Biodegradable Architecture

Finite Construction for Endless Futures

by

Munira Z.Karimjee

A thesis submitted to the Faculty of Graduate and Postdoctoral Affairs in partial fulfillment of the requirements for the degree of

Master of Architecture

Azrieli School of Architecture and Urbanism

Ottawa, Ontario

Abstract

The now defunct National Round Table on the Environment and the Economy (NRTEE) states that a brownfield is a large piece of land that has become contaminated, and subsequently abandoned, due to past commercial and industrial activities.[1] While brownfields have a dubious legacy, a transformative potential exists from a social, economic, and—most of all—environmental perspective.

Utilizing Paul Stamet's exploration of myco-technologies which has demonstrated new ways of rehabilitating degraded landscapes—along with ideas of biomimicry, this thesis seeks to study the interrelationship between architecture, landscape, and decay. The concept of biodegradable when applied to architecture becomes a manifestation of this interrelationship.

Biodegradable architecture suggests simultaneously both construction and demolition. The project explores the idea of a permanent building that produces impermanent and ephemeral architecture. These ideas manifest themselves as a factory for biodegradable architecture, where mycobricks are manufactured.

1 Government of Canada. National Round Table on the Environment and Economy. Cleaning Up the Past, Building the Future. Ottawa. 2003. Web. 4 Feb. 2014.

Acknowledgements

I'd like to thank my advisor Dr. Stephen Fai, for his support of my ideas and sense of humor.

To Mike Getz and Mark MacGuigan; arriving to the conclusion of my studies has been all the more pleasant with your assistance throughout the years.

I wish to thank a well-timed response from Philip Ross, who kindly answered my questions and enabled me to tie in a few missing pieces.

There were all the various people in the computer lab who generously took their time to help me advance my computer skills a lot. Special thanks to my coffee shop colleagues for allowing me to talk endlessly about everything except thesis things. Thank you to my classmates who were with me in the basement that also let me ramble and who provided meaningful feedback.

I am indebted to the unexpected friendships I have made over the years. I am especially thankful to Ryan, Claire, Evan, Gabriela and Chrissy for the long discussions, words of encouragement and unique insights into many things (including) and beyond my thesis work.

Thank you to my parents and my cousin for their enduring patience and for their support in whichever way possible they could lend it.

Finally, I'd like to express my sincerest gratitude to the most unreasonably modest, Jessica Coburn whose friendship has brought an awesome combination of dark humor, kindness, wisdom and a tremendous source of comfort to me.

For my mother and my father; the most original dreamers that I know—I continue to be inspired by you.

Table of Contents

Introduction

I remember my first act of environmental vandalism: my cousin and I kicked an ant hill and decided to play with the dirt. I was spared the consequences of my actions but unfortunately my younger cousin was not. The ants crawled over her body until they were sprayed away with water. For me, there still remains a healthy amount of fear (and awe) for ants.

I think, more importantly, this early childhood memory instilled within me a great respect for the natural built environment. These are surroundings that humans have had very little to do with until recently in the history of human evolution. Following the industrial revolution, nature was seen as something to be conquered, humans against the wilderness. Now, it is quite obvious that humans exist and nature persists. With this paradigm shift, arrived the idea of biomimicry—a human systems design process that is almost always preceded by the question: what would nature do here? More specifically, biomimicry is seen as innovation inspired by design. Janine Benyus, a major proponent behind this concept, posits that biomimicry allows us to learn from nature. That is, there is an opportunity to be a part of our environment instead of apart from the nature that surrounds us.[1]

In that light, biodegradable architecture is an investigation into a materiality that supports "polite" decay. Equally, it is an attempt to view architecture as a decomposable object. Actually, a lot of architecture already exists as a product with a shelf life. The problem is what exactly happens with the architectural debris? Through their book *Cradle to Cradle,* architect William McDonough and chemist Michael Braungart extend the idea of biomimicry to suggest wastage as a positive. In other words, design can be conceived so that it is possible that its wastage equates to abundance.[2] For example, oyster mushroom farmers are left with spent compost (once the mushrooms have flourished) which can be used for remediating toxins from contaminated brownfields.

Brownfields are characterized as abandoned, contaminated lands, the result of past industrial and commercial activities.[3] Brownfields, however, hold the potential to implement aspects of biomimicry and thereby create an economically, socially, and environmentally thriving landscape. This is because brownfields can be healed through natural methods, in other words, bioremediation.

A type of bioremediation involves the use of fungi which is called mycoremediation.

There have been a number of studies in researching the successful application of fungal processes in a wide array of fields, from agriculture, to food, to environmental applications. Biologist Dilip Arora agrees, citing that the study of fungal biotechnology is continuing at a remarkable rate. The applications of fungal biotechnology are extremely exciting, from providing food security, agriculture fungicides to most importantly, environmental applications.[4] Utilizing the research of leading mycologist, Paul Stamet's explorations of "mycotechnologies" have demonstrated new ways of rehabilitating degraded landscapes. Along with ideas of biomimicry, this thesis seeks to study the interrelationship between architecture, landscape and decay.

Beginning with a brief overview of brownfields and brownfield development in Canada, Chapter 1 also explores a specific analysis of one of Ottawa's key brownfield sites, LeBreton Flats. Chapter 2 delves into current remediation technologies used to detoxify brownfield sites, with a focus on mycoremediation. Following an analysis of various types of remediation methods, Chapter 3 offers an examination of how brownfield development is advantageous to a city in a number ways, including from a historic urban cultural landscape perspective. A closer investigation of brownfield remediation when viewed as a business model reveals it as an opportunity for revitalizing neighbourhoods. Lastly, Chapter 4 outlines the proposed project, a factory for biodegradable architecture that produces mycobricks. These bricks made of mushrooms are used to facilitate a changing park proposal. The National Capital Commission's (NCC) plans to create a festival park plaza designated for music festivals in particular. A landscaping proposal also examines the way that landscape urbanism in conjunction with remediation can create an impetus for extending what urban infrastructure means. Because the bricks are decomposable, the park is able to adapt as required while benefiting the land. These components of the project explore the idea of a semi-permanent architecture that produces impermanent and ephemeral architecture.

Notes

1 Benyus, Jane. “Biomimcry.” *Nature’s Operating Instructions: The true biotechnologies*. San Francisco: Sierra Club Books, 2004. 5. Print.

2 McDonough, William, and Michael Braungart. *Cradle to Cradle: Remaking the Way We Make Thing*s. New York: North Point Press, 2002. Print.

3 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 5 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf>.

4 Arora, Dilip. *Fungal Biotechnology in Agriculture, Food and Environmental Applications*. New York: Marcel Dekker, 2004. X. Print.

Chapter 1: Brownfield Development

The now defunct National Round Table on the Environment and the Economy (NRTEE) states that a brownfield is a large piece of contaminated and abandoned land, the result of past commercial and industrial activities.[1] While brownfields have a dubious legacy, there is a transformative potential that exists from a social, economic, and—most of all—environmental perspective. This chapter investigates the etymology of a brownfield, the benefits and barriers to brownfield development specific to Ottawa, and lastly a focus on the brownfield LeBreton flats, the proposed site for the project.

Fig. 1.1 The NRTEE was active between 1988-2013 providing reports on Canada's economic and environmental status.

The NRTEE was an independent policy advisory agency to the Government of Canada. Their mission was to mediate economic and environmental concerns within public policy choices. NRTEE's aim was to provide feasible suggestions for sustainable development. It was active between 1988-2013 where it published many priority reports about forests, water issues, energy, air, climate issues, infrastructure, and brownfields.[2] At the end of March 2013, funding for the NRTEE ended and it was officially dismantled by the Conservative government under Stephen Harper.[3]

1.1 Brownfield Definition

The term “brownfield” was created in the early 1990s. At that time emerging regulatory frameworks were being formed to protect the environment—frameworks that effectively limited “the reuse, clean-up, and redevelopment of former industrial and commercial sites”, otherwise known as brownfields.[4] The most suitable definitions of a brownfield arrive from the NRTEE and the United States Environmental Protection Agency (USPEA). In particular, USPEA expands on the previous definition of brownfields, to state brownfields as “real property, expansion or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant”.[5] Brownfields are often used interchangeably with the term contaminated or polluted land.

