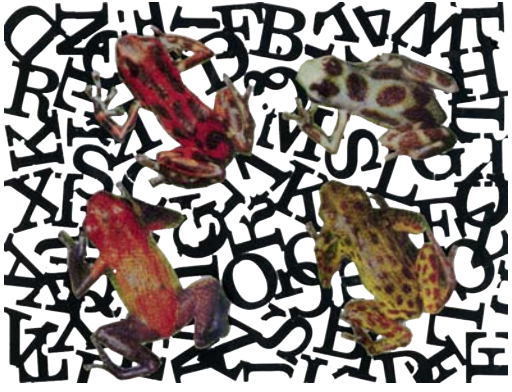
CONSEQUENTIAL LANDSCAPES

a design response to anthropogenic climate change



Matthew J Derksen

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A Practicum submitted to the Faculty of Graduate Studies of the University of Manitoba
in partial fulfillment of the requirements of the degree

Master of Landscape Architecture

Department of Landscape Architecture
Faculty of Architecture, University of Manitoba

Abstract

The relationship between humans and the rest of the natural world has become discordant. Many of the harmful effects of this relationship, such as unsustainable forestry practices and oil spills, are easily visible. Conversely, much of the harm, such as the effects of climate change, is subtle and difficult to perceive.

Landscape architecture, as a discipline and practice, is well-suited to lead a shift toward a healthier relationship between human and non-human nature. This practicum seeks to make various climate change-related phenomena within Manitoba landscapes visible. Conceived as tourist destinations, three distinct landscapes likely to undergo dramatic climate change-induced alterations are identified. For each site an intervention is proposed highlighting these changes. Thus, a global phenomenon is made visible at a local scale.

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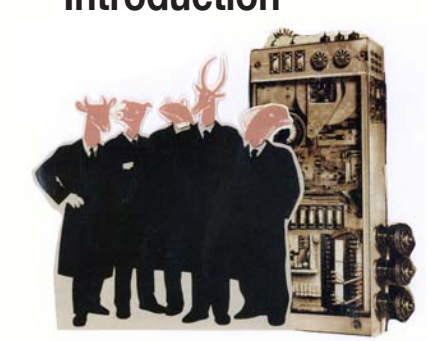
Introduction



In the written statement included in my application to the Landscape Architecture Pre-Masters program I wrote that I wanted to use creative means to contribute positively to the environment. This was the focus of the statement because, at the time, that was what I thought landscape architecture was about and I believed in the value of such a goal. Although I have since learned that there is much more to landscape architecture, I still think its highest potential remains in the arena of improving the health of people and the environment.

There is a potentially catastrophic environmental crisis looming that prompts the question: can landscape architects and corresponding educational institutions do more to combat human-generated climate change? Despite decades of increasing public awareness on environmental issues, large-scale degradation continues and meaningful action against climate change remains elusive. Although the practice of landscape architecture has, at times, acted in accordance with social and environmental causes, current environmental trends require a stronger voice and more committed practise from landscape architects.

One often hears about the need for a global shift in attitudes and understanding about our environment. Such a cultural shift is a slow process that will require contributions from many sectors of society, and the discipline of landscape architecture is uniquely positioned to take a leading and significant role. This practicum's designs place climate change in the limelight. They attempt to make the impacts of climate change visible by revealing various phenomena taking place in Manitoba's landscapes and providing experiences that prompt questions regarding the nature of people's relationship with the rest of the natural world.

ENVIRONMENT

Landscape architecture with a cause

HURRY

Historically, designed landscapes have served many functions, from expressing monarchal control to providing places of contemplation. In North America, landscape architecture has a strong history of promoting social ideals; from the University of Virginia where Jefferson sought to lay the groundwork for an egalitarian environment, to Olmsted's landscapes which responded to health and social issues arising from rapid urban industrialization and population growth. As environmental issues entered mainstream consciousness in the 1960s, Ian McHarg and others were instrumental in linking landscape architecture to environmentalism, the social movement broadly defined as being concerned with the health of the environment. Landscape architecture's ties to social causes, however, do not define the discipline but rather are a special interest of some landscape architects.

Despite McHarg's efforts to focus landscape architecture on ecology, many landscape architects remained unconvinced, maintaining that designing ecologically sound landscapes is the business of ecology and science, not of artistic endeavours (Howett, 1987; Meyer, 2000). In the 1970s, however, some landscape architects, influenced by phenomenological artists like Robert Irwin, Robert Smithson and Mary Miss, sought to bridge the gap between ecology and design. Meyer suggests that the influences of art and science on landscape architects such as Anne Whiston Spirn, Michael Van Valkenburgh and Lawrence Halprin, vitally contributed to the integration of environmentalism

into landscape design. Meyer characterizes these designers as designers who "*...created designed landscapes that operated as focusing lenses for knowing the natural world, that instigated aesthetic experiences that reduced barriers between humans and the natural world, and that functioned as physical catalysts for changing social rituals affecting the natural world*" (p.191). Responding the to the social concerns of their time, these landscape architects strived to keep Olmsted's vision of landscapes that benefit social needs alive by focusing their work on the growing awareness of environmental degradation.

However laudable these design intentions sound, attempts to attain these goals seem to remain the proclivity of a minority of landscape architects. Howett (1987) suggests that landscape architecture's *"...historic isolation, since Olmsted, from the central philosophical, ideological, literary, and artistic debates of our own time must finally be overcome if a new generation of landscape architects is to be capable of imagining and creating the landscape forms that would similarly express the highest values and aspirations of American culture on the eve of the third millennium*" (p. 5). This statement not only implies that consensus among landscape architects regarding these central ideas is needed, but that the discipline ought to aspire to the highest value of its society's ideals. Although to say that survival of a society ranks high within our societies' ideals sounds so obvious as to be condescending, many of our society's institutions do not behave accordingly. More particularly, if landscape architects are to aspire to the highest value of our ideals, a clearly stated goal of mitigating climate change would reflect a desire to work toward a globally relevant ideal.

Accordingly, Howett (1987) cites ecology as a source for new landscape styles, promoting a natural as opposed to picturesque aesthetic. These landscapes reflect environmental values and function more like natural landscapes. It should be noted that Howett also emphasizes the role of aesthetics in ecological landscapes, seeking "...*an expansion, not a diminishment of sensibility… The domain of aesthetics must come to be seen as coextensive with the ecosphere, rather than narrowed to its traditional applications in art criticism, so that aesthetic values may no longer be isolated from ecological ones*" (p. 6). Environmental values within landscape architecture often seem to exist only as a vague association with the discipline and are ill-defined without critical examination or commitment.

Landscape architecture and environmentalism

Although environmental concerns have existed throughout most of human history in one form or another, the publication of Rachel Carson's book Silent Spring in 1962 has been identified as the beginning of Modern environmentalism (de Steiguer,1997). A variety of academic disciplines produced a body of environmental literature in the following decade that shared one common goal: to reform human attitudes and behaviour toward the environment. Within this common goal, however, were numerous disparate views on the causes and solutions to the myriad of environmental problems.

Attempts to coalesce these different views resulted in two broad philosophies: ecocentrism and anthropocentrism. Briefly, ecocentrist thought espouses that every living entity has an equal right to exist, assigning people the same inherent value as any organism. Conversely, anthropocentric thought identifies humans as central actors on the planet. Although these categories are themselves a significant division within environmental groups, they are overly simplistic and viewpoints can easily permeate these boundaries. There are also differences between environmental groups on how they try to advance their causes. Whereas mainstream groups operate within legislative and electoral spheres, alternative groups generally opt to stage protests to inform and gain support for their causes (Kline, 2007). These types of differences result in mixed and potentially conflicting messages, causing additional challenges for environmental groups to garner public support and advance their agendas. Unfortunately, landscape architecture seems to have inherited this unsettled state.

Evidence for diverse philosophical perspectives can be found within some of the literature produced by landscape architecture organizations. Nadenick and Hastings (1999) found that the language pertaining to environmental issues within the American Society of Landscape

Architects (ASLA) “Code and Guidelines for Professional Conduct” is derived from a collection of different environmental philosophies, many of which position people differently within the natural order of the world. The Manitoba Association of Landscape Architects’ (MALA) Code of Conduct sounds uncommitted to the environment, simply asking its members to “understand” and “be mindful of” their environmental responsibilities. More committed and consistent language pertaining to environmental responsibilities within codes of conduct and ethics may help advance landscape architecture’s environmental efforts.

Codes of professional conduct and ethics that guide the work of landscape architects may better serve environmentally responsible aspects of its members’ works by acknowledging, and exploring the implications of, the pervasive anthropocentric position within society and the profession. Additionally, these texts could express the importance of communicating environmental goals to clients, promote such communication and encourage collaboration and consultation with other professionals such as ecologists and foresters. Consensus on these matters among provincial associations may prioritize environmental responsibilities and encourage regular updating and discussion of environmental goals and standards. In their current form, however, these texts indicate that the practice of landscape architecture in its everyday manifestation is unclear on what its role is concerning the environment. It should be possible for landscape architecture associations to advance and coalesce environmental efforts.

PEOPLE

Human and non-human nature relationship

"With every breath you take you participate in a dynamic exchange of global metabolism."
(Thomashow, 2002).

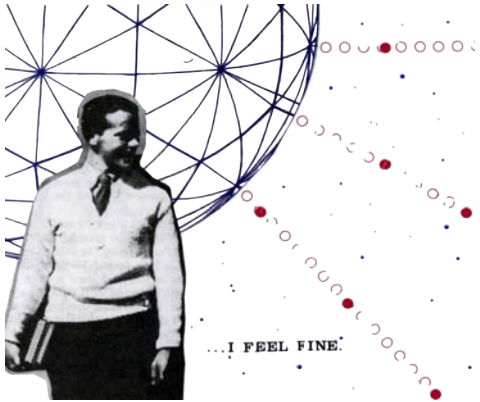
Landscape architects often express a desire to connect or re-connect people and nature through design. Nadenicek and Hastings (2000) cite "*creating harmony between humans and nature*", "*providing unity in nature*," and "*healing the environment*" as examples of the character of phrases frequently used in landscape projects' expressed design intentions. What these phrases actually mean, however, can be unclear. Does reducing conflicts between people and animals by reducing contact between them create harmony? Are we unified if a flooding river is forced off its' natural course? Do we include ourselves when we seek to heal the environment? What does it mean to connect with nature?

Connecting with nature likely means different things for different people. It may be a passive experience, the by-product of an activity such as fishing or walking in a park. It may result from purposeful effort, such as learning to recognize and name local flora or taking a zoology course. Connecting with nature may occur subconsciously, having no recognizable impact on one's life, or it may be part of a lifelong

endeavour for spiritual fulfillment. Emerging oneself within the natural world may indeed foster a feeling of oneness with nature to varying degrees, but these experiences are not necessarily readily available for many, nor are they likely sufficient in scope to mend the rift between culture and nature.

If we are to understand global environmental change, it is crucial that these experiences trigger further thought about connections between local ecology and larger ecosystems and ultimately the global biosphere (Thomashow, 2002). For landscape architects to convey these connections we must attempt to understand how we have arrived at our current state of disconnect with nature and how this relationship impacts our well-being and the state of the environment. If part of the solution to the global environmental crisis is re-connecting with nature, then these local-to-global connections must be made. As part of this expansion of knowledge, a larger understanding of ourselves and our place within the larger ecological story is imperative to re-connecting.

Environ(mental) health



Two hypotheses that conceive of humans as a piece within, as opposed to distinct from, the rest of the natural world are Biophilia (Wilson, 1983) and Gaia (Lovelock, 1987). Biophilia suggests that we have an "*innate tendency to focus on life and lifelike processes*."; a trait that represents an evolutionary advantage. Just as our ability to walk upright bestowed us with survival advantages, our attraction toward nature has survival advantages. The Gaia hypothesis conceives of the Earth as having evolved and functioning as a single entity, with all forms of life as components of a homeostatic system. These hypotheses place humans within a system; unique in abilities but not in value. Both hypotheses express a relationship between humans and nature so fundamental to our existence that removing ourselves from this environment might result in a disruption of life sustaining equilibrium. Indeed, this disruption is made evident in a growing body of literature demonstrating that not only do people have a preference for landscapes representative of our evolutionary surroundings, but that our health is directly related to aspects of nature (see Frumkin, 2001; Maller et al., 2009 for review).

