), it is of importance that the ecosystem functions and services that support water supply and quality be safeguarded (Gleeson, et al., 2020). Ecological restoration (ER) strategies can be undertaken in watersheds as an approach for slowing, halting, or reversing ecosystem degradation and preserving these water centric ecosystem functions (Simonson, et al., 2021). This is the context within which the thesis has been situated. Long-term warming continues. The IPCC 6th Assessment report estimated that the "Global surface temperature was 1.09 [0.95 to 1.20] °C higher in 2011–2020 than 1850–1900" (IPCC, 2023, p.42). Increases in the intensity and frequency of extreme precipitation events and prolonged droughts are two effects of this warming trend (Masson-Delmotte, et al., 2022) that are impacting most watersheds on Earth. The IPCC 6th assessment report and other studies such as (Steffen, et al., 2018; Ripple, et al., 2019) indicate that the earth System state is on a trajectory towards a global tipping point from which it may be impossible to return. Motivated broadly by the need to find new or improved ways to communicate this urgency, I explored the use of art as a medium for communicating ER messaging to practitioners, disciplinary experts, and the public.

A specific research gap for ecological art being needed as a tool for communicating the importance for resilience in complex watershed systems was identified. There is a known need for water-cycle diagrams that incorporate connections between people and water across spatial and temporal planes within the context of global hydrology (Abbott, et al., 2019). This thesis sought to provide an exhibit of visual and kinetic art objects created and operated by an ecological artist to help meet the need to visually incorporate connections between people and water within the context of changing global hydrology.

Communicating ecological restoration messages using "Diagrams that effectively teach how nested connections influence water availability in specific geographic places" Abbott et al, 2019 p.3052), may help to influence decision makers in a shift towards more resilient watershed systems (Fandel, Breshears, & McMahon, 2018). Ecological art has shown potential to improve communication of knowledge transfer within and between research disciplines, the public, policy makers, and the multitude of professional practitioners (Roosen, Klockner, & Swim, 2017).

The ER solution pathway I chose to have the thesis artworks portray was *restoring connectivity and capacity can increase watershed system resiliency* introduced in section 2.2. The aim of this was to explore the use of ecological art as an interface for communicating a functional restoration message to both lay and expert audiences. This message represents a science-based approach- aimed at increasing socio-ecological watershed system resiliency- as a climate change response (Steffen, 2011; Simonson, et al., 2021).

The machinery of the message these thesis artworks are meant to communicate is the importance and complexity of the interacting hydrological systems that make up the current water balance on Earth – made up of surface fresh and salt water, atmospheric water, groundwater and ice (Gleeson, et al., 2020). It has been suggested that if increasing the capacity for volumetric water storage on the landscape is done at a watershed scale, a cumulative effect of these methods could be preserving this global water balance (Kravcik & Lambert, 2015; Kovac & Kravcik, 2023). This type of watershed restoration work has been developed and linked directly to societal benefits at local scales (Reig, Larson, Vionnet, & Bayart, 2019). The Anthropocene epoch can be envisioned as a dynamic equilibrium for the Earth System state, with the predictable climatic patterns strongly influenced by the Earth system water balance (Jackson, et al., 2015), which is in turn influenced by global temperature ranges and associated atmospheric carbon levels (Pachauri & Meyer, 2014).

Terrestrial and aquatic ecosystems have succeeded and coexisted within this Earth system state during the Holocene and now the Anthropocene epoch, and have acted as carbon sinks, and providers of ecosystem services during these millennia (Wohl, 2013). The water balance of each watershed supports the biodiversity of these carbon sinks, which contribute to both flood and drought mitigation for surrounding social infrastructure (Palmer & Ruhl, 2019). Restoration of water storage capacity and lateral hydrological connectivity can increase watershed system resiliency at a local level and may help support the resilience of the current Earth System state (Kravcik & Lambert, 2015).

Use of art as a medium has ties to on-going interest in how information (or data) is visualized and presented, and what obstacles exist to communicating science (Gabrys & Yusof, 2012; Reinsborough, 2020). In fact, the importance of how ‘experts’ communicate with each other and with the public became more apparent during the COVID-19 global pandemic (Getson, et al., 2022). Overall demand has increased for more effective sharing of science across

disciplines and better transfer of science-based information to the public. This concern was relevant to my enquiry into art as a communication medium. The process of communicating scientific findings is a critical step in the decision-making process leading towards implementing a response to the data (Burns, O'Connor, & Stocklmayer, 2003). There is also more focus on ensuring that attention is paid to the needs of the audience receiving the information. This attention should include "the language, images, and format to choose and the take-home message scientists want everyone to remember" (Goldstein, Murray, Beard et al., 2020, p. 987).

As was shown by a quick search of publications by year using relevant keyword(s) in the University of Waterloo and OMNI libraries (OMNI-18 Ontario University Libraries linked though an academic search tool), the number of articles on communication using art or incorporating art-based research (ABR) into the research methodology has been increasing, since ABR's formal inception in 2012 (Brinkmann, et al., 2019). Based on the purpose of an exploratory study, this seems a positive indicator regarding my research. One aspect of exploratory research is its interest in seeing whether a topic is worth studying further (Creswell & Creswell, 2018). According to Cresswell (2018), when the researcher begins an exploratory study, there are usually very few publications on the topic. As well, the research question may have an element of multi-, trans-, or cross-disciplinarity. Exploratory research is concerned with the potential of a topic to be 'emerging' (Zukauskas, Vveinhardt, & Andriukaitiene, 2018). The increase in publications therefore suggests that my topic was worth studying.