1.2 Benefits of developing brownfields

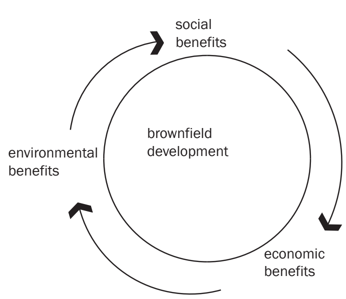


Fig. 1.2 Brownfield development benefits.

Since this time, cities have begun to see multiple benefits and advantages to developing brownfield land, including economic, social, and environmental.

Redeveloping brownfields is economically beneficial because it creates new opportunities for businesses that choose to develop on brownfield sites (for instance, being able to develop in city centre areas at lower prices), along with the creation and implementation of new clean-up technologies such as mycoremediation.[6] Since qualified experts are needed for proper clean-up of the site, it demands specific professionals who are qualified for such remediation work.

When a brownfield is elected to be remediated, an increase for all three levels of government is made through the development of new economic bases aiding property, income, and capital taxes. From a municipal perspective, a redeveloped site raises property tax revenues, which helps municipal governments finance public services.[7] At a provincial and federal level, brownfield investment creates increases in sales tax, goods and services tax, and revenues as well as bring up tax revenues.[8] On a micro-level, areas around brownfield sites have increased home values due to their redevelopment;[9] similarly, potential liabilities are diminished, such as polluted bodies of water.[10] In urban centres there is often very little or no available greenfield sites (pieces of land that have had no prior development on them) left—making decontaminated brownfield sites extremely attractive real estate. This is especially true in Ottawa, where many prime real estate locations are current brownfield sites.

Fig. 1.3 Partially remediated brownfield adjacent to the War Museum.

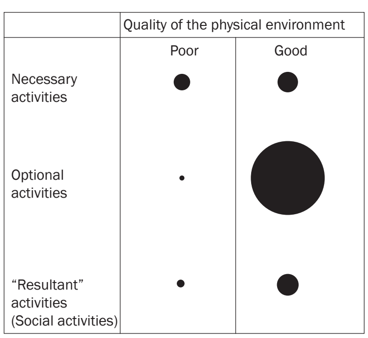


Fig. 1.4 Good quality outdoor spaces significantly increases social activty.

Some of these sites (for instance, LeBreton Flats) are currently urban blights despite the fact that remediation is taking place on these sites.

As environmental eyesores, contaminated lands severely impede positive social impact within a city. A positive social impact can be made by having a public place that is not only aesthetically pleasing but provides a pleasant experience as well. With redevelopment, a brownfield site not only acts as a catalyst for economic growth but for urban renewal as well. For example, depending on how the brownfield site is developed it can increase access to centrally located affordable housing. Furthermore, a better quality of life is possible when people are more easily connected to work, home, and recreational activities—all of which are made possible through centrally located brownfield redevelopment.[11] The space between work, home, and recreational activities is similar to what urban design consultant Jan Gehl cites as the three types of outdoor activities: necessary, optional, and social activities. Social activities, in particular, are spontaneous because in most instances they arrive from the other two categories (necessary and optional; work and home spheres). He elaborates his point by saying that these activities, these connections are formed "because people are in the same space, meet, pass by one another, or are merely within view."[12] Here lies the potential of brownfield sites to become the much needed public spaces within the city core. Where public space was not planned for, these abandoned fields can now fill that void.

On an environmental level, developing brownfield land significantly reduces urban sprawl. For every hectare of brownfield land used, roughly 4.5 hectares of greenfield land is saved from being developed.[13] As a result, the NRTREE has found that as much as up to $66 000 in transportation costs are saved when brownfields are redeveloped for residential purposes in comparison to greenfield development.[14] Moreover, increased housing on brownfield land close to workplaces allows the transportation needs of the residents, workers, and businesses to be significantly reduced—resulting in decreased transportation emissions.

The existence of pollutants on brownfield sites poses some risk to surrounding neighbourhoods and residents. Remediation of these sites allows improved environmental conditions and the removal of any threat to health and safety from past (mis) uses of the land.[15] Not only do these spaces enjoy greater environmental quality but future populations are able to benefit as well. Many cities have or are in the process of turning brownfield sites into urban park spaces or open spaces that are well integrated into the fabric of the city.[16] In this type of scenario, it is easy to see the economic, social and environmental benefits.

1.3 Key Challenges to Brownfield Development

Despite the benefits to developing brownfields, there are several challenges such as: financial barriers, reuse planning, clean-up considerations and environmental liability issues.[17] One prominent financial barrier is that often the clean-up cost of a brownfield site is ultimately more than the value of the property. As such, private lenders are hesitant to provide loans to damaged lands. This is particularly, true when clean-up costs are heavily dependent on environmental assessments —assessments that usually take longer than the real estate developments. Another challenge is reuse planning: often community goals and solid environmental information are lacking. As a result, sites are not able to reach their full potential because those involved are not fully informed. This leads to the final and most pertinent barrier to brownfield development, which is environmental liability. [18]

The Environmental Protection Act, otherwise known as the EPA, is a legislative framework overseeing aspects of environmental liability in Ontario. In 2001, the Brownfields Statute Amendment Law was passed, effectively creating legislative space for the revitalization and redevelopment of abandoned brownfields in Ontario.[19] A Record of Site Condition (RSC) is conducted to ensure that land is suitable for its intended use. This summary is an assessment of the following 5 conditions: (a) ownership of the property and current state of the property, (b) any environmental reports in regards to the property, (c) a list of environmental site conditions, (d) a serious inquiry into past environmental site conditions has been undertaken by a qualified person, and (e) the qualified person's assessment that all conditions for an environmental were made and in accordance with the Regulation, and the property is suitable for the proposed use.[20] What this technical legislative information means is that these laws—while creating regulation as they should—also make liability a very salient concern for proprietors wanting to develop brownfield land. Developers and property owners are entrusted to know about past and future liabilities. Taking responsibility for these liabilities often acts as a deterrent for many prospective private proprietors and investors.