Kaplan (1992; see also Kaplan and Kaplan, 1989) found that people prefer images of nature scenes over scenes of buildings, as the Biophilia hypothesis would lead one to expect. Biophilia would also lead us to predict that we would have a preference for the type of environment that Homo sapiens evolved in as suggested in the savanna hypothesis (Orians 1986). Indeed this preference has been

demonstrated across cultures and geographical regions (Balling & Falk, 1982; Ulrich, 1977), suggesting that this preference is innate as opposed to a product of culture. Natural landscapes also seem to have a restorative or calming effect on people (Frumkin, 2003). In addition to subjective indicators of nature preference, a number of studies indicate our physiology responds favourably as well. Stress indicators are decreased when viewing nature scenes (Ulrich et al., 1991), views of nature are correlated with fewer reported ailments for people with a nature view (Moore, 1981) and improved recovery from surgery (Ulrich, 1984). Encounters with animals, through pet ownership (Katcher & Wilkins, 1993) or through a variety of animal-assisted therapies (Fine, 2006) can positively impact our mental and physical well-being. These observed health benefits also suggest that we are not only able but pre-disposed to connect with nature.

Although it may be easy to think of these beneficial effects of nature as individual remedies, like taking an Aspirin, it may be more appropriate to see them as setting the stage for a return to a normal condition. This idea is reflected by Wilson (1983) who states "*I will make the case that to explore and affiliate with life is a deep and complicated process in mental development. To an extent still undervalued in philosophy and religion, our existence depends on this propensity, our spirit is woven from it, hope rises on its currents*" (p. 2). The language Wilson uses resonates with ecocentrism, but one can infer the same story from scientific evidence. The health benefit studies may be merely

illustrating how our well-being is currently diminished due to our dysfunctional relationship with nature. A similar inference can be made from a line of research in behavioural neuroscience.

A branch of neuroscience examines the brain's ability to alter its function and the biology that underlies behaviour. Early studies that inspired this line of research looked at the differences between rats that lived in complex environments that contained opportunities for a range of environmental stimulation, and rats that were housed in standard laboratory cages, which are comparatively limited in physical and mental stimulation. These studies demonstrated, and continue to demonstrate, that the mammalian brain changes in response to environmental stimulation in many ways, including changes in glial brain cells (Jones & Greenough, 1996), cell metabolism (McCloskey, Adamo, & Anderson, 2001), vasculature (Kleim, Cooper, & Vanden- Berg, 2002), neuron and synapse morphology (Faherty, Kerley, & Smeyne, 2003; Federmeier, Kleim, & Greenough, 2002) and number (Kleim, Lussnig, Schwarz, Comery, & Greenough, 1996). These elements are thought to form and support the neurobiological substrate of learning and memory. There is overwhelming support for the notion that environmental stimulation (tactile, visual, auditory, proprioceptive) has profound effects on everything from observable motor behaviours to protein synthesis that support changes in cells responsible for the altered behaviours (Derksen et al.., 2006).

The laboratory cages housing the animals impose an impoverished environment that does not resemble the natural conditions a rat would typically inhabit. Therefore, whereas the control groups never experience an environment that they normally would during development, the experimental groups of rats do. The experimental manipulation is attempting to isolate one or more variables that represent a facet of

"We may expect, as a matter of fact, that science will furnish the objective proofs of suppositions about man's needs for a living environment which we, at present, can only guess at through timid intuition; that one of these days we shall find the intricate neurological bases of why a leaf or a lovely flower affects us so very differently than a broken beer bottle."
(litis, 1973, p. 7)

normal development. Therefore, the observed effects in the experimental groups may reflect a normal condition, while the lack of effect shows the effect of impoverishment. This effect of impoverishment is conceivably analogous to what urban life is like for people compared with a hunter-gatherer existence. Although cities are certainly stimulating, their qualities are very different from those of the natural world.

We started to fundamentally change our relationship with nature with the agricultural revolution. As we civilized, we shifted away from the stimulation required for normal development, what Paul Sheppard (1982) refers to as "ontogenetic crippling". Although this shift may seem to have been gradual, in the context of human history it happened remarkably quickly - far too quickly for our biological selves to adapt. It stands to reason that such a dramatic change in environment will have dramatic effects on us. The previously discussed health benefits that nature can have may seem minor or simply novel, but there is the possibility that our departure from nature has had a deeper negative affect on our psyche.

"In a physical environment that contains very few of the visual, auditory, tactile olfactory stimulation that we evolved in, coupled with our newly acquired sense of self-awareness, the conditions for an evolutionarily familiar upbringing are all but eliminated."
(Roszak, 1992)

Louv (2005) uses the term Nature Deficit Disorder (NDD) to describe a range of symptoms like the recent increase in childhood obesity, attention disorders and depression. Louv hypothesizes that NDD results from the lack of experiences and unstructured play that occurs naturally when children spend time outdoors. This is a relatively recent phenomenon; Louv cites differences between his childhood and those of his children. NDD and the health benefits studies mentioned earlier are maladaptive responses to conditions characteristic of recent urban development. It is easy to imagine, however, that the radical differences between our current and evolutionary environments would have a general and systemic impact. This type of impact has been characterized as a profound psychological effect present in much of the human population.

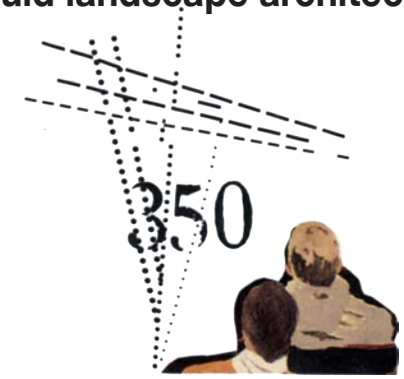
We continue to move to cities, with precious few opportunities to experience an environment similar to our unconscious home, isolating ourselves into a state of wrong-mindedness. Itlis (1983) asks "*Could it be that the stimuli of non-human living diversity makes the difference between sanity and madness?*" (Iltis, 1980, as cited in Kelert, 1993, p. 65). This statement may sound extreme, but our hesitation to prevent the catastrophic consequences of climate change predicted by climate scientists is commensurate with the severity of the diagnosis.

Roszak (1992) suggests that "*While many criteria might be nominated, there is surely one that ranks above all others: the species that destroys its' own habitat in pursuit of false values, in willful ignorance of what it does, is "mad" if the word means anything*" (p. 68). This statement highlights the bizarre nature of what we are doing to the earth, largely the result of acquiring products that translate into massive profits for a tiny percentage of the world's population. Large companies spend billions of dollars and use psychologically sophisticated means to convince us that we need to own a lot of stuff; bigger and better TVs, more prestigious cars, the latest fashions and ipods that are obsolete the moment they are taken out the package. The extraction and manufacturing processes that make all this stuff rely on exploiting disadvantaged nations and are ecologically unsustainable. Yet market forces indicate that we are willing to make this trade: lots of stuff that leaves us void of any real or lasting value in exchange for the rights of others and our life support system.

Our willingness to trade away the earth's resources is profoundly detrimental to the health of present and future generations and is a symptom of a disconnected relationship. If this line of thought has any value, connecting with nature is more than just a pleasant sounding idea for landscape architects to sell a design with. It is vitally important to the well-being of the planet, including people.

LANDSCAPE ARCHITECTURE

(How) Should landscape architecture bother?



"Where are the books? The poems? The plays? The goddamn operas?"
(McKibben, 2005)

Bill McKibben calls on artists to produce works that make climate change part of our culture, so that its reality "registers in our gut". Should we not add 'landscapes' to McKibben's query? Situated at the confluence of culture and environment, landscape architecture is uniquely positioned to lead the Herculean challenge of shifting a cultural mindset. Howett (1987) suggests that as part of a new landscape aesthetic commensurate with Olmsted's social values, "...*new forms must reflect the awakening of our generation to ecological consciousness, and the growing popular understanding of the degree to which the natural world is, in Aldo Leopold's words, 'interlocked in one humming community of co-operations and competitions, one biota'*" (p. 7).

Cook (2000) refers to a new paradigm, characterized by a dynamic and changing nature of communities and ecosystems, as opposed to a state of stable equilibrium, recognizing the "...*overwhelming influence of human culture on all natural systems and the worldwide impact of certain cultural practices such as the burning of fossil fuel, the release of ozone-destroying chloroflurocarbons and the introduction of alien species. The new paradigm challenges any clean distinction between culture and nature*" (p. 121).

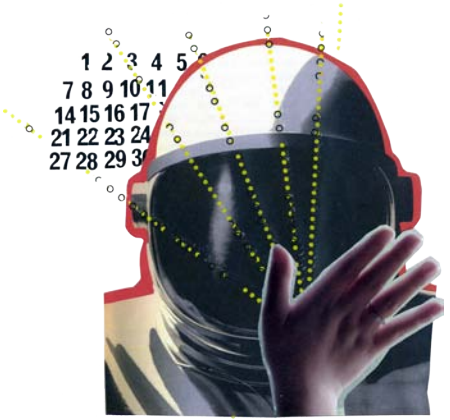
Mazria (2006) suggests that while professionals focus on combating climate change, professional schools should "*... require the establishment of mandatory programs that promote creative problem solving relevant to climate change. Such programs must incorporate into all core courses a deep understanding of the relationship between nature and design - an area in which many landscape architects have strong grounding*" (p. 131). Surely it is beneficial for different schools to have different approaches to teaching environmental design, but it may be prudent for all schools to share this goal. Mazria goes on to say "*As an interim measure until such programs can be developed, all design studio instructors should require that student work engage the environment in a way that dramatically reduces or eliminates the need for fossil fuels*" (p. 131). Reducing or eliminating fossil fuels from the design process is not only necessary in combating climate change, but is also a practical measure for students transitioning into the workforce. Demand for "green" design has increased exponentially in recent years and is likely to continue to do so. Currently, "green" design is most popularly pursued by attaining some level of LEED® certification. Although the CO2 reductions achieved by current LEED® projects are modest, it is a step in the right direction, as it promotes a measurable and tangible shift in how we design and develop the built environment.

Similar to LEED®, which focuses on building design and construction, the Sustainable Sites Initiative (SITES™) has developed a rating system specifically for designing sustainable landscapes. SITES™ is an "interdisciplinary effort to create voluntary national guidelines and performance benchmarks for sustainable land design, construction and maintenance practices." (Sustainable Sites Initiative, n.d.). Such guidelines are of course good practice; all designers should try to minimize local and global environmental damage normally associated with development. The benefits of these efforts can often be quantified, such as volume of on site water storage capacity and percentage of local or salvaged materials used. Beyond these measurable aspect of landscape design, however, are unquantifiable intangible qualities that can reflect and challenge a culture's psyche. If there is to be a widespread cultural shift toward a mindset that truly strives for and embraces a sustainable way of life, this quality of design must try to re-conceptualize our relationship with nature.

Projects that educate and challenge perceptions of nature and environmental issues are often referred to as environmental or land art. Artists and/or landscape architects generally highlight the project's artistic concept or narrative as opposed to a site's ecological functioning emphasized by SITES™. Sometimes seen as unprofessional, if not unethical (Nadenicek and Hastings, 2000), this strategy attempts to influence attitudes, perceptions and ultimately behaviour. The impact of such work cannot simply be added up and is not subject to objective analysis. To argue that environmental or land art is unethical, however, is to deny landscapes their ability to participate in culture building. A practical argument for including this approach within an environmental vision for landscape architecture can be gleaned from Peter Walker's temporary installation Ground Cover.