From the literatures I reviewed, it was found that as a medium art has an ability to embody, through form, metaphor, materials, symbolism and methods, complex and even emotionally laden ideas, or concepts (Davies, 2015). The use of ecological Art pieces, as a metaphor for resiliency in watershed systems, has been an attempt to communicate the specific message - restoring connectivity and capacity can increase watershed system resiliency. The ecological art exhibit presents a method of watershed restoration through use of kinetic and artistic symbolism, as a potential solution path for increasing socio-ecological system resiliency, at a local and possibly global water balance scale (Kravcik & Lambert, 2015; Kovac & Kravcik, 2023). The ecoArt exhibit attempted to distill these complex concepts of watershed restoration into a simplistic form that can be tangibly felt and experienced through the medium of interactive sculpture.

The thesis artworks embody concepts from SES theory, tipping points, and the Earth System state, with emphasis on Holling's work. Holling introduced important ideas in the application of ecological system states and what it takes for these systems to transition into alternate stable states (Gunderson & Holling, 2013). The Holling's Loop also includes concepts such as the adaptive management cycle and panarchy. I wanted to address a restoration practitioner's interest in "applied" thinking about management approaches in a watershed and tie them back to the aspects of Holling's adaptive management loops and aspects of SES theory.

Under a socio-ecological systems lens (Partelow, 2018), my research question asked: Can ecological art - interactive, sculpture-based art specifically - be used as an alternate medium to text-based and/or oral methods for communicating ecological restoration (ER) messaging? I consider that the answer is "Yes." The loose feedback I was able to gather from participant-viewers of the artworks, along with the literatures on the role of art in communication, provide tentative support for my answer. As a medium, art may be used to communicate elements of the science of ER for watershed restoration work to diverse audiences. Ecological art appears worth considering as an alternative medium for ER communication. The art-science intersection is an important one. As a 24 February 2021 editorial in *Nature,* titled "Collaborations with artists go beyond communicating," has indicated: "scientists are increasingly seeking out visual artists and designers to help them to communicate their work to new audiences" (Nature, 2021, p. 528).

5.1 Recalling the artworks prepared for the thesis

Recalling the artworks and case study (detailed in Chapter 4), a short meta narrative follows. The message that restored connectivity and capacity can increase watershed resiliency was explored with the Willow Creek Beaver Wetland Complex (WCBWC) case study. The WCBWC case study provided a platform for qualitative observations of increased water storage capacity and lateral connectivity that were restored by beavers over a period of seven years (Dittbrenner, Shilling, Torgersen, & Lawler, 2022). The process of viewing a watershed system through the WCBWC case study, combined with literature review, led to a synthesis of systems and hydrological theories envisioning a watershed as a functional system (Association of State Flood Plain Managers, 2008). This incorporation of the watershed restoration message developed through literature review and field based observations gave rise to Arts Based

Research methods that inspired the exhibit of ecological art, developed to communicate this ER message.

The movement of the water in the Holling's hydrology loops can be felt as the loops are manipulated, and this informs the pattern of movement necessary to keep the water in a state of flow. This interaction is meant to symbolize how humans' effect and are affected by the resiliency of watershed systems at various scales, through our watershed management decisions, daily actions, and interactions with our local and global water resources.

The *WaterShed* houses the interactive ecological art exhibit. The *Handheld Holling's Hydrology Loops* represent local watershed systems, and the suspended *Bioregional Holling's Hydrology Loops* represents the larger watershed systems that are linked through the interaction of evapotranspiration, precipitation, and water storage on the landscape. The *Earth System State Water Balance* sculpture represents how the cumulative action people take at the local watershed level becomes amplified through regional water cycles and at the level of the Global water balance. We can choose to act in a way that maintains the dynamic equilibrium of these cascading water systems or we can act in a way that could tip us out of this Earth System state water balance into one that will be less favorable for humanity (Burtensky, Baichwal, & De Pencier, 2018; Gleeson, et al., 2020; Ripple, et al., 2019; Steffen, et al., 2018).

The pieces were arranged under separate artistic sub-narratives to distill the concepts of the ER message. By breaking down the various aspects of the ER message content into smaller learning chunks, the artmaking offered a scoped and tiered approach for knowledge transfer about watershed resiliency. This approach reflected a style of experiential learning that can assist with knowledge transfer (Lapum & Hume, 2015) utilizing visuals, such as art and sculpture to communicate science information. Moreover, my use of a human-centered and kinetic art form gave opportunity for participant-viewers to tangibly feel, experience, and if not understand, then glimpse the scientific/ER concepts through a process of kinesthetic learning (Foster, 2011).

The artistic symbolism therefore aimed to contextualize connections among healthy functional watershed systems, science-based watershed restoration pathways, and human actions and choices. These connect to the ER message's main point concerning resiliency, thereby preparing for the proposition that if enough watersheds are managed as resilient hydrological systems at a local level, doing so could have a stabilizing effect on the Earth System water

balance, which several studies have indicated is a possibility (Abbott, et al., 2019; Fairfax, 2021; Kravcik & Lambert, 2015; Steffen, 2011).