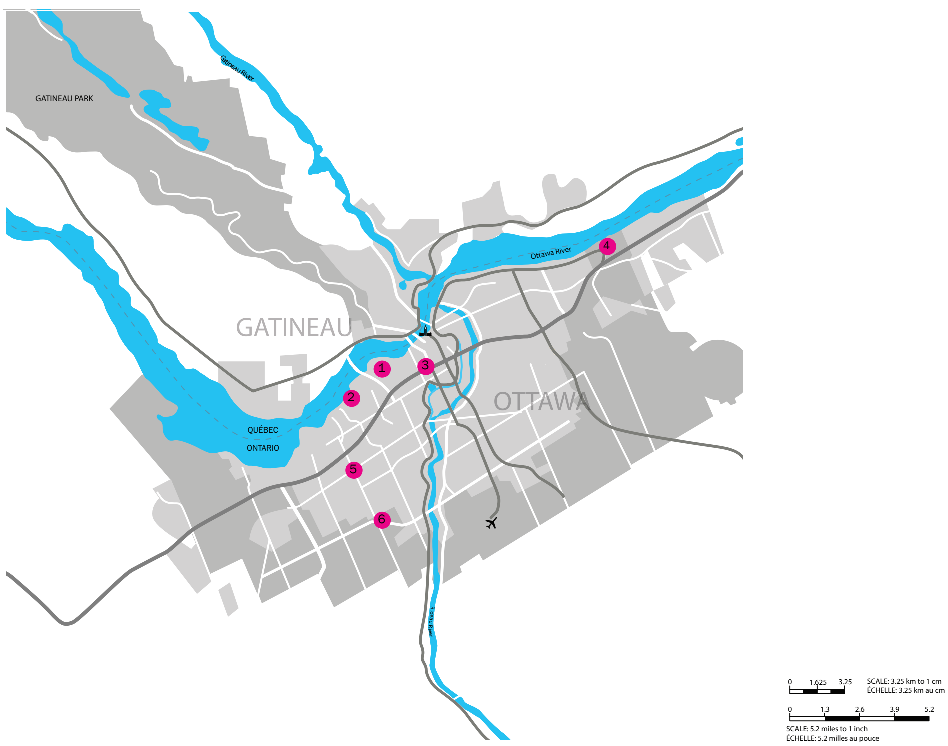
1.4 Situating the site

There are brownfields in nearly every developed nation across the world. While Canada has a less significant industrial history in comparison to other countries, (namely the US), in both countries, the brownfield sites are centralized to specific city cores.[21] In Canada, there are approximately 30 000 brownfields that manifest themselves in various ways: as discarded rail yards, former refineries, dilapidated warehouses, and essentially anywhere that toxins have seeped into the land. Ottawa is no exception. Being a historically industrial city, Ottawa hosts a large number of brownfield sites.[22]

Ottawa is a unique city in the wider scope of brownfield development in Canada.[23] This is

Fig. 1.5 Six major brownfields of Ottawa

1. LeBreton Flats
2. Bayview Yards
3. Landsdowne Park
4. CLC Rockliffe Lands
5. 1357 Baseline Road
6. 300 West Hunt Club Road



because Ottawa started out as a small industrial lumber town, which has created an interesting brownfield landscape. A key example, and the case study of this thesis, is LeBreton Flats. LeBreton Flats is a brownfield site located in close proximity to the War Museum, Parliament Hill, and Ottawa's downtown. Presently, the site is owned by the National Capital Commission (NCC). The site has a varied and lengthy history prior to the NCC taking over.

Fig. 1.6 Fire burning on LeBreton Flats. High winds carried sparks and embers across the Ottawa River.

Fig. 1.7 After the fire.

Before 1900, the site was mainly used for lumber and railway industries, but there were also residential units and neighbourhood retail facilities. This accounting for much of the pollutants found in the land. In the spring of 1900 a large fire decimated the site leaving behind ash and fire debris. After the fire, the site re-established itself with industrial manufacturing industries. Automobile service stations and scrap yards were also established in the years 1940-1950. In April of 1962, approximately 3 000 residents and property owners were given expropriation notices by the NCC. As a part of an overall plan envisioned by Jacques Greber, LeBreton flats was demolished so that a better view would be available from Parliament Hill.[24] Towards the end of 1965, Ottawa's most infamous and greatest urban renewal project was underway.[25]

Since then, the area has primarily sat vacant, albeit having been briefly a sanitary landfill site for use after the demolition, and a snow removal dumping site between the years of 1970-1990. The site has remained a sore topic of discussion because of the sudden expropriation of its residents and because, although many plans and redevelopments have been envisioned, little of them have come to fruition. The fascinating past of LeBreton Flat's previous neighborhood combined with decades of stagnant urban planning have molded the site into a fascinating cultural landscape.

Fig. 1.8 Soil contaminants: petroleum hydrocarbons, volatile organic compounds, polyscyclic aromatic hydrocarbons.

Political issues of the site aside, the soil contains extensive contaminants such as: petroleum hydrocarbons (PHC), volatile organic compounds (VOC), polycyclic aromatic hydrocarbons (PAH) and metals. Construction debris is buried beneath the site in addition to these pollutants.[26] As a result, the NCC has estimated the remediation costs to be roughly $71 million.[27] Once the land is remediated, the NCC intends to allocate 40% of the land to green spaces such as: a festival park, public space and recreational paths. The rest of the land will be designated for office spaces, street-level retail

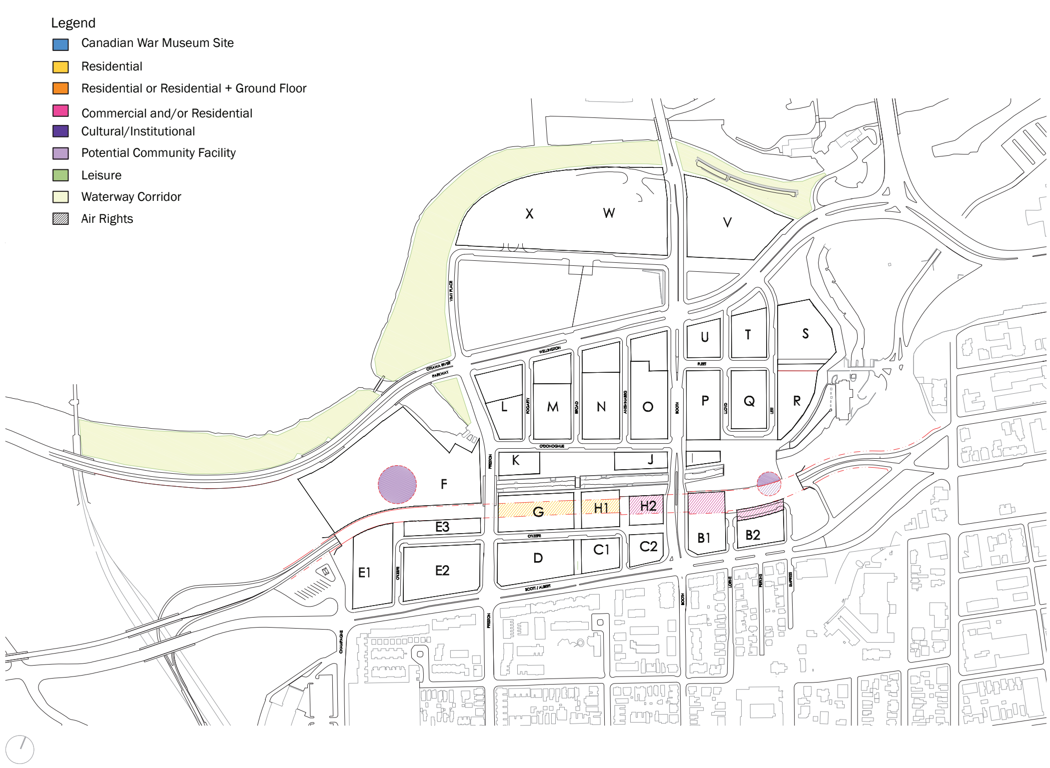


Fig. 1.9 NCC's proposed allocation of retail, residential and recreational spaces.

venues, and a mix of housing types and sizes. [28] The NCC aims to have the site remediated by 2017 and plans to use excavation as the remediation technique deemed most sustainable. This is because large portions of the polluted soil will be used to contour and fill Ridge Road. Otherwise, the contaminated soil will be diverted to an off-site waste disposal facility. [29]

Fig. 1.10 Levels of remediation on LeBreton Flats.

1.5 Conclusion

Brownfield development holds an incredible amount of potential to completely transform parts of a city and even the entirety of city itself. With the many advantages to brownfield development and the number of brownfield lands in Ottawa, it is safe to conclude that the transformation of these lands would only have a positive impact on the city of Ottawa. LeBreton Flats has been a contentious piece of land for many decades. The betterment of this piece of land creates an opportunity for not only the land to be remediated but gives it a new historical, cultural, economic, and social revision. With brownfield development entering the realm of landscape design, there is also an opportunity to incorporate a public space that grows into a park for all ages and for all social classes. The first step to enabling brownfield development as a catalyst for landscape design and social renewal is the act of remediation itself. The physical amelioration of the land leads to renewal and improvement in many other dimensions.

Notes

1 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 4 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf>.