Installed in 1995 in the courtyard of the California Center for the Arts Museum, Ground Cover portrayed a scaled down representation of earth's surface composition. Symbols were used to represent different components of the earth's surface. For example sand and Scotch pine seedlings represented deserts and forests respectively, while the space each symbol occupied reflected its global surface area. Within this scheme, a single marigold represented all parks and gardens, which is .02% of the earth's surface (Gillette, 2006). Part of what Walker was trying to convey by highlighting the tiny percentage of land directly impacted by landscape architects was that the majority of urban and land pollution does not result from the work of landscape architects. Landscape architecture that integrates environmental values into projects may therefore be the most effective means of contributing to environmental causes. Moreover, environmental art and ecological goals are not mutually exclusive. William MacElroy and Daniel Winterbottom coined the phrase "infra-garden", which describes a landscape that incorporates landscape art in order to support ecological and social values (Thompson and Sorvig, 2008).

Now what?



Can evolutionary theories and artistic endeavours help provide an appropriate foundation for landscape architecture to effectively tackle climate change? Thus far I have suggested that landscape architecture is able to contribute toward improving the environment and that human and environmental heath are symbiotic. Landscape architecture may ameliorate this relationship, perhaps most compellingly by challenging people to ponder and re-evaluate our relationship to the natural world. This is a complex and daunting task, but there has probably never been a better or more urgent time to take on this challenge and who better to do so than landscape architects.

DESIGN INTENTIONS

This practicum is about landscapes intended to make climate change perceivable and to encourage contemplation of our place in, and relationship with, the natural world. Interventions on sites likely to change in a somewhat predictable manner link the vast and abstract concept of global climate change to the sites' features and characteristics. The designs make climate change visible and present by revealing its effects on a smaller, observable scale. Design that anticipates and welcomes climate change poses questions about its inevitability, its upsides, its downsides, and it prompts reflection about the future and the consequences of visitors' actions.

Precedents

The following are descriptions of projects that possess qualities that helped to inform my approach to design and exploration of issues germane to this practicum's design intentions. These works are expressed in a variety of media.

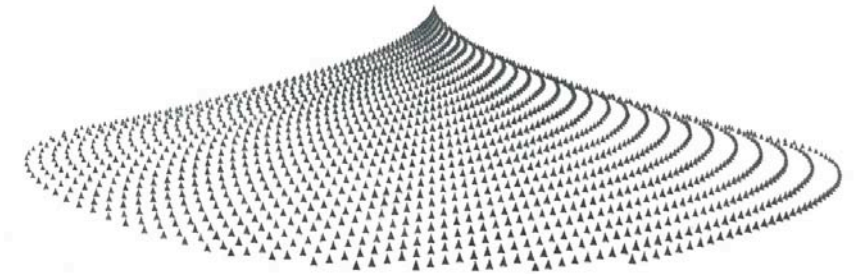
Landscape Journal Cover, 1998

1. Human-Nature Relationships

Eco-Revelatory Design: Nature Constructed/Nature Revealed exhibited works that explored human-non-human nature relationships. Catalogued in a 1998 Landscape Journal special issue of the same name, these projects reveal natural processes and influences of human activity. Eco-revelatory design helps to elucidate the relationship between people and nature by revealing these influences that are often kept hidden.

2. Environmental Art/Environmental Remediation

Agnes Denes's Tree Mountain is 11,000 trees planted by 11,000 people from all over the planet and is a rare example of environmental art and reclamation. The project, announced by the Finnish government at the 1992 Earth Summit in Rio de Janeiro, is intended to contribute to ecological wellness (Lippard, Smith and Revkin, 2007). The land is to be protected for the next 400 years, eventually becoming a virgin forest. Tree Mountain's scope in terms of time and purpose are emblematic of what my practicum aims to achieve.



Tree Mountain, 1996

Tree Mountain, 2009

3. Shifting scale

Global climate change is massive in scope and complexity. It impacts the entire planet in different ways that tap into systems that interact on a planetary scale. To help make sense of this, it may help to present a shift in scale from something more tangible and immediate to something that connects to the larger phenomenon. Artist Nancy Holt achieves this reduction in scale by bringing the vast space of the desert back down to human scale in her project Sun Tunnels (Lailach, 2007). The tunnels are four, six meter long concrete tubes about three meters in diameter. They form an X oriented according to summer and winter solstices. Holes are drilled into the concrete that form scale representations of four constellations.

Sun Tunnels

Depicts two million plastic beverage bottles,
the number used in the US every five minutes.

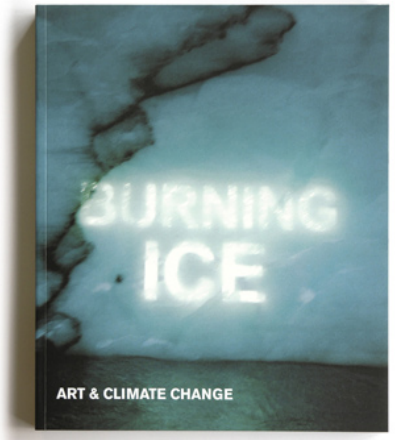
Detail

In his Running the Numbers series, photographer Chris Jordan composed artworks from images of massive quantities of consumer products (sheets of paper, plastic bags, cell phones etc). These images are paired with statistics about their consumption in the United States, for example the number of plastic bags used every five seconds. By providing detail and large scale images, these works allow for a visual shift in scale that represent difficult to comprehend mass consumption.

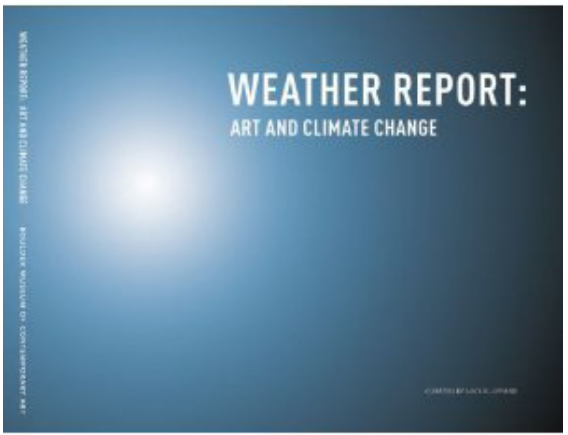
4. Climate Change

The Cape Farewell project brings an eclectic group of scientists and artists together on a schooner called the Noorderlicht. They travel to the arctic where the effects of climate change are examined through samples, measurements, photographs, writing and pretty much anything else. The first expedition took place in 2003 and there have been annual trips with touring exhibitions since. This project creates a direct conduit between science, a changing environment and public consciousness through the work of the artists. This project also speaks to the importance of artists of all media to convey this crucial message.

Weather report (Lippard et. al., 2007) was an exhibit at the Boulder Museum of Contemporary Arts curated by Lucy Lippard featuring 51 artists who created work specifically about climate change. The range of works in this exhibit reflect the complexity of climate change, tackling issues such as individual responsibility, alternative energy sources, human/nature interdependence, and habitat. Artists were able to access scientists working in the field that they hoped to address. The abstract nature of some of the pieces present perspectives that are able to encapsulate a phenomenon that is daunting in scope and amount of information.



Burning Ice book cover



Weather Report book cover

5. Ecological degradation

The site of a decommissioned landfill, Byxbee Park does not try to cover up the unpleasantness of the site's history. Instead its past is revealed through surface elements such as the pole forest. The site has been capped with two feet of clay, and trees cannot be planted on site because their roots will penetrate the cap and expose the garbage underneath. A forest of telephone poles has been placed there instead. This type of intervention speaks directly to the connection between consumptive behaviour, land use and environmental implications.

Byxbee Park telephone poles

Map of National Tourist Routes

6. Landscape Tourism

Norway's National Tourist Routes feature innovative architectural interventions along 18 tourist routes. Implemented by the Norwegian Public Roads Administration and scheduled for completion in 2016, the overall scope of this project is impressive. The routes are intended to take drivers off main highways and through various and often dramatic landscapes. The architectural interventions act as rest stops and allow visitors to view and engage the landscapes in new ways.

This project offers compelling reasons to slow down and take in both landscape and architecture. Each installation responds to its surroundings and presents a particular view of nature, and in their forms, a memorable and unique experience.

Its focus on natural landscapes could arguably classify this project as ecotourism. Ecotourism is a complex phenomenon that is growing in popularity, expanding its influence on all concerned parties, sometimes for better, sometimes for worse.

Eco-/Nature-based tourism

The United Nations World Tourism Organization (UNWTO) declared 2002 the International Year of Ecotourism and indications are that the popularity of ecotourism will continue to grow in the foreseeable future. Both the concept and practice of ecotourism are complex phenomena with numerous issues. For example, in practice ecotourism can encourage trampling on virgin land and the benefits promised to local communities often don't happen; as a concept there are many different definitions and stakeholders (Bjork, 2007), which have the potential to cause conflict and discrepancies between host countries, tourists experiences and their expectations, and corporate motivations. Green washing is becoming more common, as the attractive features associated with ecotourism are used to market unsustainable tourism (Dawson, 2009). As the appeal of ecotourism reaches a mass audience, the sustainable objectives of ecotourism become increasingly difficult to maintain. The different concepts and definitions of ecotourism may include or be distinct from such terms as green tourism, alternative tourism, ethical tourism, conservation tourism and so forth (Dawson, 2009). While some researchers and planners feel a universal definition is needed, others feel it would be too restrictive.

The UNWTO defines ecotourism as: “All forms of tourism in which the main motivation of tourists is the observation and appreciation of nature, which contributes to its conservation, and which minimizes negative impacts on the natural and socio-cultural environment where it takes place” (Becken and Hay, 2007, p. 86). This definition focuses on destination level impacts and overlooks the addition of greenhouse gasses generated through ecotourism that often leave a larger carbon footprint than regular tourism, which illustrates a discrepancy between concept and actual ecotourism. Despite its complications, ecotourism provides a useful framework with which to conceptualize the overall scope of this practicum’s designs are consonant with this practicum’s goals. Within the numerous definitions for ecotourism are recurring themes such education, enriching experiences and love of nature that are consistent with this practicum’s design intentions. Conceiving of these designs as tourist destinations provides another dimension with which to explore these goals.

In many ways my practicum began upon learning of the Norway Tourist Routes and its rest stops. Whereas these interventions display a variety of spectacular vistas and landscapes in Norway, the current project is intended to reveal Manitoba landscapes that are potentially susceptible to the effects of climate change. A framework similar to that of the Tourist Routes provides a useful structure to include the various landscape of Manitoba. Having had the opportunity to visit some of the Norway installations first hand, I was able to experience the scale of the projects, how they engaged the road and visitors and the sensorial qualities of the sites. They framed certain views, took me into thin air and placed me at the edge of dramatic transitions between land and water and land via beautiful and innovative architecture. Each site was easily accessible from a highway but varied somewhat in the scale at which they acted as an interface between the visitor and landscape.

Some of the advantages to framing this practicum's designs as ecotourism are:

1. Promote local tourism
The potential benefits of Manitobans visiting these sites are twofold. Air travel associated with tourism is a growing source of C02 emissions and one of the major impediments to sustainable tourism (Becken and Hay, 2007). For example, average CO2 emissions per passenger from London to Costa Rica is twice the annual CO2 output of individual Costa Ricans. Although slight, encouraging Manitobans to stay within their own province encourages fewer C02 emissions.

There are also potential benefits to be had from Manitobans learning more about their own province. Getting to know one's local environment may help to engender attitudes favourable toward supporting environmental agendas.

2. Opportunities to expand an environmental message
Due to their locations, travel would be required for most people wanting to visit these projects. It would be possible to organize group tours to encourage more visitors and reduce the amount of fuel needed to get that number of people there. These tours could further this concept by using vehicles that run on non-fossil fuels, providing locally produced lunches in re-usable containers and the like.

3. Appeal to a wider audience
Tourism, especially ecotourism, is an immense and growing industry and although our devotion to economic development has a lot do to with the state of the environment, tourism's current and future ability to generate economic growth make it particularly relevant to sustainable development (Fennell, 2003).

CLIMATE CHANGE

History

At the time during which the theoretical underpinnings of CO2's potential to alter global climate was discovered, it is was difficult to conceive of human activity as a CO2 source large enough to cause such an effect. Nature, climate included, was something that humans adapted to, not influenced. Building on the work of Joseph Fourier and John Tyndall, Svante Arrhenius made the theoretical assertion in 1896 that changes in atmospheric CO2 could impact climate (Downie, Brash and Vaughan, 2009). Still, the knowledge that climates had changed in the past and the immutable view of nature rendered the thought of humans changing the climate easily dismissible (Weart, 2008).