5.2 Artmaking considerations

Art's long-established position as a medium for conveying ideas, knowledge, and advocacy is seldom questioned (Davies, 2015; Adams, 2002; Van der Sluijs & Peratt, 2009). From my study, I found that for a researcher interested in art-science work or in including ABR in their study methodology, there are many works of other artists (and ecological artists) and scholars that can be helpful. As presented in Chapter 2, I explored ten ecological artworks, viewing the pieces and reading about the artists, their inspirations, and motivations. Furthermore, literature review uncovered some aspects of artworks, objects and performances that support teaching or knowledge transfer (Gabrys & Yusof, 2012).

It is known that artworks can be designed to elicit feelings, perhaps sorrow, fear, grief, alarm, in order to trigger a response or action in audience members (Davies, 2015; Brinkmann, et al., 2019). Moreover, I was aware of ecological anxiety and also the reported psychological tendency that some people have to suppress or reject uncomfortable thinking around climate change (Clayton, Manning, Krygsman, & Speiser, 2017; Kurth & Pihkala, 2022; Aptner, 2013). In response to the barrier eco-anxiety may have to environmental communication, I decided to craft the thesis artworks in a way that offered the chance for evoking a *positive* connection to be associated with watershed restoration.

This is a practice suggested by Gabrys & Yusof (2012). This approach had some influence on my subsequent decisions about art style, materials, and form as well. Although I incorporated imaging or materials that might be alarming, such as use of animal bones, skulls and apocalyptic visuals and narratives in the framing of the research context, within an increasingly unstable Anthropocene epoch,- I chose to use bright colours or and intriguing but neutral imagery and shapes in the main ecological art exhibit. In response to the environmental communication barrier of discipline specific language I tried to create connections between familiar words and discipline-specific words with tongue-in-cheek titles and the use of unconventional materials. Furthermore, the interactive sculptures I created all involve movement, which is meant to allude to functional ecological restoration working in watersheds at different scales, which can support both individual and societal resiliency.

Another implication from this exploratory study is that an art-science researcher may want to deliberatively reflect on who their audience is going to be. As previously mentioned, this is a known communication challenge in many disciplines (Goldberg, Gustafson, Leiserowitz, Van Der Linden, & Rosenthal, 2022). The implication is that the researcher would likely want to be reflecting on audience needs while at same time ensuring the scientific worthiness of the information or results. According to Goldstein, Murray, Beard et al. (2020), "[a]udience needs should drive the choice of both content and delivery method, and tailoring the message is about choosing the best medium to reach the audience" (p. 987). This audience priority is believed to apply whether or not art is an element of the researcher's communication strategy, data generation, or reporting phase. I considered how to balance making the ER message understandable for non-experts while retaining its value or interest for experts. Towards this, I chose to keep the artmaking strongly coupled with the science basis of the ER message that the artworks were crafted to convey.

It may be worth noting that among researchers, the "desire for public understanding of science" can be "grounded in a deficit model of the public;" in other words, a belief that the public lacks scientific understanding (Getson et al. 2022, p. 3). I mention this because it has been recognized as one reason that the public does not always accept ideas, knowledge, or approaches that scientists present (Goldberg et al., 2022). This can be a bias that is not always acknowledged and one that it has been suggested ABR may help smooth. Working as a solo art-science researcher I observed that artists not only process their own emotions but also offer them up to share with others. These considerations can have some influence over how the art is created as well as how it is experienced by the audience.

5.3 Reflecting on the identified communication barriers

The thesis literature review (Chapter 2) identified discipline-specific language and ecological anxiety as two barriers that can impede ER communication. The barrier of discipline specific language is an overall science communication challenge. In the following sub-sections I discuss some implications and possible insights regarding these barriers.

5.3.1 On discipline-specific language

Regarding the on-going barrier of discipline-specific assumptions and ways of doing enquiry, these can require "context knowledge" that not only the public but also research team

members need to share and rely on. Yet not everyone involved may have access to or understand this context knowledge. An unfavourable implication that can extend from this is that, without adequate context knowledge, "researchers in other fields, policymakers, or the general public may not…understand *why* a specific finding is exciting, thereby making it easy for scientific findings or recommendations to be ignored" (Goldstein, Murray, Beard et al. 2020, p.987). The need therefore exists to delve properly into the different knowledges, practices, and priorities that guide disciplinary expertise not only among researchers but also across public communities which also have their own practices, beliefs, and ways of knowing (Moon & Blackman, 2017).

Differing perspectives on climate change were found within various stakeholder groups in the United States, such as agricultural producers and climate scientists during a literature review of political science, psychology, sociology, and communication studies (Egan & Mullin, 2017; Getson, et al., 2022). This mistrust in climate science may be furthered by poor communication approaches (Egan & Mullin, 2017). Components of these communication challenges are:

- terminology that has more than one understood meaning
- concepts of scientific uncertainty; pre-existing stakeholder knowledge
- risk evaluation
- possible mistrust in the messenger delivering the climate change information
- the timescale of climate change (Egan & Mullin, 2017).