2 Government of Canada. National Round Table on the Environment and the Economy. *Our Mission*. 2013. Web. 28 Jan. 2014. <http://collectionscanada.gc.ca/webarchives2/20130322143635/http://nrtee-trnee.ca/mission-––finding-sustainable-pathways>.

3 Grandia, Kevin. “Leaked: National Roundtable on the Environment and Econom’ys Final Farewell Report.” *Desmog Canada*. Web. 17 Mar. 2014. <http://www.desmog.ca/2013/03/26/leaked-national-roundtable-environment-and-economy-s-final-farewell-report>.

4 Hollander, Justin, and Julia Gold. *Principles of Brownfield Regeneration*. Washington: Island Press, 2010. 1. Print.

5 United States Environmental Protection Agency. (2014). *Brownfields and Land Revitalization*. 2014. Web. 13 Feb. 2014. <http://www.epa.gov/brownfields/>.

6 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 2 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf>.

7 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 4 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf>.

8 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 4 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf>.

9 De Sousa, Christopher. “Assessing the Effect of Publicly Assisted Brownfield Redevelopment on Surrounding Property Values.” *Economic Development Quarterly*. 2.23 (2009): 95-110. Print.

10 Sarni, William. *Greening Brownfields.*New York: McGraw-Hill, 2010. eBook.

11 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 5 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf>.

12 Gehl, Jan. *Life Between Buildings: Using Public Space*. Washington: Island Press, 2011. 12. Print.

13 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 4 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf>.

14 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 28 Jan. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf>.

15 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 4 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf>.

16 De Sousa, Christopher. *Brownfields Redevelopment and the Quest For Sustainability*. Amsterdam: Elsevier, 2008. 155. Print.

17 United States Environmental Protection Agency. *Brownfields and Land Revitalization*. 2012. Web. 5 Feb. 2014. <http://www.epa.gov/brownfields/overview/anat_bf_redev_101106.pdf>.

18 United States Environmental Protection Agency. *Brownfields and Land Revitalization*. 2012. Web. 5 Feb. 2014. <http://www.epa.gov/brownfields/overview/anat_bf_redev_101106.pdf>.

19 *Brownfields Statute Law Amendment Act*, *2001,* S.O. 2001, c. 17.

20 McMillan Binch LLP. *Brownfield Tool Kit*. 2005. Web. 17 Feb. 2014. <http://www.mcmillan.ca/Files/Brownfield_Toolkit_0405.pdf/>

21 De Sousa, Christopher. *Brownfields Redevelopment and the Quest For Sustainability*. Amsterdam: Elsevier, 2008. 6. Print.

22 Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 4 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf/>.

23 Ousley, Mark. “Capital Brownfields: An Assessment of Brownfield Planning Policy in the City of Ottawa, Ontario.” University of Waterloo, April 2013. Web. 10 Feb. 2014. <https://uwspace.uwaterloo.ca/bitstream/handle/10012/7545/Ouseley_Mark.pdf>.

24 NCC Watch. Web. 6 Feb. 2014. <http://www.nccwatch.org/blunders/lebreton.htm>

25 City of Ottawa. Heritage Ottawa. *Heritage on LeBreton Flats: Commemorating the 1962 Expropriation*. Ottawa: 2012. Web. 3 Mar. 2014. <http://heritageottawa.org/en/heritage_lebreton_flats_commemorating_1962_expropriation>.

26 Government of Canada. Canadian Environmental Assessment Agency. *LeBreton Flats Remediation and Infrastructure Project*. Ottawa: , 2012. Web. <http://www.ceaa.gc.ca/052/details-eng.cfm?pid=63727>.

27 Willing, J. *Cost of Cleaning up Contaminated Soil at Ottawa’s LeBreton Flats Could Top $71 million, National Capital Commission says*. *Ottawa Sun,* 22 Dec. 2012 Web. 4 Feb. 2014. <http://www.ottawasun.com/2012/12/22/cost-of-cleaning-up-contaminated-soil-at-ottawas-lebreton-flats-could-top-71-million-national-capital-commission-says> .

28 Capitale. *LeBreton Flats Revitalization*. Web. 4 Feb. 2014. <http://www.canadascapital.gc.ca/planning/master-plans/lebreton-flats-revitalization>

29 Lapointe, François, Fred Gaspar, and Eric Soulard. “LeBreton Flats Remediation and Infrastructure Project.” *NCC-CCN*. NCC, 13 11 2012. Web. 10 Feb 2014. <http://www.ncc-ccn.gc.ca/sites/default/files/pubs/2.00_-_2012-p79e-board-remediation_of_lebreton_north.pdf>.

Chapter 2:
Brownfield Remediation

Remediation of contaminated land is an action that eliminates or mitigates contaminants found in the land.[1] Successful brownfield regeneration relies on various remediation technologies that depend on how heavily polluted the land is. Consequently, brownfields can be enhanced into usable pieces of land in a number of ways. There are two categories of remediation: in-situ and ex-situ. In-situ treatments involve treating the pollutants without removing the soil, whereas ex-situ methods require excavation or removal of the contaminated soil. A brief overview of remediation technologies is necessary in order to situate the proposed method of treatment for LeBreton Flats.

Overview of Remediation Technology

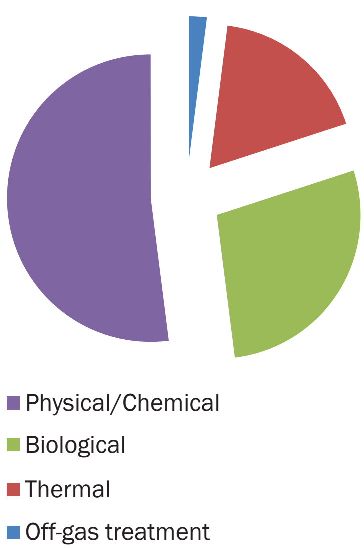


Fig. 2.1

2.1 Remediation technologies

According to the United States Environmental Protection Agency (US EPA), remediation technology falls under four categories: physical, biological, thermal and off-gas treatments.[2] The following descriptions give very brief explanations of common remediation technology in each category: physical (excavation), thermal (incineration) and off-gas (thermal desorption). For the category of biological techniques, the most common remediation technique is naturally, bioremediation. The remainder of the chapter focuses on a subset of bioremediation, a relatively new technique called mycoremediation.

Excavation

This process involves isolating and scooping out contaminated soil so that it can be placed in an approved landfill. Excavation requires use of a bulldozer or a backhoe for the soil to be displaced and cleaned. Alternatively, the toxic soil can be cleaned on-site. The consequent holes are used as a part of the design strategy or filled up with clean soil.[3]

Incineration

With incineration, pollutants are burned at extremely high temperatures to expunge the harmful chemicals. It requires an incinerator on-site, or for the hazardous material to be transported to an incinerator. Once the contaminated soil is put into the incinerator, the amount of heat and air is controlled so that a higher percentage of detrimental toxins will be removed. The waste product from the process of incineration is poisonous and must be deposited in a licensed landfill.[4]

Overview of Physical/ Chemical Remediation Technology

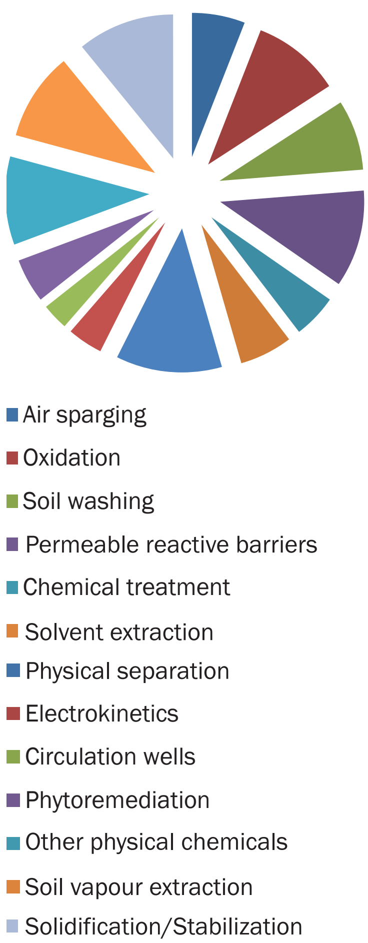


Fig. 2.2

Thermal Desorption

The volatility of the toxins found in the despoiled land is heated up so that can be eliminated from the solid soil matrix. Whereas the incineration method destroys the pollutants by heating and burning, thermal desorption breaks the pollutants down by chemicals. Two components are required for this type of remediation: a desorber and an off-gas treatment system. Desorbers are enkindled rotary systems that inclined rotating metallic cylinder to heat the solidified pollutants. The heat is transferred though conduction in a cylindrical wall. With this kind of system, the solidified pollutants are separate from the flame or the products of combustion. The volatized pollutants are then collected, destroyed and released into the atmosphere. [5]