In 1938 Guy Steward Callendar made a direct link between observed rising temperatures and human generated CO2. At the time, however, this was one of many explanations for global warming put forth and rejected by scientists of all stripes, so it too was shelved (Weart, 2008). Since then, more accurate observations and increasingly sophisticated scientific tools have steadily made the link stronger and stronger, culminating with the IPCC's 2007 report definitively stating that human activity has raised the Earth's temperature. And all the while levels of human generated CO2 have continued to increase exponentially.

Despite unprecedented agreement among scientists, opposition to the idea and science of climate change remains. A significant portion of this opposition can be attributed to deliberate campaigns designed to create false uncertainty surrounding climate science. For example, the Union of Concerned Scientists (2007) have outlined how Exxon-Mobile has used the same tactics to spread misinformation on climate change as the tobacco industry had for 40 years to successfully suppress definitive information linking smoking to cancer and lung disease.

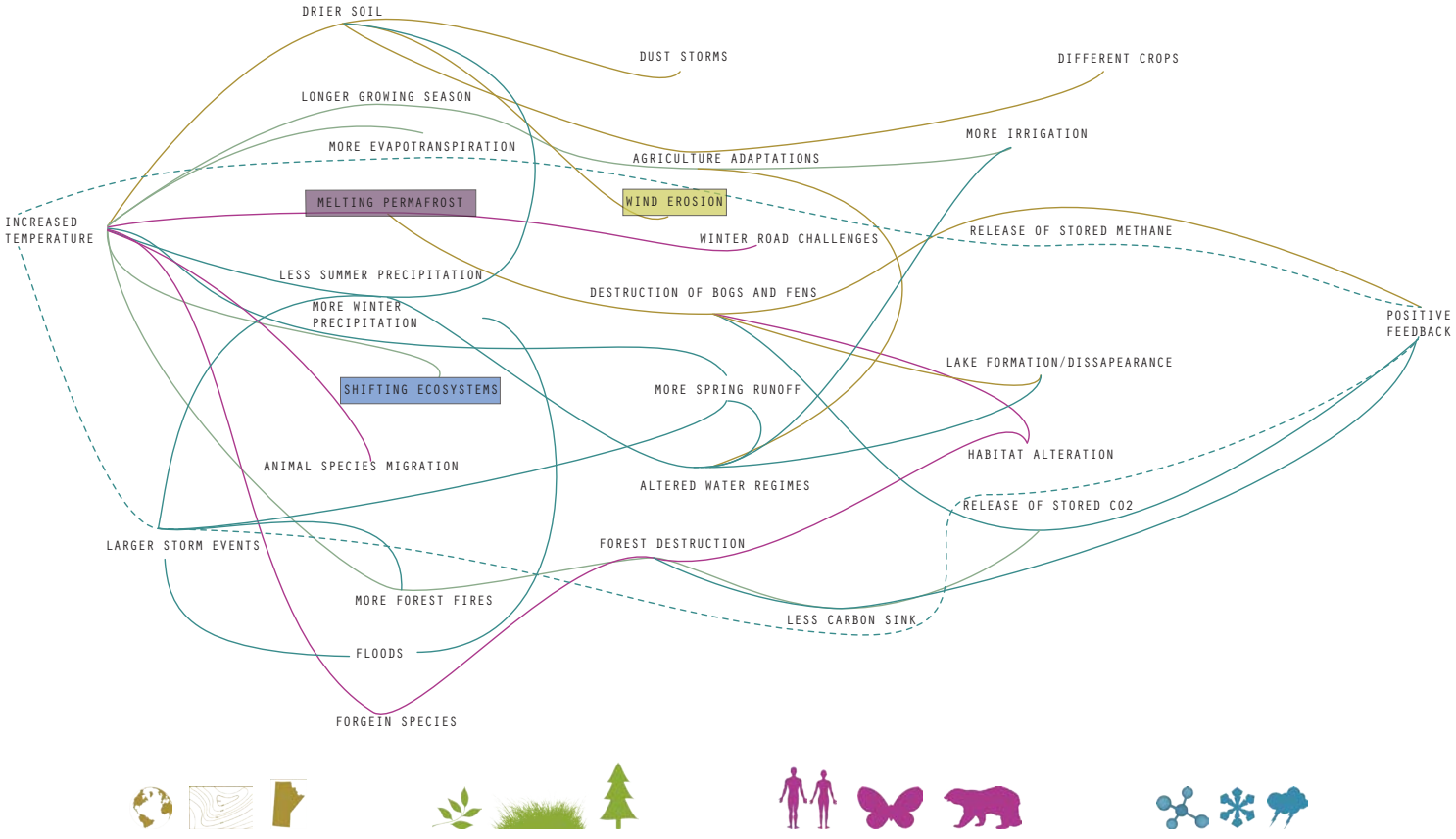
Global Impacts

Even among those that accept human activity as the main driver in climate change, there is debate regarding severity of the impacts, the nature of the relationship between CO2 and temperature, how best to combat the impacts and even if temperature might be trending downward. Although it is beyond the scope of this practicum to get into this debate or defend a certain position, what appear to be the consensus predictions are used as a basis for further discussion.

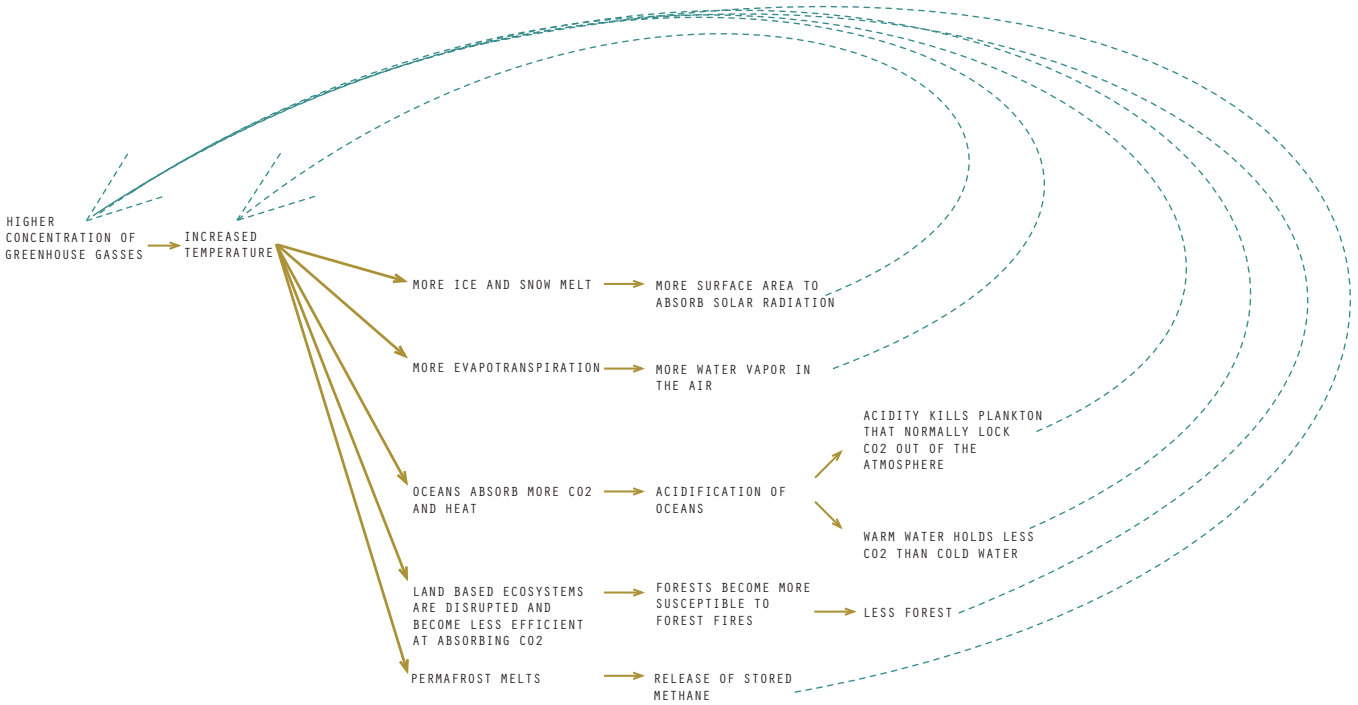
At the time of writing, atmospheric CO2 concentration is 390 parts per million (ppm) and climbing. Although some sources suggest historical concentrations have been much higher at times, there is a growing consensus that believe the highest concentration compatible with human life as we know it is 350ppm (Hansen et al., 2008). It is estimated that a global rise of more than 2ºC above the preindustrial temperature will trigger positive feedback cycles that will push temperature beyond our control to an inhospitable steady state. These positive feedback cycles stem from rising temperature and include the release of methane, a potent greenhouse gas, that is currently stored in oceans and permafrost, the reduced ability of the oceans to store CO2, and decreasing amounts of snow and ice resulting in more solar radiation being absorbed by the planet.

The earth is already 0.8ºC warmer than it was prior to the industrial revolution and as some evidence suggest there is a lag between CO2 concentration and temperature so that even if all CO2 emissions stopped immediately, the amount of CO2 already in the atmosphere is likely enough to increase global temperatures by 2ºC.

Some of the major geophysical and climatic symptoms of global warming-induced climate change are predicted to be rising ocean levels, melting arctic ice, increasing frequency of major storms and changing ecosystems (Henson, 2006). In turn, some of the most significant geopolitical implications are likely to be related to food and potable water shortage, human migration and national security (Dyer, 2008).



Theoretical interrelationships of systems susceptible to climate change



Positive feedback cycles accelerating climate change.

In Manitoba

Second to the arctic, the Canadian prairies are likely to experience the greatest temperature increases due to rising atmospheric CO2 concentrations (Scott and Suffling, 2000). How some of the predicted climate change symptoms may be felt in Manitoba can be imagined. Rising ocean levels will impact coastal communities along the north-western shore of Hudson Bay; melting arctic ice may impact shipping routes that may pass through Churchill; southern Manitoba will be prone to more frequent flooding and droughts. Sauchyn and Kulshreshtha (2008) identified the following as some of the most salient impacts climate change may have on the Prairie provinces:

- water scarcity
- ecosystem disruption via shifts in bioclimate, fire and insect disturbances, stressed aquatic habitats and introduction of foreign species.
- losing cold winter advantages, such pest regulation, use of winter roads, forestry and energy winter operations
- increased variability leading to more frequent droughts and more severe flooding.