Some strategies to combat these communication challenges are to modify the terminology used in presentations to align with the stakeholder group in the audience; undergoing communication training and research as a science communicator; seeking to understand the audience/stakeholders knowledge set; working with trusted messengers that understand the audience's perception of risk associated with climate change; working to frame the concepts of climate change timescale in terms that relate decision-making processes tied to management of stakeholder's resources (Egan & Mullin, 2017). Art as a medium or complementary element to a scientific communication is one approach that researchers can use to make complex science more relatable and valued by lay audiences.

Ecological artists' work often aligns with work to conserve and restore the collective Commons, including both biological and cultural resources (Kagan, 2014). This creative work is

often done across both geographic and temporal scales ranging from local, to bioregional to global and from the immediate to the geological (Kagan, 2014). Ecological artists also focus on the dialectic that is often represented between humanity and the natural world and present works that break down this separation (Kagan, 2014). However, this removal of the dichotomy between nature and the human is not meant as a simplification, but rather an aspect of complexity inherent in current global biological systems (Kagan, 2014). Insights from system theory, ecology and complexity research are the focus of ecological artists such as Helen Mayer and Newton Harrison, Aviva Ramani and Alyce Santoro (Kagan, 2014). Ecological artists are often multidisciplinary practitioners who may design and implement green or blue infrastructure projects that adhere to their aesthetic and theoretical creativity and design and who are actively involved in participatory research (Kagan, 2014). The phenomenological process often used by ecological artists is embedded in sense or place-based practice, knowledge, and observation, and can drive iterative exploration and experimentation that leads to art creation (Kagan, 2014).

5.3.2 On ecological anxiety

A congruence emerged regarding the two barriers I set out to explore within this thesis in that discipline specific language became a barrier in the growing field related to Eco- anxiety. A conflation of terminology such as eco-anxiety, climate anxiety, planetary/environmental dysphoria' environmental grief, environmentally induced distress, ecological grief, solastalgia, eco-angst, eco-anger, eco-depression, and environmental distress has emerged in various literature in recent years (Coffey, Bhullar, Durkin, Islam, & Usher, 2021). This variation in discipline specific language causes confusion and difficulty operationalizing these terms, in what is becoming a growing field of study within psychology and environmental literature. This range of terms also has varied definitions, but they all relate to distress caused by the plight of the environment (Coffey, Bhullar, Durkin, Islam, & Usher, 2021). Eco-anxiety is the most common of these terms, used in media as well as literature, and in a report published by the American Psychological Association it is defined specifically as "a chronic fear of environmental doom" (Clayton, Speiser, & Hill, 2021, p. 71). More research is needed to clarify the linguistic and conceptual understanding of eco-anxiety, from a global, not just western perspective, and one that incorporates an integrated socio-ecological systems approach (Berry, Waite, Dear, Capon, & Murray, 2018)

Additional definitions and descriptors associated with eco-anxiety were gathered in a systematic scoping review of 68 journal articles published in the Journal of Climate Change and Health (Coffey, Bhullar, Durkin, Islam, & Usher, 2021). Two pertinant decriptors are: a perception that the ecological systems that support life are in the process of collapse (Albrecht, 2011) and that this is a direct threat to the existance of human societies (Spratt, 2019). A survey of 16–25-year-olds in 10 countries (N=10 000) showed 75% reported a fear of the future in response to climate change (Hickman, et al., 2021). Climate change will disproportionately affect young people who have limited access to decision making power, and thus become more susceptible to climate anxiety (Hickman, et al., 2021). Non-constructive worry related to climate change is associated with negative emotions or experiences such as: panic attacks; guilt; fear; sleeplessness; frustration; debilitating worry and suicide (Coffey, Bhullar, Durkin, Islam, & Usher, 2021; Berry, Waite, Dear, Capon, & Murray, 2018; Verplanken, Marks, & Dobromir, 2020). However, eco anxiety can be experienced on a spectrum, with constructive worry regarding climate change being linked with motivation for pro-environmental action (Stollberg & Jonas, 2021; Verplanken, Marks, & Dobromir, 2020).

5.4 Reflecting on the thesis strengths and limitations

As with most research, at the completion of the study it can be possible to see limitations (or strengths) that may not have been as evident at the outset.

5.4.1 Art style

Use of ecological art in its many forms can be a good fit as an alternate medium for conveying ecological or environmental messaging since ecological art can be "envisioned as a means to an end: improving our relationship with the natural world" (Ellison & Borden, 2019, p.1). This is a strength of my choice of ecological art. However, an audience's interpretation or interest in an artwork or performance is believed to be highly personal. Irrespective of an artist's intention, therefore, a participant-viewer may engage with and interpret 'meaning' according to the philosophy or worldview they hold and their own lived experience (Larkin, Watts, & Clifton, 2006; Creswell & Creswell, 2018). It is, therefore, almost certain that some people will not like my artworks. For example, some may not like how they look, or not think they are 'serious,' or not accept the pieces as 'sculpture'. Likewise, some participant-viewers may not even agree that

ecological art is a 'legitimate' form of art, period. To this criticism I would respond that I am a 'Rubbish artist', the repurposing of unconventional materials into functional process based ecological artworks is an underlying subtext of my ER message (Boetzkes, 2014). However, any of these above-noted possibilities can be considered a limitation because all would constrain, to varying extent, the medium's potential for communicating the ER message if the artworks are found to be off-putting to viewers.