Bioremediation is the use of biological techniques to clean up polluted environments. Specifically, it necessitates the use of microorganisms, which are pivotal to the deterioration of particular toxins.[6]

Bioremediation is an appealing solution to many contaminated sites because it can be an effective solution to the more resistive components of oils. Unfortunately, it can be a more costly option because the soil being treated might require extra manipulation, more chemical applications, and added microbes to augment the degradation

Overview of Biological Remediation Technology

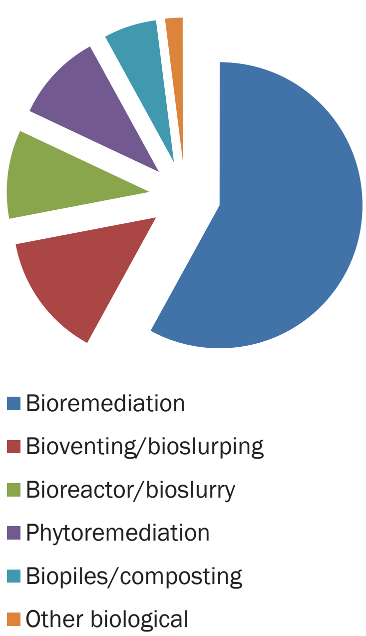


Fig. 2.3

process. Often times bioremediation can require a long time-span, however, there is a high potential for roughly quick treatment times depending on the type of bioremediation used.[7]

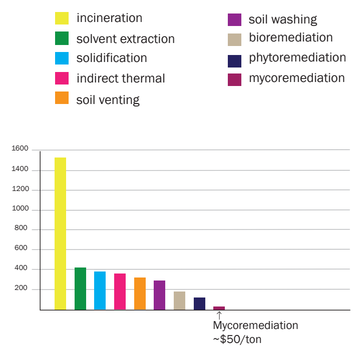


Fig. 2.4 Remediation Technology.

Graph. P.Stamets. *Mycellium Running*. First. New York: Random House, 2005. 91. Print.

2.2 Mycoremediation

Mycoremediation is a subset of bioremediation and an emerging technology. It is derived from mycology; a field of biology devoted to studying fungal life. Paul Stamets is a mycologist committed to promoting the benefits of mushrooms. He is spear-heading a new way of healing damaged earth through the use of "myco-technologies".[8]

To understand the process of mycotechnologies it is first important to understand how mushrooms grow. The mushroom is the edible, fleshy part of a larger organism that grows underground called mycelium. Mycelia help to maintain a healthy ecosystem by creating soil in which other plants can grow. Once the mycelium begins to decompose the wood mixture, mushrooms are able to sprout. When a mushroom sprouts above ground it is considered a defining moment in the life cycle of the mycelium. This is because once the mushroom is formed, specialized cells on the gills or the pores produce spores that are released into the air. As these spores begin to germinate, a new bed of mycelium (mycelial mat) is formed. In addition, bacteria use rotting mushrooms as an abundant base for

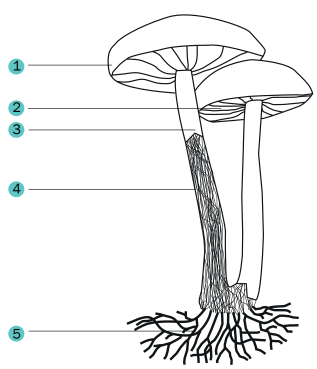


Fig. 2.5 Parts of a Mushroom.

1. Cap
2. Gills
3. Stalk
4. Hyphae
5. Mycelium

growth, allowing the release of nutrients and a multitude of microbes that destroy the structure of mushrooms as they melt into the soil. Soon after, the bacterial influx facilitates the emergence of plant communities. Ultimately, nature fosters complex partnerships of interdependence, with fungi creating the path to ecological recovery.

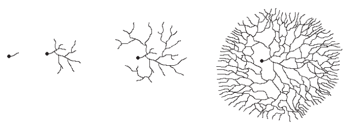


Fig. 2.6 Diagram showing the expansion of mycellium structure.

Mycellium refers to the mass of branches (the vegetative part of the fungus). Hyphae is the name given to the branches.

Mycotechnologies, then, involve the multiple ways in which mycelium membranes can be used to salvage ecosystems. This is because, mycelium breakdown chemicals as they do wood compounds. As a treatment, then, mycellium is first mixed in with polluted soils, and then placed as a mat over toxic areas in one or many treatments. The enzymes that are then secreted by particular fungi digest lignin and cellulose, the primary structural components of wood. This is key to the process because these digestive enzymes can also break down a surprisingly wide range of toxins that have chemical bonds similar to those in wood. The ability for mycotechnologies to salvage ecosystems is dubbed “mycorestoration” by Stamets. Mycorestoration involves using fungi in different ways to form four different categories: mycofiltration, mycoforestry, mycoremediation, and mycopesticides. Mycofiltration is a way to reduce silt from upstream pollutants. Mycoforestration is where forest health is ameliorated through the

Fig. 2.7 Oyster mushrooms (Pleurotus ostreatus).

Fig. 2.8 Maitake (Grifola frondosa).

Fig. 2.9 Reishi (Ganoderma lucidum).

use of mushrooms. Mycopesticides uses mycelium to minimize and control pest populations. Lastly, mycoremediation involves using fungal resources to facilitate brownfield remediation. In Stamet's words, "mycoremediation is the use of fungi to degrade or remove toxins from the environment".[9]

These fungi, or mushrooms as they are commonly referred to can be placed into two sub-categories because of the way they rot: brown rotters and white rotters. White rot fungi are more abundant than brown rotters. Brown rotters produce enzymes to decay hemicellulose and cellulose and create dry rotting wood. Meanwhile, white rotters produce enzymes that break down the brown fibre in wood, leaving the cellulose largely intact and therefore giving the wood a white appearance. Examples of powerful white rot mushrooms include: oyster mushrooms (Pleurotus ostreatus), maitake (Grifola frondosa), turkey tail (Trametes versicolor), reishi (Ganoderma lucidum), and artist conk (Ganderma applanatum). White rot mushrooms are mycoremediators of toxins held together by hydrogen-carbon bonds. Moreover, only white rot mushrooms seem to produce specific types of enzymes that mineralize wood, and therefore are especially efficient in breaking down hydrogen-carbon bonds. Since many of the bonds that hold plant material together are similar to the bonds

Fig. 2.10 Turkey tail (Trametes versicolor).

Fig. 2.11 Artist conk (Ganoderma applanatum).

found in petroleum products - including diesel, oil, and many herbicides and pesticides - mycelial enzymes are adept for decomposing a wide spectrum of durable toxic chemicals.[10]

From these complex processes it is safe to say that mycelium are a catalyst for life, and as such mycotechnologies are a perfect solution to bringing brownfield sites back to life.