This practicum's designs explore the following phenomena:

- Melting Permafrost
- Soil/wind erosion
- Shifting Ecosystems

SITES

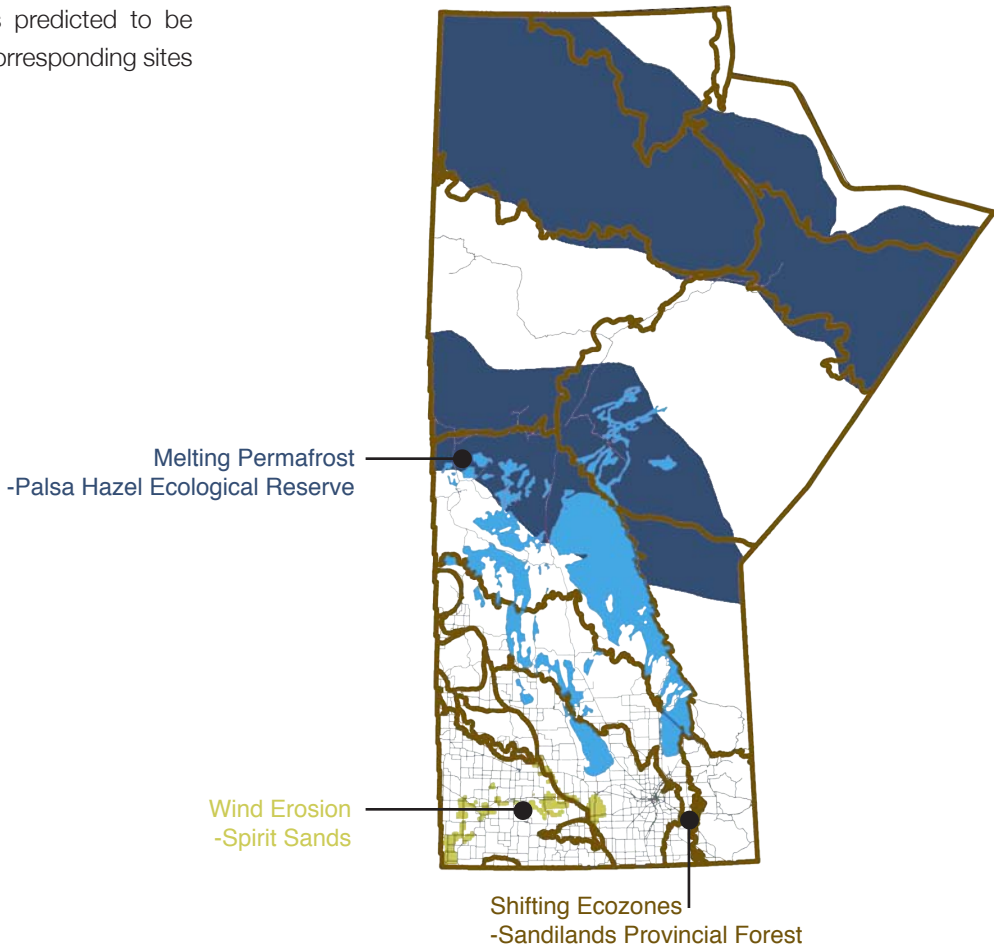
Site Selection Criteria

The selection of potential sites began by creating maps highlighting areas of Manitoba where the predicted impacts would likely occur.

Map	Source
Soil/wind erosion	https://mli2.gov.mb.ca//environment/index.html
Shifting ecosystems	http://atlas.nrcan.gc.ca/site/english/index.html
Melting permafrost	http://atlas.nrcan.gc.ca/site/english/index.html
Manitoba Highways	https://mli2.gov.mb.ca//roads_hwys/index.html
Protected Areas	https://mli2.gov.mb.ca//adminbnd/index.html

These maps were overlaid on a map of Manitoba's Protected Areas. Protected Areas are established to conserve and protect areas of Manitoba that have been deemed representative of unique landscapes, critical habitat or contain diverse flora and fauna. Protected areas within 1 kilometer of a highway that overlapped one of the climate change phenomena were identified in the interest of selecting easily accessible sites. This procedure yielded seventeen sites, eleven of which I visited. During these visits I tried to get a sense of the landscape, their current uses, relationships to nearby communities and appropriateness for the type of project, however vague, I had in mind. Ultimately, three sites were chosen corresponding to three different phenomena.

Synthesis map showing geographical areas predicted to be affected by climate change and locations of corresponding sites for design interventions.



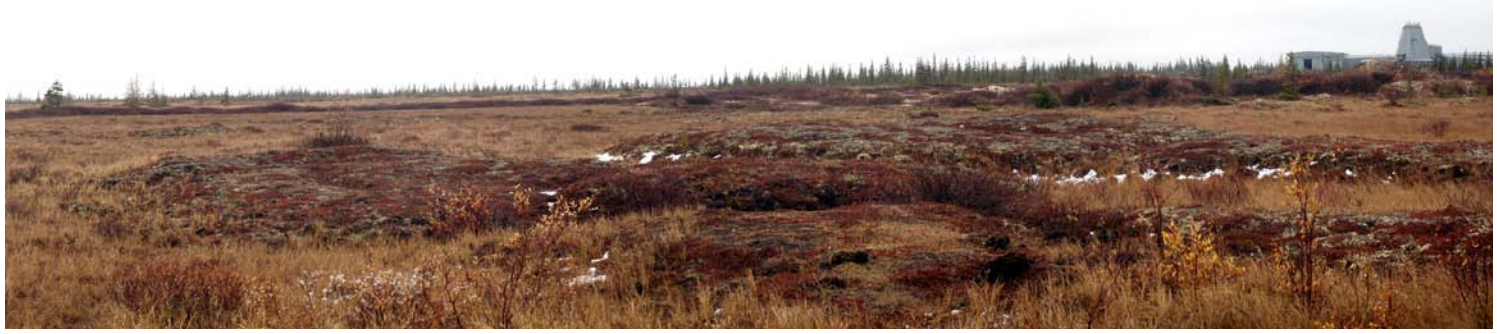
Selected Sites
Palsa Hazel

Palsa Hazel ecological reserve is located within a region where peatlands are extremely sensitive to climate change. It was given protected status to preserve the palsa formations in the area. Palsas are mounds of earth with a core of frozen peat and/or ice, 1-12 meters in height and varied in shape (Davis, 2001). They generally range from 100 to 2000 years old but can be up to 10,000 years old. Once they collapse, however, they may leave little evidence of ever having existed.

Palsas form where there is permafrost. Permafrost is defined as any soil that has remained frozen for at least two consecutive years (McFadden, 2000) but almost all natural permafrost is thousands of year old. There are three types of permafrost: continuous permafrost is part of a large subterranean sheet in the arctic; discontinuous permafrost occurs further south and occurs in isolated segments as it thins and; a third zone of sporadic discontinuous permafrost occurs further south. This third zone of sporadic permafrost is where Palsa Hazel ecological reserve is located. In these regions, palsa exists due to the insulating properties of peat (Sollid and Sorbel, 1998) and this is thought to be the case for the palsas in Palsa Hazel Ecological Reserve (Halsey, Vitt and Zoltai, 1995).

Aerial photograph of Palsa Hazel Ecological Reserve

Although local factors (slope, aspect, vegetation, show cover, surficial materials, the presence or absence of an organic layer, soil moisture content and drainage) play a role in the location of permafrost within the discontinuous zone, climate remains the main factor. (Smith and Burgess, 2004). Indeed, palsas can indicate changes in climate (Sollid and Sorbel, 1998) and have been shown to degenerate during recent warming (Zuidhoff and Kolstrup, 2000).



Palsa mounds near Churchill, Manitoba

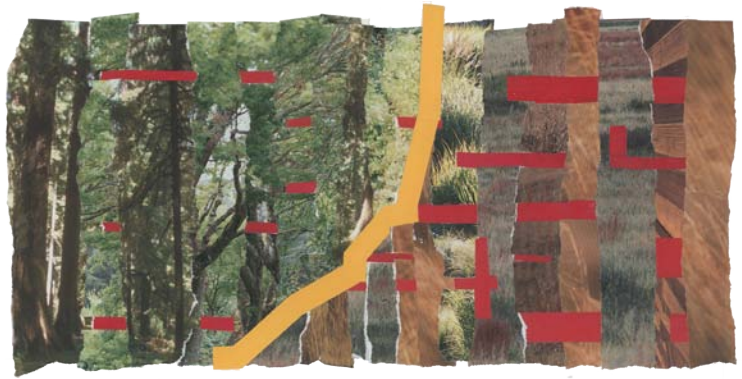
Selected Sites
Spirit Sand Hills

Spruce Woods Provincial Park is located within an area that is considered both highly sensitive to climate and extremely sensitive to wind erosion. Within the park boundary is Spirit Sand Hills, an area that contains approximately 960 square km of contiguous sand dunes. The sand was deposited by the Late Wisconsin ice sheet up to 70 meters deep (Rogosin, 1996). Shaped by prevailing North-West winds, there is evidence that the area has undergone periods of relatively moist conditions alternating with periods of major drought. Currently, the dunes are relatively stable and vegetated, with only 5% of the contiguous dune area considered active. Evidence from air photos reveals that vegetation encroached into areas of exposed sand between the late 1920s and the 1960s, but have since remained consistent (Wolfe et al., 2000). The Brandon sand hills, also in Southern Manitoba, show evidence of recurrent intervals of dune activity and stability, which may correspond with periods of regional drought and the presences of vegetation respectively.

Dune activity may increase if prolonged drought or climate warming were to occur (Wolfe, 1997) and there are signs that this may already be occurring. Already stressed aspen are expected to suffer dieback if moisture levels decline, while bur oak may survive in some areas, forming a more open savanna landscape (Henderson et al., 2002).

There are over 120 sand fields in Canada's southern prairies and they remain largely undeveloped due to their low fertility and high potential for erosion. These same attributes, however, make sand dunes an important indicator of climate change and the impacts on the stability of the prairies as a whole (Geological Survey of Canada, 2001).

Selected Sites
Sandilands Forest



Pocock Ecological Reserve lies adjacent to Sandilands Provincial Forest, which is in the boreal transition ecozone (Rogosin, 1996). During my site visit to Pocock I also explored part of the Sandilands area. Subsequent investigations revealed part of the forest as suitable for this project. This area of the forest is well used for recreation, such as mountain biking, cross country skiing, ATVing and snowmobiling.

Climate change is likely to have significant impacts on global ecosystems, including forests. (Melillo, 1999; Shriner and Street, 1998). Potential factors affecting forests are changes in temperature, hydrological cycles and the introduction of pests, such as the mountain pine beetle, which can survive year round in the absence of severe winters. Jack pine is the dominant species in Sandilands forest, which is predicted to undergo a Northward shift in climate-envelope latitude between -5.5 and -3.5 degrees latitude (see McKenney et al., 2007b for an explanation of climate-envelopes). According to IPCC models, forests would have to migrate at a rate of approximately 10km/year on average, which is much faster than than the 10-100m/year that natural migration is thought to occur (McKenney et al., 2007a).

Exactly how climate change will restructure forests is unclear. Current forest compositions are likely to change as tree species redistribute independently, resulting in new species combinations (Williams et al., 2004). Although there is evidence of previous dramatic forest

restructuring due to climate fluctuations, the rate of anthropogenic climate change will be much faster than that of any rate in the past and will outpace forests' ability to migrate (Malcolm, Markham, Neilson and Garaci, 2002). Sandilands Forest may be particularly prone to changes due to its transitory condition. Some researchers anticipate even small temperature and precipitation changes could have large effects on future forest growth and survival, especially at ecosystem margins and threshold areas (Rehfeldt, Ying, Spittlehouse and Hamilton, 1999).

To combat forests' inability to migrate quickly enough to keep pace with climate change, actively introducing new species has been suggested as part of future forest management policies (Thorpe, 2006). There is already research in British Columbia that is engaged in relocating 16 different tree species up to 200 kilometers from their origin to experimentally test their ability to move into new areas (Marris, 2009). This type of intervention is referred to as assisted migration or managed relocation.