On the other hand, that I included interactivity, informed by dance, can be considered a strength insofar as thoughtful display of processes broadly supports knowledge translation. Moreover, some literature points to the learning value of kinetic and active engagement approaches (Teixeira-Machado, Arida, & Mari, 2019). One of my aims in designing the artworks was that individual pieces offered participant-users different entry points for engagement. Having art pieces such as the *Hand held HH loops* provided an opportunity for each individual to start interpretation of the ER message from the position most comfortable for them. This is a benefit that art as a medium can provide over text-based or verbal communication.

The various entry points to the artworks were also intended to demonstrate the value art has for making an ER communication both engaging and fun for beginners. Indeed, audience members gravitated towards the unique shapes and general outlandishness of the thesis artworks. The 'strangeness' of the pieces led some participant-viewers to ask me questions and sparked curiosity in others that led to their trying the interactive pieces themselves. Engagement went both ways, with participants offering experiences about their own watershed or making other environmental comments. This type of social exchange corresponds with Ban et al's (2013) remark that watershed systems must be managed to include the human element on the landscape before meaningful restoration can take place. Furthermore, that some participant-viewers indicated that they felt that the concepts expressed were tangible, aligns with findings on the effectiveness of learning about climate change through art (Bentz, 2020).

The interactive and functional aspects incorporated in the artworks presage a constraint. The art style and form (especially the 'functional' element) may have led some participant-viewers to experience these works as technical models rather than as sculpture or art. If so, the implication would be that some of the benefits of art as a medium would have been weakened or removed, thereby reducing its overall value and effectiveness for communicating the ER message. However, ecological art is often non-conventional in form (Kagan, 2014) and

frequently coupled with scientific or practitioner-based functional processes (Roosen, Klockner, & Swim, 2017). Various elements of technical knowledge or perspective were a feature of a number of the ecological artworks that I presented earlier in the thesis (Chapter 2.), for instance: *The Gift of Water* by Jackie Brookner, a functional fountain that operates as a water filtration (p. 47); *Waterlich* by Dan Roosegaarde, a mobile light installation (p. 41); *Escape Velocity V* by Zai Tang, a sound-theatre installation that uses birdsong and animal noises (p.39); and *Rain Project* by Changwoo Ahn, a functional example of an applied wetland treatment (p. 43).

We should be aware that the art form may not have been inclusive or accessible for certain participant-viewers. For instance, given that it is known that there are various styles of learning, some audience members may not have felt comfortable with the interactive artworks or, perhaps, with *any* kind of 'active learning' approach. For these participant-viewers, unfortunately, the art style I chose is a barrier and would be either less effective or not at all effective for communicating the ER message. Another possible limitation arises over the physical skills required to engage some of the pieces. As not everyone has the same physical flexibility, coordination, strength, and or/motor skills, for some participant viewers, engaging the artworks may have been too physically challenging or even impossible. For example, from a physical standpoint the *Earth System state Water Balance* sculpture is unsuitable for people with mobility challenges. It cannot accommodate participant-viewers with a wheelchair, walker, or accompanied by a companion/support person.

5.4.2 Artworks' effectiveness was not evaluated via a social science study

Applying a social science framework would be a useful next step. It was outside of my thesis' scope, but my thesis establishes the actions that can facilitate investigation into the measurement or evaluation of the effectiveness of the artworks at conveying the embedded ER message. My scope and focus was to produce art and solicit audience responses – my framework is doing ecological art rather than claiming to do a formal social or qualitative study. To that end, I was successful at getting facilities to show various pieces of the ecological artworks ten times and gathered informal comments from audience members. The caveat is that, for example, when I showed selected pieces of the exhibit at University of Waterloo's Institute for Complexity and Innovation workshops and seminars, the audience was self-selecting. They also likely shared the 'context(ual) knowledge' I referred to previously; if absent, that usually impedes science

communication to non-discipline-specific public. I gathered some feedback when I showed select pieces at the Bruce County Museum & Cultural Centre, at the Artists on the River art show, and during the University of Waterloo GradFlix competition. In those settings, that the remarks were positive and that the art itself sometimes sparked content-conversation lend anecdotal evidence that the ER message was communicated at least to some extent. Likewise, it is encouraging that the YouTube channel I host, displaying the Ecological art created during this thesis, continues to gain views.

5.4.3 Impact of COVID-19 on live showings of the artworks

The COVID-19 pandemic shutdowns delayed any exhibitions of the work in three-dimensions until the spring of 2023. Videography, still photography, and written descriptions of the pieces were developed to stand in for the actual artworks, which greatly affected the experiential aspects of engagement. Likewise, from a design perspective, the size of the interactive exhibit made it very demanding to set up and transport. For this reason, the more permanent *WaterShed* installation was created to digitize the thesis artworks and to reduce the transport and display aspects of the exhibit, except for the Handheld Holling's Hydrology Loops, which are easily transportable. A modified display was created utilizing a chin-up bar as a fulcrum and metal poles to suspend the *Bioregional Holling's Hydrology Loops* to display the ecological art exhibit at the Math for Complex Climate Change Challenges workshops with the Waterloo Institute for Complexity and Innovation, Fields Institute and Perimeter Institute.