2.3 Why mycoremediation & bioremediation?

With the use of mycoremediation toxic landscapes can turn into usable, thriving real estate. It provides- an inexpensive solution; the cost is significantly reduced since thousands of tonnes of polluted soil do not need to be moved to a remote toxic waste storage site. Whereas the current remediation technology employs techniques that render the earth lifeless, bioremediation and more specifically mycoremediation, prescribes a flourishing environment.[11]

The Washington State Department of Transportation (WSDOT) maintenance yard is an excellent example of a mycoremediation case study. Between 1997 to 1998, Stamets was a part of a research group conducting experiments with Batelle—an independent research facility under the umbrella of Pacific Northwest National Laboratory which works for the Department of Energy in

U.S.A.[12] As a technology development organization, in addition to an independent research laboratory, Stamet's work with Battelle provided an instance to test mycoremediation.[13]

The former maintenance yard for trucks that the Washington State Department of Transportation in Bellingham, Washington, had managed for over 30 years was extremely toxic. Approximately 2% of the soil was polluted with diesel and oil or 20 000 parts per million (ppm) of total aromatic hydrocarbons (TAHs). While that amount might not appear significant, it is around the same amount of contaminants found on the beaches of Prince William Sound after the *Exxon Valdez* spewed its 11 million gallons of petroleum in 1989.[14]

Fig. 2.12 Oyster mushrooms growing on contaminated soil.

Photograph. P.Stamets. *Mycellium Running*. First. New York: Random House, 2005. 91. Print.

Four piles of diesel polluted soil were set aside by the WSDOT in the spring of 1998 for the purposes of remediation experimentation. The piles of soil were roughly 1 metre high (3 feet), 6 metres in length (20 feet) and about 2.5 metres (8 feet) in width. One pile was colonized with mycelial spawn for oyster mushrooms while the other 2 piles were colonized using different bacterial treatments. The remaining pile was an untreated control. The mushroom inoculated pile was kept under a shade cloth while the other piles were covered with black plastic tarps so that they could be protected from the rain. Nearly 4 weeks later, the scientists came back to 3 piles of lifeless piles of dirt that stank of crude oil. They were pleasantly surprised by the fourth pile. To their amazement they found “a huge flush of oyster mushrooms numbering in the hundreds”.[15] This was particularly shocking for the scientists because such large numbers of mushrooms are usually found in nutrient rich environments, not in heavily polluted soils. As the abundant crop began maturing, insects began to lay their eggs in the soil, which then attracted birds, which brought seeds. The once lifeless pile of soil turned into its own flourishing ecosystem.[16]

Fig. 2.13 Regreened pile of formerly contaminated soil.

Photograph. P.Stamets. *Mycellium Running.* First. New York: Random House, 2005. 91. Print.

Along with creating a diversified biosphere within a short timeframe, the researchers found that the oyster mushrooms were edible as well (after some time had passed and the mushrooms had been deemed safe after being tested for chemicals). Battelle researchers also concluded that the total petroleum hydrocarbon levels had dropped dramatically within 8 weeks, making the soil acceptable to be used for freeway landscaping.[17]

2.4 Why isn’t mycoremediation more popular then?

Biological and legal factors have made it difficult for bioremediation to take off as a commercial practice. One drawback, according to Stamets, is that as an emerging science, mycoremediation has yet to be proven as a profitable practice -

despite the fact that it is a cost-effective solution. Another issue is that mycoremediation lacks plain unequivocal evidence to its effectiveness. Meaning that, many times, mycoremediation becomes too effective and inadvertently succeeds in cleaning several targets. This subsequently poses a legal problem by violating an issued patent designed for fungi remediation. While the patent violation might be inadvertent, it is not a good defence against a lawsuit. The issue of patents act as good hindrance against the wide-spread use of mycoremediation.[18]

In spite of these barriers, mycoremediation still has an exciting potential to become a commercially viable business. For example, mycoremediation projects can be congruent side activities from “spent” compost found on a mushroom farm. Spent compost or otherwise known as “mushroom compost” is soil that is full of intertwined mycelial threads. It is discarded soil once mushrooms have flushed “to the point of diminished returns”.[19] As it turns out, farmers growing oyster mushrooms have very limited market for their spent compost once the mushrooms have been harvested—presenting a wonderful opportunity to use this material for mycoremediation. Stamets ardently views not using this type of by-product as an inefficient use of resources. In fact, he adds that this is a notion that goes well with the concept of natural capitalism; a term coined by Paul Hawken who is a prominent environmentalist and entrepreneur .[20] Mushroom farms begin to set the stage for regional mycoremediation enterprise.[21]

2.5 Biology as business

When Hawken uses the phrase natural capitalism, he alludes to the notion of a new type of emerging economy.[22] It is an economy that is expanding on what nature means; nature that is no longer a wild wilderness to be conquered but an environment that we participate in—without rendering the earth crippled. For Hawken, commerce *is* the solution where the merging of economics and environment acts as the second industrial revolution.[23] Calculated design of industrial facilities can accomplish a better preservation of the landscape and environmental conservation.[24] Achieving this type of architecture requires a design process based on values where design is a thoughtful outcome that is as aesthetically engaging as it is environmentally sound.[25]

These are ideas that are sprouting in many places. It is a notion that has been extensively covered in Michael Braungart and William McDonough's *Cradle to Cradle: Remaking the Way We Make Things.* Architect Braungart and chemical engineer McDonough are proponents of a design method that utilizes a biomimetic approach; efficient design that is primarily waste free. Their holistic framework towards design was put into practice when the duo was contacted by DesignTex, a subsidiary of Steelcase, to envision and develop a compostable upholstery fabric. They were asked to create an attractive yet unique fabric that was also “environmentally intelligent”. To paraphrase the case study, ultimately Braungart and McDonough designed a comfortable fabric that not only did no harm but was nutritious to the environment. For example, what this meant for the textile mill where the fabric was being produced was that the water coming out of the factory was cleaner than the water going into the factory.[26] The benefits of their design approach were tremendous. Workers no longer had to wear gloves and masks, which gave them little protection against the toxins they normally worked with. The textile mill was no longer required to submit regulatory paperwork, freeing up time and resources. Furthermore, the end product, the fabric itself, could be disposed of by the user. It could be thrown away guilt free into a soil or compost heap.

2.6 Benefits of mycoremediation technology to LeBreton Flats

Using mycoremediation technology on LeBreton Flats can provide numerous benefits, similar to the cradle to cradle approach. LeBreton Flats has many contaminants that are particularly well suited to be remediated by oyster mushrooms (best for petroleum hydrocarbons).[27] Other pollutants found on LeBreton flats are lead and mercury, which are best alleviated by the parasol mushroom (macrolepiota procera) and the penny bun (boletus edulis) respectively.[28] Harvesting mushrooms on LeBreton Flats creates space for an emerging science and an emerging business model. On a gastronomic level, LeBreton Flats could become an extremely large mycofarm, and a space able to provide mushrooms to the restaurants and mushroom enthusiasts of Ottawa. Consequently, filling this particular niche of the food industry with its placement on a brownfield may make for an interesting eco-tourism attraction. Mycoremediation offers a flexible approach with minimal cost and effort.[29] Additionally, the use of mushrooms to rejuvenate the land of LeBreton Flats allows the remediation process to become one that is visible to the people of Ottawa. Given the site's contentious history, the visibility of the remediation process could help to refresh the site historically. Symbolically, the fungi decompose past perceptions of the site as well as give new purpose to the site through its use and future landscape design proposal. The process of mycoremediation will allot usable soil for many other purposes such as freeway landscaping and the project proposal.

2.7 Conclusion

Among the variety of remediation methods, bioremediation is most ideal for LeBreton Flats because it allows for the potential of a cradle to cradle method of design. There is an opportunity to have mycoremediation create a unique business model that is based on biology and a system inherent to nature. As an emerging science, mycoremediation also facilitates opportunity for this type of science to gain empirical evidence. It is a method that cannot gain in popularity without municipalities taking a risk. The risk is relatively small for the exciting amount of potential that mycoremediation holds. Particularly, in the realm of design—landscape design will soon become synonymous with an aesthetic way of remediation that captures the essence of landscape urbanism.