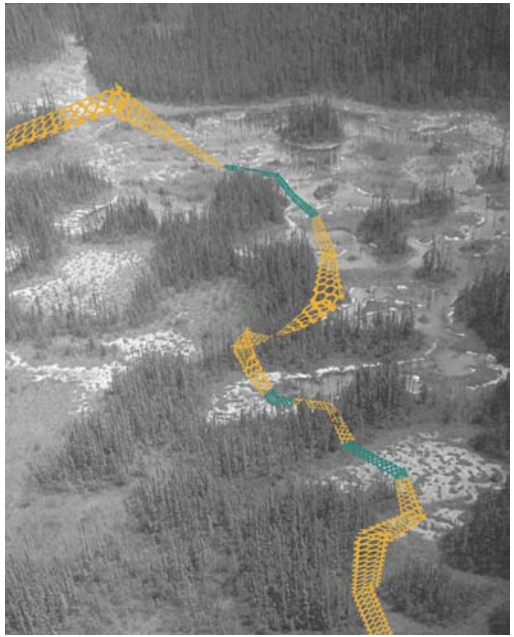
INTERVENTIONS

Thaw Walk

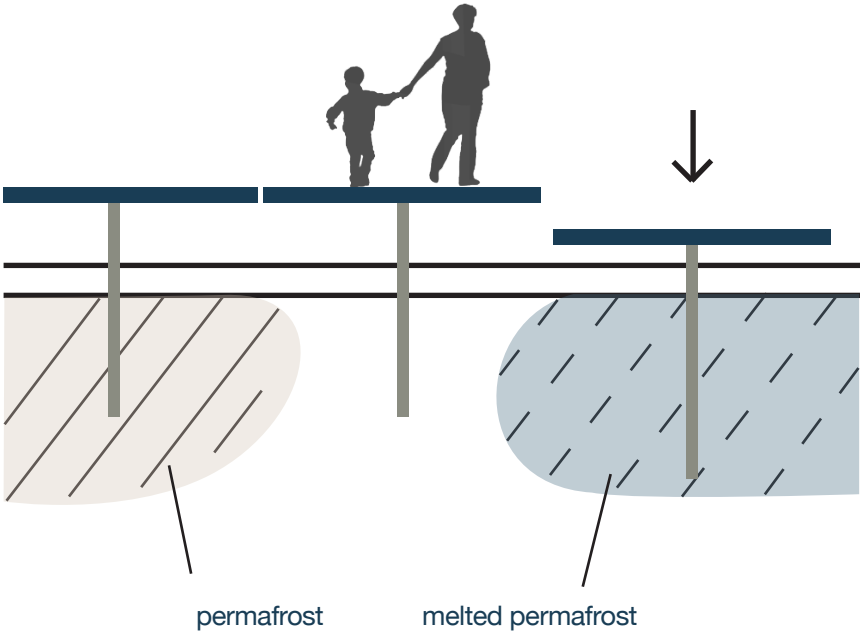
If it remains frozen, permafrost can provide solid foundation to build upon. Normally, building on permafrost employs various techniques to prevent permafrost melting. Buildings should be constructed on piles and elevated foundations to prevent heat from the building from melting permafrost (Seifert, 1994). Piles are placed in augured holes which are then filled with slurry and left to refreeze for a year. Alternatively, refrigeration coils can be used to hasten freezing. There should be four-five feet between the ground and foundation for ventilation.

Without these precautions buildings are subject to significant shifting as they slowly melt the permafrost beneath. This effect can be quite specific, as sections of homes that were built over permafrost will sink below sections that were not. Therefore, a survey must be taken to identify where the permafrost is and is not.

As described earlier, Palsa Hazel is an area with sporadic permafrost. This intervention is an elevated walkway that reveals melting permafrost underground by anchoring foundational posts into the ground; some in permafrost and others not. Care will be taken to ensure that thawing does not result from construction so that any subsequent melting can be more accurately attributed to climate warming. While the unfrozen ground will remain relatively stable, the frozen ground is subject to dramatic settling. As permafrost melts, the posts will shift and settle, altering the course of the walkway. Over time, a once level walkway will become uneven, reflecting subterranean changes that are likely attributable to a warming climate.



Thaw walk concept image

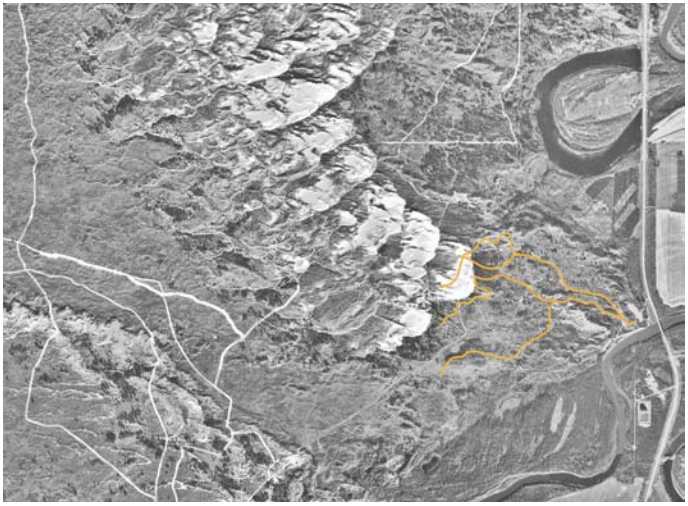


Portions of the walkway settle as permafrost melts

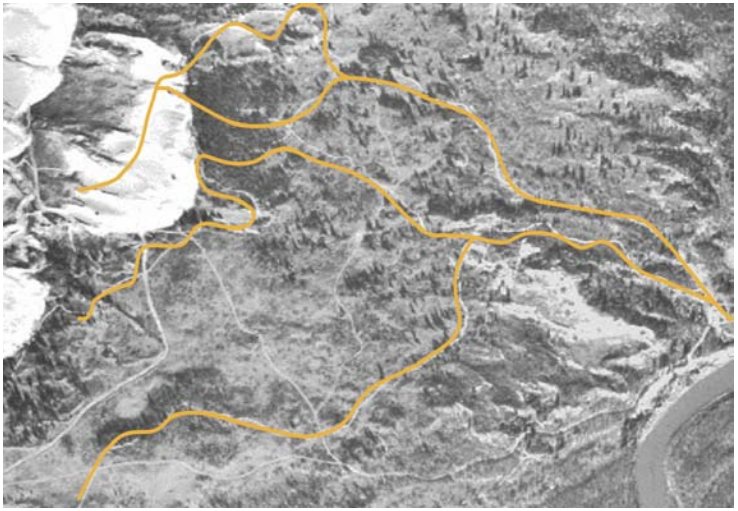
Sand Shapers

As southern Manitoba become more arid, the sand dunes at Spirit Sands are likely to become more active as vegetation dies. The dunes will increase in size as areas of open sand and rate of dune movement increase. More sand will be available to be picked up by wind and deposited elsewhere.

This intervention will be located along a trail oriented Northwest to Southeast that was formerly used by tanks from nearby Canadian Forces Base Shilo. It will compliment the existing site's trails. Near the base of the nearby dune on the northernmost part of the trail, a large, curvilinear wall will stand facing the advancing dune. A viewing platform will rise from the sand floor and amble around the wall, offering alternate views to examine the feature and sand. Four more of these features will be repeated in the dune's path along the trail.

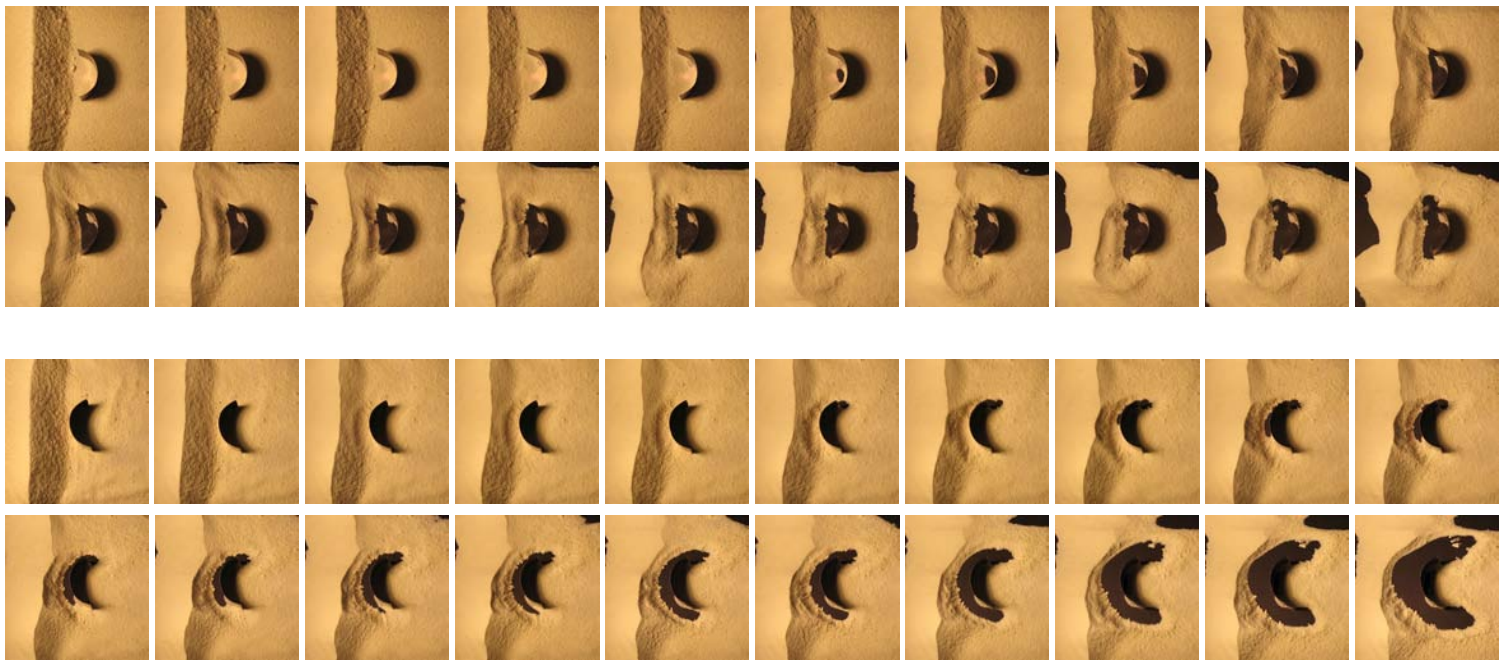


Aerial photo showing direction of dune movement to the south east.



Self-guiding trail system at Spirit Sands (in yellow).

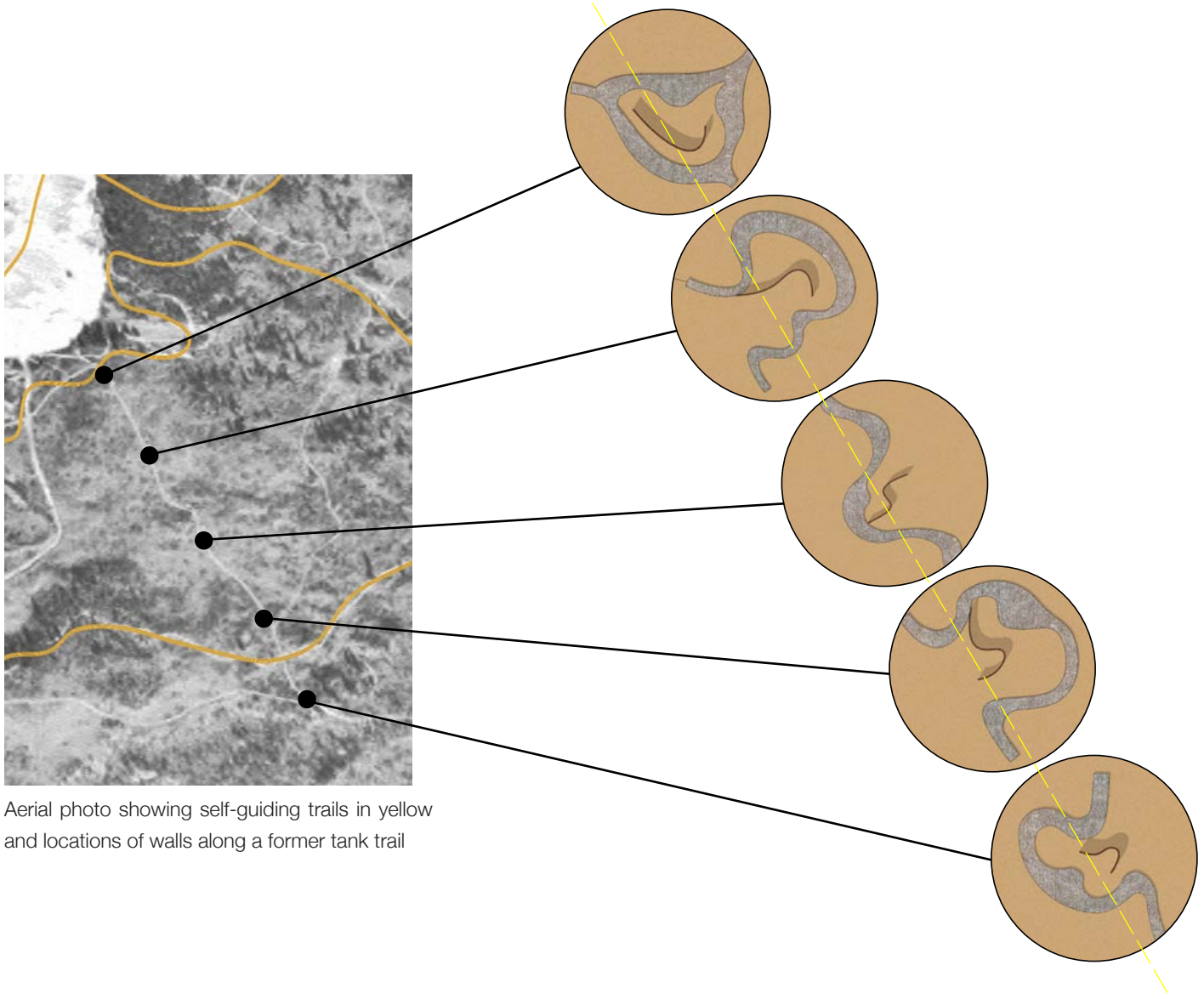
Experiments attempted to create a small scale dune to see how a barrier would influence its movement. Using skim milk powder and a fan, I set up a camera pointing down on the improvised dune and took one photograph every minute for a few hours while the fan blew the powder past a small barrier. Over 300 images were then compressed into short video clips. Although it is impossible to replicate what would actually occur in the real world, the video clips did reveal general patterns of how wind eddies and particle deposition and movement may occur around a vertical barrier. Within these general patterns, it was also revealed that different micro conditions will likely occur in response to variously shaped barriers.