5.4.4 Ability of ER message to capture participant-viewer interest

It is also useful to acknowledge that the ER message chosen as the theme of the thesis artworks, irrespective of its scientific foundation and socio-ecological systems framing, may not catch the interest of some participant-viewers. This could be a reflection that the knowledge elements I focused on as key components of the ER message were not the 'right' ones for some people. If so, engaged learning, or active learning, whether in an art form or in text-form would not be likely to have good uptake. However, according to Reinsborough (2020), it is known that "(d)ifferent aspects of (art-science) collaboration or its outcomes may be seen as useful to different parties" (p. 9).

5.5 Future work

5.5.1 Pedagogical Potential in the kinetic aspect of thesis artworks

Visual and performing arts aim to foster "embodied ways of knowing" that help synthesize complex ideas in a manner both interesting and helpful for knowledge transfer (Smyrnaiou, Sotiriou, Eleni, & Papadopoulou, 2016). In using dance as one design factor of the thesis artmaking, the human 'body' becomes itself a place of inquiry and understanding (Bagley & Cancienne, 2002) for the ER content that the participant-viewers were exploring. This aspect of choreography interweaves use of recurring themes with performative skill-based movement (Csikszentmihalyi, Abuhamdeh, & Nakamura, 2014). The ecological restoration message is portrayed in a kinesthetic, functional, and physical manner that has been linked to a sense of accomplishment, tangential or parallel, in the learning (Pentassuglia, 2017) that Csikszentmihalyi (1990) has called "flow." For these reasons, I arrived at a proposition that would be relevant to learning and how art as a medium can assist in knowledge transfer. The question is, might engaging with the *Water Balance* kinetic sculpture and *Handheld Hollings Hydrology Loops* bolster a participant-viewer's learning of the embedded ecological restoration message by inducing a so-called flow experience?

The thinking behind this proposition was sparked when I came across several studies during the literature review that suggested that performative tasking can give an added boost to information acquisition (Vitters & Csikszentmihalyi, 2000). As well, in another study by Kontra, Lyons, Fische & Beilock (2015), the process of kinetic learning was shown to increase learning of scientific concepts when sensorimotor regions of the brain are linked with reasoning. Csikszentmihalyi's (1990) "flow model" relates to the mental state of a person executing a task that requires using a challenging skill set. In their chapter on "Flow and the Foundations of Positive Psychology," Csikszentmihalyi, Abuhamdeh & Nakamura (2014) offered compelling evidence that activities that have a high challenge-skill ratio have association with a heightened level of happiness and satisfaction (pp 227–238). They based their accounting on 30 years of interview data collection from experts in many fields and disciplines. Therefore, regarding my artworks, an area to investigate could be what impact the feeling of satisfaction has on uptake of the ER communication? To carry out such an enquiry would require first demonstrating that engaging the *Handheld Holling's Hydrology Loops* and *Earth System State Water Balance* does challenge a participant-viewer at both mental and physical levels; and second, establishing

whether any ‘reward’ feeling of satisfaction is subsequently occurring that assists knowledge uptake.

The movement required to interact with some of the thesis art pieces also symbolized the physicality that watershed restoration requires and also that restoration practices *are* actions. This was a nod to my own engagement in ER fieldwork. In terms of the challenging physical labour required for planting trees and installing stakes and piezometers, for example, can leave one with a feeling of well-being, which is an allegory the kinetic artwork sought to provoke.

Whatever feelings the participant-viewers may have associated with the thesis artworks, the artworks provided an example of use of art as a medium for communicating an ER message: that increasing connectivity and capacity can increase watershed system resilience. The interactive and functional ecological art was meant as a metaphor for transforming watershed systems towards resilience (Yu, et al., 2020). The physical connection of the artist or participant-viewers to the ecological artworks was meant to symbolize that human behaviour now affects the functioning of almost every watershed on earth (Abbott, et al., 2019). The extrapolation from engaging the artworks would be that we can benefit ourselves and the earth through taking part in ER or other environmental actions. This is true whether the actions are immediate (e.g., connection with community members involved in environmental work) or more long-term societal goals. If people made informed decisions to act in a restorative way towards local watershed systems, by increasing connectivity and capacity, we may be able to influence hydrological feedback loops and prevent tipping the Earth System state water balance into an unfavourable regime (Gleeson, et al., 2020).

5.5.2 A study to evaluate the effectiveness of the thesis artworks

As noted earlier in the chapter, an evaluation to investigate the ecological artworks’ effectiveness in conveying the chosen message was not carried out. As I have not undertaken to apply to a PhD program, I do not envision having the appropriate opportunity during which to conduct such a study. However, should another researcher wish to, I would suggest that a first step may be to determine through a literature review what methods and measures are available for assigning participant stakeholders to initial ‘knowledge’ categories in order to establish a knowledge baseline. Then, participant knowledge could be pre-surveyed and, following engagement with the artworks, post surveyed. Methods for survey and collecting these data

might include 1:1 structured interview and self-reporting surveys. A social study of this nature would need to be done in accordance with the relevant University's ethics practices and principles. Appropriate and reliable (i) self-reporting survey tools and (ii) ranking matrices with coding of responses could be prepared to analyze the knowledge uptake of participants (Groenland, 2014). Two presentations could be made to participant-viewers, wherein employing the artworks are conceived as an 'intervention.' Under such a research design, participants could be grouped according to their baseline level of expertise, for instance, and thereafter each group could be divided in half, with one half receiving the 'intervention' in the form of the artworks and the other half receiving a text or data centric presentation. The 'effect' in terms of knowledge uptake could be evaluated within groups and perhaps across groups. The qualitative research strategy adopted could be as simple or as complicated as the research scope and time permitted.