Notes

1 Government of British Columbia. Ministry of Environment.*Acronyms and Definitions*. Web. 18 Mar. 2014. <http://www.env.gov.bc.ca/epd/remediation/a&d.htm>.

2 United States Environmental Protection Agency. *Innovative Remediation Technologies: Field-Scale Demonstration Projects in North America*. 2012. Web. 20 Feb. 2014. <http://www.clu-in.org/download/remed/nairt_2000.pdf/>.

3 Hollander, Justin, Niall Kirkwood, and Julia Gold. *Principles of Brownfield Regeneration*. Washington: Island Press, 2010. 33. Print.

4 Hollander, Justin, Niall Kirkwood, and Julia Gold. *Principles of Brownfield Regeneration*. Washington: Island Press, 2010. 33. Print.

5 Hollander, Justin, Niall Kirkwood, and Julia Gold. *Principles of Brownfield Regeneration*. Washington: Island Press, 2010. 36. Print.

6 Collins, Chris. "Implementing Phytoremediation of Petroleum Hydrocarbons." Neil Willey. *Phytoremediation:Methods and Reviews*. Totowa: Humana Press, 2007. 102. Print.

7 Collins, Chris. "Implementing Phytoremediation of Petroleum Hydrocarbons." Neil Willey. *Phytoremediation: Methods and Reviews*. Totowa: Humana Press, 2007. 102. Print.

8 Ausubel, Kenny, and J.P Harpignies. *Nature's Operating Instructions: The True Biotechnologies*. San Francisco: Sierra Club Books, 2004. 33. Print.

9 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 86. Print.

10 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 89.Print.

11 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 93. Print.

12 "About PNNL." *Pacific Northwest National Laboratory*. U.S Department of Energy. Web. 7 Feb. 2014. <http://www.pnnl.gov/about/>.

13 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 92. Print.

14 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 92. Print.

15 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 92. Print.

16 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 92. Print.

17 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 92. Print.

18 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 93. Print.

19 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 102. Print.

20 Hawken, Paul. "Natural Capitalism: Brother, Can You Spare a Paradigm?" *Nature's Operating Instructions: The True Biotechnologies*. San Francisco: Sierra Club Books, 2004. 147-160. Print.

21 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 102. Print.

22 Hawken, Paul. "Natural Capitalism: Brother, Can You Spare a Paradigm?" *Nature's Operating Instructions: The True Biotechnologies*. San Francisco: Sierra Club Books, 2004. 147-160. Print.

23 Hawken, Paul. "Natural Capitalism: Brother, Can You Spare a Paradigm?" *Nature's Operating Instructions: The True Biotechnologies*. San Francisco: Sierra Club Books, 2004. 147-160. Print.

24 Rogers, Jean. "Industrial Evolution: prevention of remediation through design " *Manufactured Sites: Rethinking the Post-Industrial Landscape*. London: Spon Press, 2001. 106. Print.

25 Rogers, Jean. "Industrial Evolution: prevention of remediation through design " *Manufactured Sites: Rethinking the Post-Industrial Landscape*. London: Spon Press, 2001. 106. Print.

26 McDonough, William, and Michael Braungart. *Cradle to Cradle: Remaking the Way We Make Thing*s. New York: North Point Press, 2002. 105-109. Print.

27 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 93. Print.

28 Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. 106. Print.

29 Ley, Justin. "Mycoremediation." *Bioremediation*. Wikispaces. Web. 3 Mar. 2014. <http://bioremediation123.wikispaces.com/Mycoremediation>.

Chapter 3:
Landscape as Verb

Fig. 3.1 Eisenman's Wexner Centre at Ohio State University is an architectural representation of palimpsest.

Palimpsest as concept in landscape architecture means there is an opportunity to implement diverse layers of landscape both geographically and culturally.

Landscape urbanism is an important topic. It is particularly relevant in Canada, because along with the shear amount of geography, Canadian heritage is inextricably connected to its landscape. With this type of cultural and geographical climate lies an opportunity to embrace landscape urbanism as a building block for identity making. In other words, landscape urbanism has the potential to provide the framework for bridging abandoned industrial landscapes (brownfields) into culturally appropriate, socially viable, environmentally friendly and even economically vibrant landscapes. Rather than hiding a polluted past, the industrial heritage of LeBreton Flats can be revealed through ideas of a palimpsest. A designed landscape allows a physical and cultural palimpsest to unfold in an interesting way. Peter Eisenman's architectural discourse in the 1980s conceptualizes the site as a palimpsest; as a manuscript that is reused many times where the previous work is somewhat visible.[1] Viewing the site this way allows designers to utilize the history of the site and to "add a new layer of self-conscious fiction." [2] For any landscape, this is a compelling way to utilize its history and reinvent the perceived image of a physical landscape through design. Especially in a Canadian context, landscape urbanism helps situate new infrastructure as a means of creating and maintaining identity. For LeBreton Flats, remediating the polluted soil on site allows for the physical and cultural heritage to be reclaimed for the public through landscape urbanism.

Overview of landscape urbanism

The history behind the term landscape urbanism and the evolution of the discipline has made pinpointing its definition into a somewhat nebulous and contested subject. Through the work of Patrick Geddes, a Scottish town planner, who introduced regional planning to architecture, Aldo Leopold, a forefather to the modern environmental movement, environment and planning became forever coupled. Their efforts, among other theorists provided the groundwork for regional environmental planning. Most notably, it led to the development of the ideas of Ian McHarg. In 1954, McHarg was given the opportunity to establish the University of Pennsylvania's landscape architecture and regional planning program. His vision of landscape architecture has profoundly impacted the discipline ever since. Another professional program that heavily influenced how the discipline took shape was Harvard University's landscape architecture department under the guidance of Hideo Sasaki. At this time, landscape architecture played a peripheral role in the process of urbanization. Moreover, the profession took on the role of conservation-based planning, with a design focused specifically on individual sites. [3]

From this period onwards, and between the years 1960 to 1980, landscape architecture emerged into a professional discipline where it has since grown in scale and scope. [4] With land-art also gaining prominence, a gradual shift from landscape architecture to landscape urbanism began to occur.

Towards environmental stewardship

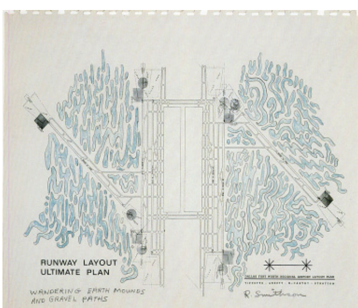


Fig. 3.2 Robert Smithson. *Dallas-Fort Worth Regional Airport Layout Plan: Wandering Earth Mounds and Gravel Paths*, 1967.
The proposal was not ever realized.

The term land art or earthworks was originally coined by the artist Robert Smithson in his proposal *Dallas-Fort Worth Regional Airport Layout Plan: Wandering Earth Mounds and Gravel Paths*, 1967. The proposal describes this particular type of art, where the earth acts as an essential component of an intentional piece of work. For him, human intervention onto a landscape was a natural as an earthquake affecting the landscape.[5] Smithson's earthworks conveyed the sense that there is no difference between culture and nature.[6] Moreover, Smithson discusses how artists are increasingly drawn to this type of art because there is an inherently creative potential of the landscape.

Accordingly, Smithson's aerial art called *Wandering Earth Mounds and Gravel Paths* at Dallas Fort Worth (DFW) Airport attempts to address an aspect of motion, which is to demonstrate time and to define space. [7] Between the way time manifests itself and defining space rests a series of ambiguities: natural/artificial, decay/stability, control/uncertainty, and waste/progress.