Sand dune experiments

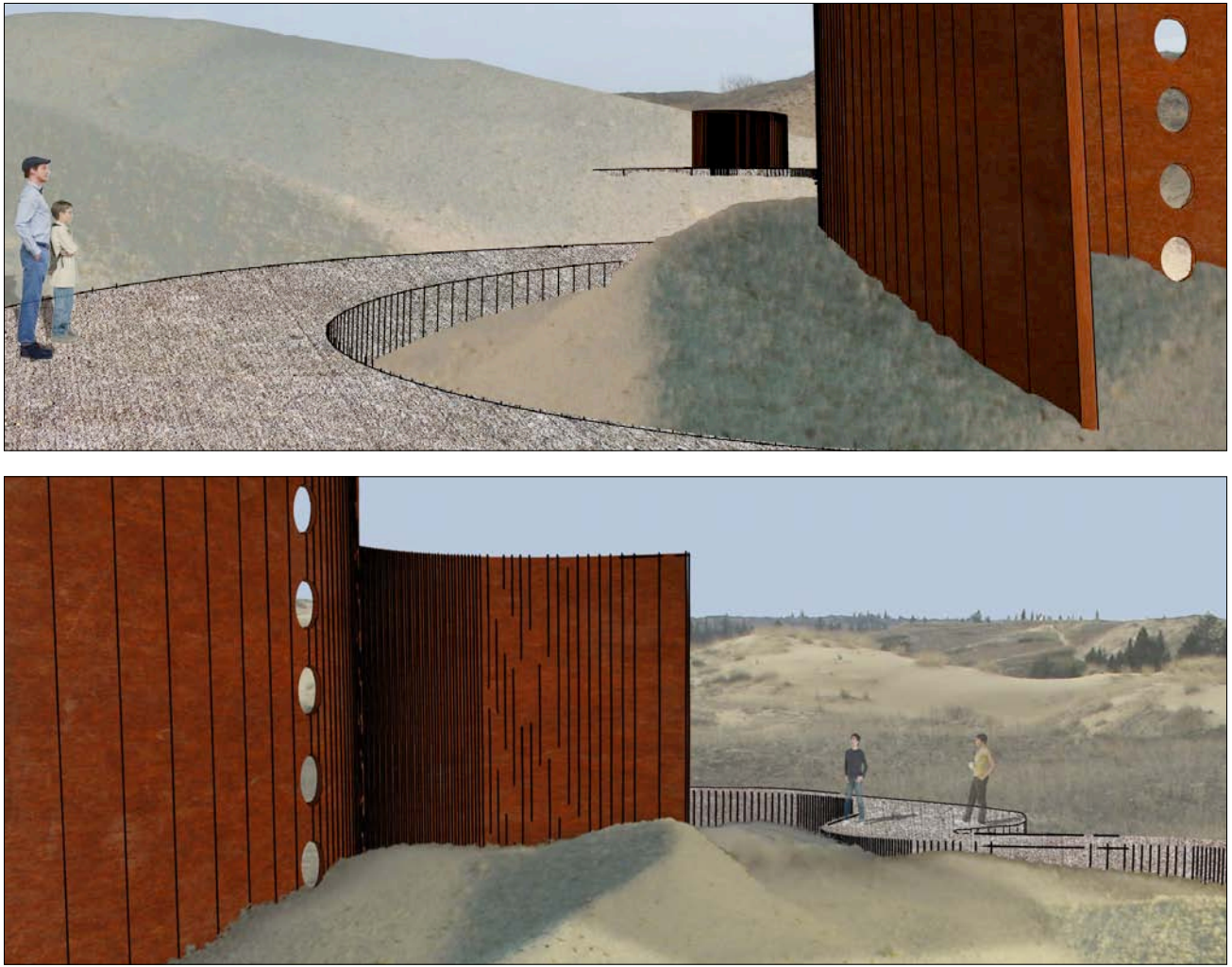
Taking cues from these experiments, the shapes of the walls are intended to manipulate the wind, carve different patterns in the sand and form micro dunes viewable from the elevated platforms. Changes in sand deposition will be observable upon recurring visits as the micro dunes shift over time. A vertical column of five holes in each wall also help to make these changes visible, as they are buried or unburied with changing conditions. Each column of holes is lined up horizontally with all of the other columns in the other walls, so theoretically one would be able to look through all the walls from one vantage point. In addition to being placed in a straight line in the dune's path, the walls are spaced equidistant apart. This spacing acts as a measuring device with which to track the rate of dune movement over long periods of time.

The various ways to view changes that have occurred on site are intended to provide visual and conceptual shifts in scale, from the changes occurring around each wall, to the changes occurring over the dunes site, to the changing global climate.



Aerial photo showing self-guiding trails in yellow and locations of walls along a former tank trail

Sand shaper wall and platform

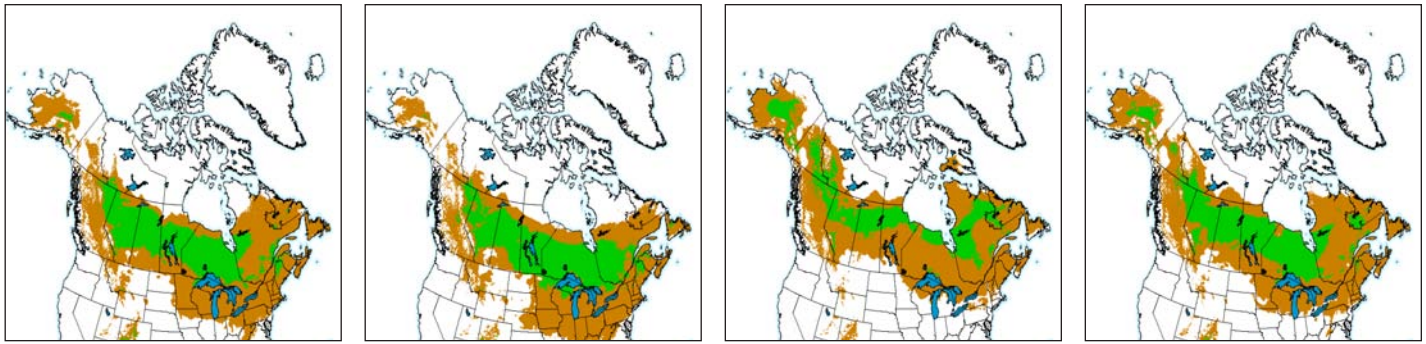


Sand shaper walls and platforms

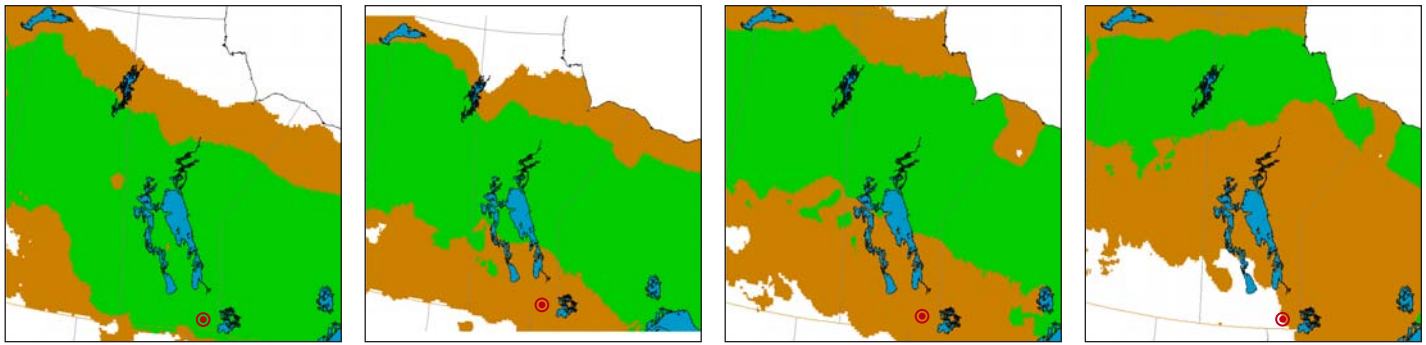
Time Zones

Like all forests, Sandilands Provincial Forest is likely to undergo significant climate change-induced transformation. What this transformation will look like is difficult to predict. A prescribed, controlled planting regime, however, will be implemented and monitored in a clearing of the Sandilands forest using plant species that do not currently grow in this region. McKenney et al. (2007a) determined the geographical range of survivability for 130 tree species based on current climatic conditions within the United States and Canada. Geographical ranges were also determined for the time periods 2011-2040, 2041-2070 and 2071-2100 using climate predictions based on an average of six different General Circulation Models. The following two pages show examples of these maps; Jack Pine is an example of a species that currently grows in the Sandilands but may not in 100 years and Sycamore is an example of a species that does not currently grow in the Sandilands but may be able to in starting sometime around 2041.

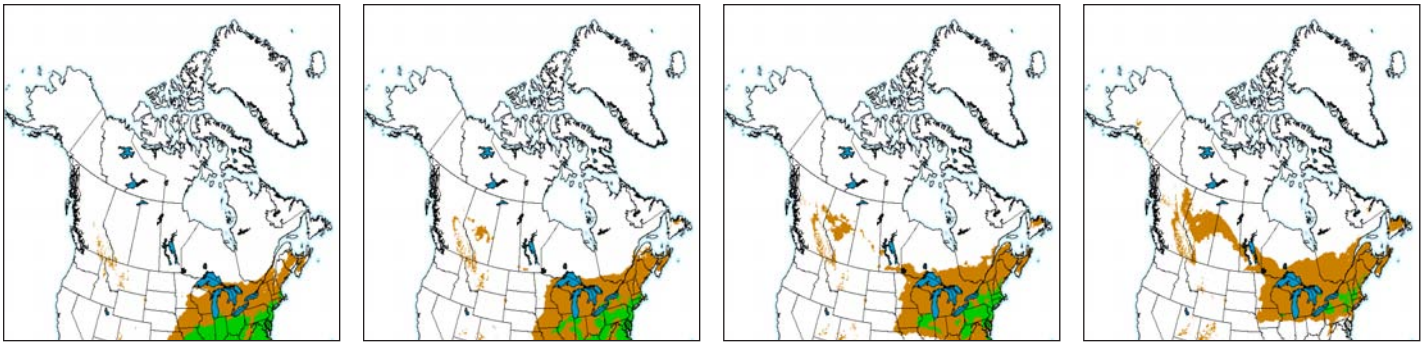
The Canadian Forest Service section of Natural Resources Canada's website features the research from McKenney et al. (2007a; 2007b). It also provides maps for numerous plant species indicating where they will grow according to current and future climate models. Predictions based on the Canadian General Circulation Model 2 climate scenario were used for this practicum. Plant species that, according to the CGCM2, do not currently grow in the Sandilands region but are predicted to be able to grow at some point in the three time periods years were selected for the planting regime.