5.5.3 Additional ideas for future research

The trends in the literatures discussed in the thesis give rise to the following additional possibilities for future studies:

***Art communication in ER / ecology / environment*:** Besides the ecological artists mentioned in this thesis, there are many other ecological artists and performers whose art practice, products, and performances consider climate change: climate response research, reactions, advocacy, and narratives. It seems worthwhile to conduct a deep, systematic review aimed at collecting the studies that have used art to communicate restoration, ecological, environmental, or climate science—and all the artists who work or have worked at this intersection. A significant contribution would certainly be to create a catalogue of these artists and their efforts. A pictorial accounting would have strong knowledge dissemination value. It would also give a boost to the many artists who are working to address climate change through their art making. If the scope needed to be narrowed, the search criteria and keywords could be tweaked to include selected genres only (e.g., ecological art, land-based art); specific art forms only (e.g., painting, sculpture, dance, music); artists-by-setting (e.g., full-time professional artists only, artists who work in academic settings only); specified time periods, or whether or not the artist is indigenous.

***Art-based research in ER / ecology / environment*:** The same systematic review approach suggested above for *Art communication in ER / ecology / environment* could be applied

to gather all the discipline-relevant studies that have used ABR in their methodology. With escalating demand for data visualizations and use of performance, artworks, and artist-scientist collaborations to enhance science communication and engagement, such a study could have value for multiple researchers. Moreover, such a review could also step into a meta-analysis to learn more about which researchers are using ABR for what types of ER, environmental or related scientific enquiries.

***Exploring dimensions of ecological anxiety*:** The research area of ecological anxiety, discussed earlier in this chapter (section 5.3.2), offers multiple research opportunities. Some of the findings I presented in the thesis could provide useful foundation knowledge, suggestions as to directions for possible research questions, and a good starting place in terms of references. The notion that ecological anxiety is a growing concern for younger people who will be increasingly exposed to the effects of climate change, make this an increasingly important topic concerning environmental education. (Coffey, Bhullar, Durkin, Islam, & Usher, 2021).

***ER science and watershed management*:** The ER message I developed for the thesis artworks to portray is a scientifically valid approach for watershed resiliency that emphasizes river connectivity, water storage capacity, flow processes, and the functions of riparian zones for sustainability of the ecosystems and the services they supply. Since rivers and their riparian zones typically intersect with human settlement / land use, advancing our understanding of how hydrological connectivity varies with changing climate conditions would help with better management of floodplains and the essential ecological services they provide. Using ABR methods I explored lateral hydrological connectivity and increased water storage capacity in the Willow Creek Beaver Wetland Complex Case Study (Chapter 4).

Interest continues in quantifying hydrological connectivity on the landscape in relation to water quality and quantity and the importance of understanding how ecosystem services influence these processes. Moreover, in a meta-analysis of all published papers on hydrological connectivity, 1980 to 2020, Zhang et al. (2021) reported very few studies before 2003 and an increase in the years since. They argue, however, that with the high variation in climate, a gap remains: “In particular, hydrological connectivity linked to social-economical-ecological-hydrological frameworks involving coordinated trans-, multi-, inter-, and separate disciplinarity is required” (Zhang, Huang, Zhang, Jinhong, & Wang, 2021 p. 5239).

***ER of profoundly degraded complex social ecological systems*:** The research reported in this thesis focuses on the use of art to communicate some key aspects of complex social ecological systems function and implications (especially concerning connectivity, system capacity and resilience). The thesis also considers their application to an ecological restoration case study on the Willow Creek Beaver Wetland Complex, that centres on rehabilitating and strengthening the resilience of an essentially desirable social ecological system. Future research could consider application in different contexts, which would entail attention to somewhat different aspects of complex social ecological systems behaviour and implications, including somewhat different implications for communication through art.

For example, application to profoundly degraded complex social ecological systems would entail more attention to the dynamics and objectives for transformation to more desirable and viable system structures, functions, capacities, and future characteristics. During the restoration planning process questions should be asked such as: who should identify these desirable characteristics and do they align with the concepts of a just transition; have multi-scale influences been considered; does the restoration design include flexibility for adaptive management considerations; have threshold uncertainty risks and opportunities been considered? The ten principles developed by Society for Ecological Restoration in partnership with FAO, IUCN and CEM to guide the United Nations decade of Ecological Restoration should be applied to the restoration planning of complex and degraded ecosystems. These ten principles are: Global Contribution; Broad Engagement; Many Types of Activities; Benefits to Nature and People; Addresses Causes of Degradation; Knowledge Integration; Measurable Goals; Local and Land/Seascape Contexts; Monitoring and Management; and Policy Integration." (FAO, IUCN CEM & SER, 2021, p. 4)

5.6 Conclusion

This exploratory thesis took a qualitative approach to investigate what art (ecological, interactive, sculpture-based art in particular) can do as a medium that provides an alternative to text-based and/or oral methods for communicating ecological restoration (ER) messaging. To meet the three research objectives that framed the study, I adopted an art-based research methodology (ABR) informed by elements of interpretive phenomenology and auto-ethnography.

First, under OBJ 1- *Evolving an ecological restoration* (ER) *watershed system resiliency message*, I developed a focused ER message for the artworks to portray: *restoring connectivity and capacity can increase watershed system resiliency*. This message reflects socio-ecological systems framing and literature review showed support for this message and further maintained that restoring the potential for water storage capacity on the landscape and lateral hydrological connectivity could increase watershed system resiliency and even influence precipitation patterns in small water cycles (Resilience Alliance and Santa Fe Institute, 2018; Hendriks, E., 2020; Johnson, Shepard, & Verdone, 2019). The emerging discipline of socio-hydrology endeavors to link water management regimes with both the small and large water cycles that make up the global water balance (Gleeson, et al., 2020) and further proposes that changing our water management regimes towards restoration could help to mitigate aspects of the Climate crisis (Abbott, et al., 2019).

These implications are embedded in the ecological art exhibit. For OBJ 2- *Grounding the art-science-communication intersectionality*, I researched how art has been used for communicating climate change and ecology narratives, and explored what ecological artists have been doing with their art. The findings (Chapter 2) were then used to guide the thesis art making for OBJ 3–Using purpose-crafted ecological art to communicate a watershed resiliency message. The resulting *WatersShed* installation, with its five themed pieces, carried the meta-narrative for increasing water storage on the landscape as one ER-based pathway for enhancing resiliency in watershed systems.

The sub-narratives of the artworks sought to link, within and across the pieces, water storage capacity, lateral hydrological connectivity, and watershed system resiliency concepts at scale. My study did not include any measurement or formal evaluation as to the 'effectiveness' of using art as a medium to communicate ER messaging. However, informal feedback received during showings of the art pieces aligned with indications from the literatures on the usefulness and promise of art as a communication medium. My study has helped put people back into visual and experiential hydrological conceptualizations of anthropogenic climate change discourses, a need identified at the outset of my exploration. Demand for improved visual (and tactile) depictions of 'science' is surging. I suggest that my thesis enquiry has demonstrated the potential of art as an alternate (or companion) medium for communicating ER concepts and the attendant need for watershed restoration work to diverse expert and non-expert audiences.

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APPENDICES

Appendix 1. Correspondence regarding permissions and use of materials

Dear Adrienne,

Thank you for contacting Studio Roosegaarde.

All the content we provide may be shared publicly if the content is credited with Daan Roosegaarde or Studio Roosegaarde.

Hereby a link to our pressroom, where you can download all our high-res photos and videos: https://pressroom.studioroosegaarde.net/.

Thank you again for mentioning one of our projects, we are honored to be a part of your masters thesis on Art as an Interface for Watershed Resiliency . Have a wonderful day, and good luck!

Kind regards,

Annabella Rijksen

Team Public Relations at Studio Roosegaarde

Hi Adrienne,

Apologies for the slow reply, I've just returned to work after a break.

Yes, you have my permission to use a documentation image of my work in your thesis. Are any of the ones on my website suitable?

Please credit as such:

Zai Tang

Escape Velocity V 2021

Installation view, Image courtesy of Singapore Art Museum

All the best!

Zai

Yes, Adrienne, of course you may use the image. Keep the environmental work going. We need you now more than ever. All of Jackie's archives have been gifted by me to the Nevada Museum of Art and Environment in Reno, Nevada. They have all of her writings, drawings, models, photography, letters, catalogs, etc.

My very best to you,

Terry Iacuzzo

Dear Adrienne

Good to hear from you and to learn that your work is progressing.

I am happy that you find one of my diagram useful.

Please use it, and please send me a PDF of your Master's Thesis when it is done, so that I can learn from what you have uncovered over the past few years.

good luck,

Jan Sendzimir

Hi Adrienne,

Great to hear about the topic of your thesis! (please make sure to send me a copy, PDF when available). You are more than welcome to use the images of the Rain Project as long as you source them (you can list my website and publications related to it). I look forward to hearing more about your work. Please say hi to Stephen!

Cheers,

Dr. Ahn

Changwoo Ahn, Ph.D. (he, him, his)

Professor, Environmental Science and Policy, GMU (http://www.changwooahn.com)

Graduate Program Director, ESP

Founding Director for EcoScience + Art & SAC (Science, Art, and Culture)@GMU

Affiliated Faculty of Biology, Civil, Environmental, and Infrastructure Engineering, Food Studies, The MicroBiome Analysis Center, and School of Art

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Hi Adrienne

Thank you for asking, but I don't have any claim on the intellectual property of Buzz's adaptive cycle. In fact, I really encourage your use and artistic interpretation of his adaptive cycle.

With all good wishes for your work,

Regards,

Lance (Gunderson)

Appendix 2 Video Files attached separately as MP4

2.1 Holling's Hydrology Loop (as shown on p. 75)

2.2 Watershed as a Functional System (as shown on p. 78)

2.3 Bioregional Holling's Hydrology Loop (as shown on p. 80)

2.4 Water Balance and HHHH (as shown on p. 85)

2.5 Art as an Interface for Watershed System Resiliency (as shown on p. 89)

2.6 Lateral Hydrological Connectivity in a Floodplain (as shown on p. 92)