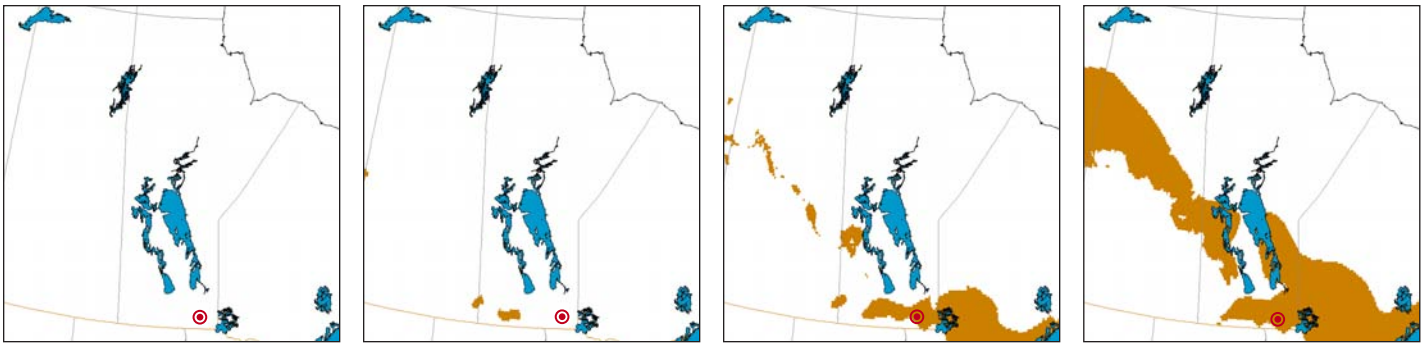
1971-2000 2011-2040 2041-2070 2071-2100



Predicted migration of Jack Pine across Canada (top row) and Manitoba (bottom row) based on the Canadian General Circulation Model 2 scenario. Brown areas represent the full range of the species and green areas represent the core range of the species.



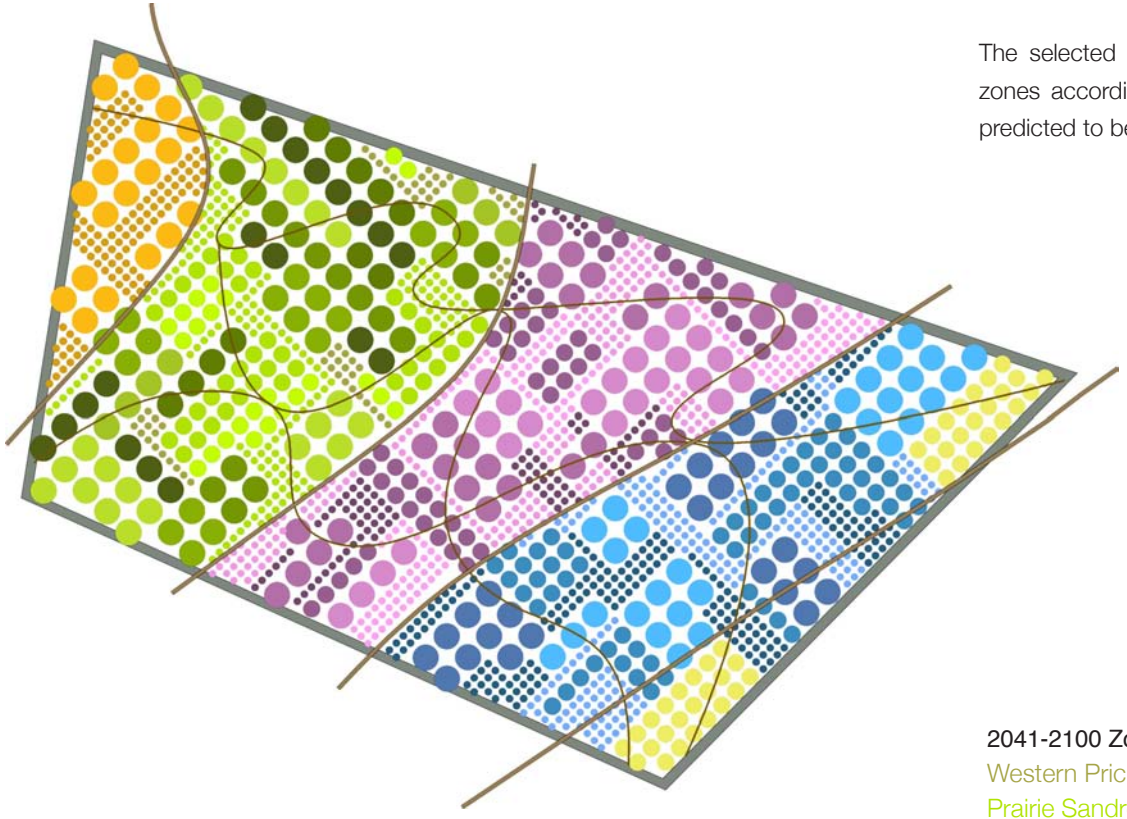
1971-2000 2011-2040 2041-2070 2071-2100



Predicted migration of Sycamore across Canada (top row) and Manitoba (bottom row) based on the Canadian General Circulation Model 2 scenario. Brown areas represent the full range of the species and green areas represent the core range of the species.

Plants are planted in zones delineated by the four walls. These walls are three meters high and run parallel to the contours of the site which is intended to block cold air flowing down the slope, creating a micro climate condition on the lower side of the wall (Brown and Gillespie, 1995). The strategy is to plant all plants on a schedule, perhaps every five years. It is likely that only few of the plants will survive the first planting but as time goes on, more and more will survive and the area will begin to fill in. As some of the later species begin to survive, some of the earlier species will die off and will be replaced by others.

Access to the site can be gained from one existing trail, from new trails that connect to other existing trails and a parking area that is part of the overall design. In the clearing, the site can be experienced from a path along the perimeter, from the tops of the four walls that span the clearing, and from serpentine paths along the ground. The walls are accessible at every point that they cross either the perimeter path or the internal paths, offering a variety of routes and perspectives to experience the site.



The selected plant species are grouped into five zones according to which time period(s) they are predicted to be able to grow in the region.

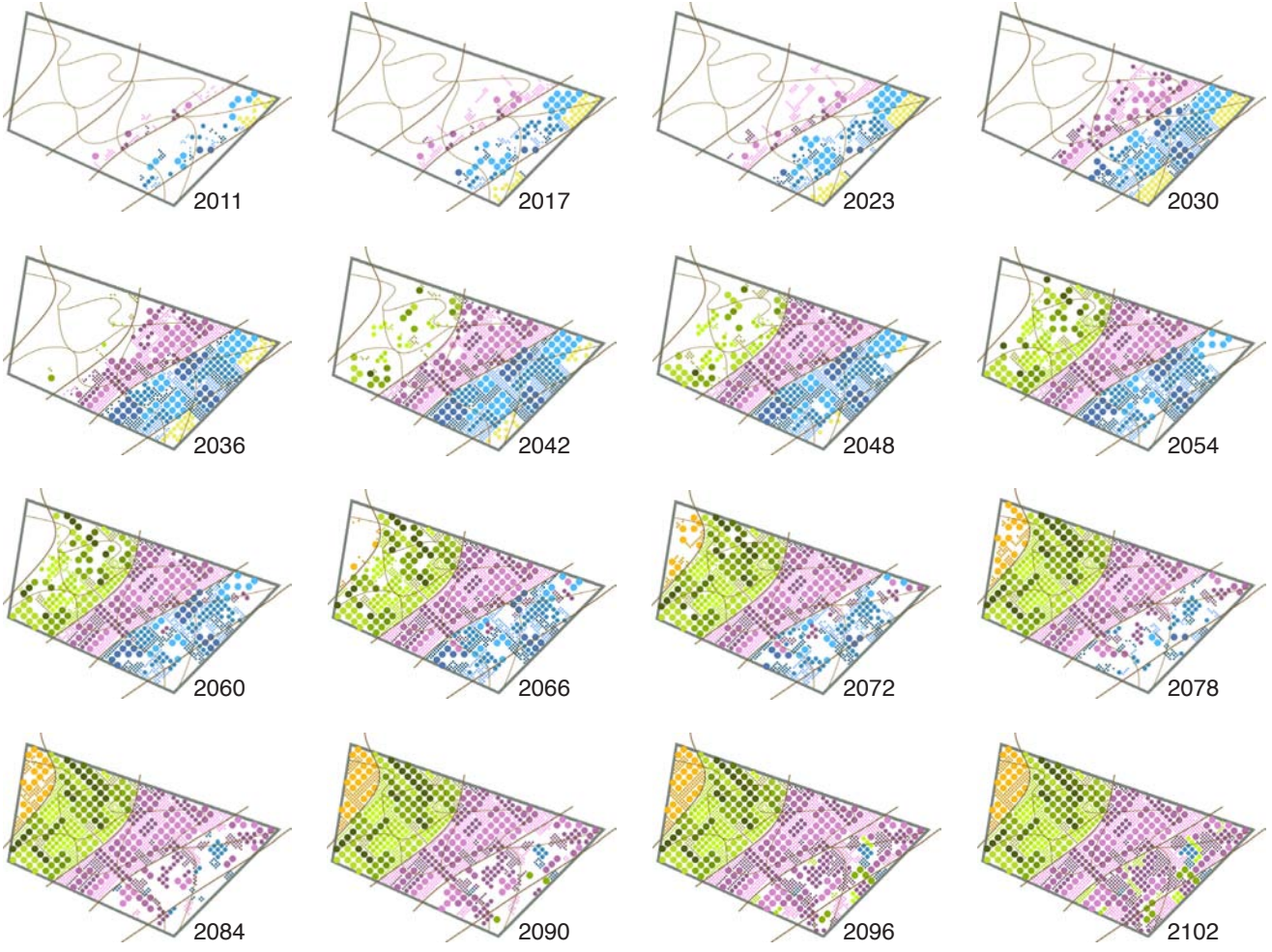
2011-2040 Zone
Common Sneezeweed

2011-2070 Zone
Black Hawthorn
Cooper's Milkvetch
Park willow
Colorado bristlecone pine
Creeping Jacob's Ladder

2011-2100 Zone
Greater Celandine
American Brooklime
Black Locust
Sweet Cherry
Rigid Goldenrod
Bull Thistle

2041-2100 Zone
Western Prickly Pear Cactus
Prairie Sandreed
Silver Wormwood
Narrowleaf Cottonwood
White Fir
American Plum
Christmas Fern
Big Leaf Maple
Horsechestnut
Sycamore

2071-2100 Zone
Red Mulberry
Rough Pennyroyal



Hypothetical 91-year outcome of the proposed planting regime.

Pre-planting

2030

2050

Anticipated scenarios in the 2041-2100 zone

Pre-planting

2030

2050

Conclusion

The urgent need to mitigate climate change requires much swifter and substantial action than we are seeing from political and corporate leaders, and although public environmental awareness has increased in the past few decades, environmental degradation continues. Greater efforts are needed if we are to stop environmental destruction. In our capacity to act as agents of social change, landscape architects and designers can focus on renewing a mutually beneficial relationship between people and the rest of the natural world.

The designs in this practicum are an interpretation of how landscapes might achieve this goal. Landscapes predicted to undergo specific climate change-induced alterations have been identified and interventions proposed to accentuate these changes. The designs promote understanding and appreciation of local ecosystems by encouraging reflection on relationships between people and non-human nature. They enable up-close experiences in landscapes with evolving narratives that become richer with subsequent visits. By revealing otherwise difficult to perceive global phenomena, these landscapes make local effects of climate change visible and palpable.

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30	Burning Ice Book Cover	'Burning Ice: Art & Climate Change' by Cape Farewell
30	Weather Report Book Cover	Boulder Museum of Contemporary Arts
31	Byxbee Park Telephone Posts	Darrell Stein
32	Map of National Tourist Routes	www.nationaltouristroutes.com
51	Aerial photo of Palsa Hazel Ecological Reserve	Manitoba Conservation
69 & 70	Predicted Migration of Jack Pine and Sycamore	Published by Natural Resources Canada (Canadian Forest Service) and Agriculture and Agri-Food Canada. Reproduced with the permission of Natural Resources Canada, Canadian Forest Service.

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