These same ambiguities (and sometimes strategies) are found in the way landscape urbanism is practiced and through the numerous attempts at being defined. Many essays that have been written to describe the specificities of landscape urbanism. The intellectual impetus for the topic began at the Landscape Urbanism conference in April 1997.[8] Charles Waldheim, one of the primary organizers of the conference outlines the term in his book *The Landscape Reader* as such*:*

"Landscape Urbanism describes a disciplinary realignment currently underway in which landscape replaces architecture as the basic building block of contemporary urbanism. For many, across a range of disciplines, landscape has become both the lens through which the contemporary city is represented and the medium through which it is constructed."[9]

Increasingly, the “realignment” of landscape urbanism is intertwined with environmental awareness and a sustainable agenda. Although, sustainability is an equally vague term, for the purposes of the discussion here, it is defined as the interrelationship between built environments with the natural. More specifically, sustainability is a philosophy derived from values-based design. Creating thoughtful design that positively impacts the environment, the economy and an overwhelmingly pleasant place for people to enjoy should be the intentions behind any sustainable building—not as an empty passage into current trends. Landscape urbanism is often sustainable because it cannot afford to be neutral or fashionable when it is a discipline dealing with interjections onto the land. With these ideas, landscape urbanism provides a framework for environmental stewarship that promotes solutions that are sensible for both nature and for people.

Fig. 3.3 Martha Schwartz Partners project in London, UK. St. Mary’s Churchyard Park. 2007.

Martha Schwartz’ vision of landscape urbanism support notions of sustainability. She posits that unlike architecture, landscape urbanism is not object-based but rather it is a “broader concept that is salient to the integration of ecological systems as they apply to the ‘systems’ of human habitation.”[10] She continues by also remarking how the boundaries between the design professions will, ultimately, be made indistinct.

Similarly, landscape architect James Corner writes in his essay “Terra Fluxus” that “certain elements within each of the design professions—architecture, landscape architecture, urban design, and planning—are moving toward a shared form of practice, for which the term landscape holds central significance, as described through the formulation *landscape urbanism.*” This nebulous term begins to act as verb, a catalyst for a new hybrid discipline that intersects architecture with landscape in a formal way.

Another landscape architect Niall Kirkwood also imagines that landscape design will eventually become a collaborative design process leading to “a fresh interpretation of neglected contaminated sites for a wide range of users.”[11] He envisions landscape architects and experts from other fields working together to develop novel and better design criteria. Kirkwood continues by noting that vegetation will be used as a healing element but also used to make spatial relationships, delineating circulation routes—all the while creating an aesthetically pleasing landscape.

A strategy that strives to imitate the natural through artifice can only be deemed as paradoxical. This is precisely the belief of Corner—landscape urbanism is an inescapable paradox. For him it is similar to the paradox found between being and becoming, between permanence and ephemerality. Moreover, he contends that "landscape *drives* the process of city formation."[12] This type of thinking echoes Le Corbusier's Plan Voisin, and the integrated rationale that with 'green' spaces arrive environments that will bring social and economic development to a city.[13] Likewise, landscape architect and professor Elizabeth Mossop offers a similar view—that landscape urbanism provides the catalyst for citymaking that takes on a "more significant political role in the debates surrounding urbanization, public policy, development, urban design, and environmental sustainability."[14]

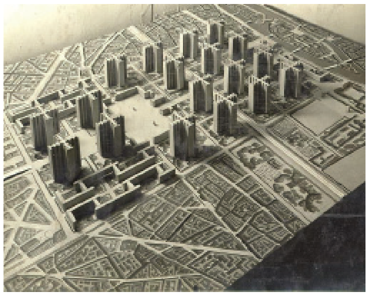


Fig. 3.4 Le Corbusier's theoretical planning scheme 'Plan Voisin", 1925. He proposes sixty story cruxiform towers in a strict grid surrounding a park-like green space.

Landscape as verb

The notion that the city can be revived through a physical remaking of landscape consequently causes a ripple effect upon the cultural landscape. As art historian Simon Schama puts it in his book *Landscape and Memory*, "landscapes are culture before they are nature; constructs of the imagination projected onto wood and water and rock."[15] In other words, the actualization of social memory onto a geographical place is something that weaves itself into the scenery—what is imagined is more important than what it is.

Interestingly, another notable art historian

Mitchell uses landscape as a verb rather than a noun, mirroring a similar approach to the way landscape urbanism is currently utilized and viewed by architecture. He differs in his approach by expressing that landscape is a medium that is a critical element to how identities are formed. Landscape is not an object, but an entity in flux the same as identities. In this manner, he explains that "...it is an instrument of cultural power, perhaps even an agent of power that is...independent of human intentions. Landscape as a cultural medium thus has a double role with respect to something like ideology; it naturalizes a cultural and social construction, representing an artificial world as if it were simply given and inevitable."[16]

When landscape is used as verb, especially when combined with memory and architecture, it creates an interesting array of symbolism. Cultural geographer Brian Osborne explores the social construction of landscape and memory in his essay *Landscapes, Memory, Monuments, and Commemoration: Putting Identity in Its Place*. He expresses the view that social construction of place maintains and fosters identities. Osborne's ideas of landscape, culture and its power are rooted around memory. He states that:
"At the root of the problem is the fact that our memory—both individual and collective—is

a pliable thing."[17]

Viewed from this perspective, not only does landscape act as a verb but also as a cultural lens. Consequently, landscape urbanism, as Waldheim puts it, provides a new strategy but also "a lens through which to see and describe the contemporary city, many of which, absent intervention by designers and without the benefit of planning, have been found to emulate natural systems."[18]

Landscape urbanism, therefore is intricately involved in the social construction of place-making. Osborne states that identity is created in response to place since there is no intrinsic identity associated with place. We, as a collective, make a place *meaning-full* through monuments, churches, neighbourhoods and architecture that is symbolically relevant.[19] These things evoke particular meanings and act as the "spatial coordinates for identity".[20] Moreover, Osborne adds to this point by noting these activities connect society through "ritualized performance, and institutionalized commemoration."[21]

Conclusion

Landscape urbanism is a connecting element between place and identity. Amongst the network of paved surfaces within a city, landscape design and the infrastructure that goes along with it, becomes a vital component in the way that these networks are connected. When landscape becomes assosiated with memory, power, it begins to act as something that informs and directs identity. Within the context of a city, landscape and the way it merges with urban elements plays an important and powerful role in the construction of place as well as identity. Given the colourful albeit tragic history of LeBreton Flats, along with a decades long unrealized urban renewal project, it is evidence that landscape urbanism (and its lack of) plays a vital role in the creation, maintenace, and perception of identity. At the same time, by attempting to reverse decades of damaging effects of the former industrial landscape as well as the NCC's expropriation process, LeBreton Flats is reclaimed as it is transformed.

Notes

1 Eisenman , Peter. “The End of the Classical: The End of the Beginning, the End of the End.” *Perspecta*. 3. (1984): 154-173. Web. 28 Mar. 2014.

2 Krinke, Rebecca. “Overview: design practice and manufactured sites.” Trans. Array *Manufactured Sites: Rethinking the Post-Industrial Landscape*. London: Spon Press, 2001. Print.

3 Mossop, Elizabeth. “Landscapes of Infrastructure”. *The Landscape Urbanism Reader,* ed. Charles Waldheim . First. New York: Princeton Architectural Press, 2006. 163. Print.

4 Mossop, Elizabeth. “Landscapes of Infrastructure”. *The Landscape Urbanism Reader,* ed. Charles Waldheim . First. New York: Princeton Architectural Press, 2006. 167. Print.

5 Krinke, Rebecca. “Overview: design practice and manufactured sites.” Trans. Array *Manufactured Sites: Rethinking the Post-Industrial Landscape*. London: Spon Press, 2001. 127. Print.

6 Krinke, Rebecca. “Overview: design practice and manufactured sites.” Trans. Array *Manufactured Sites: Rethinking the Post-Industrial Landscape*. London: Spon Press, 2001. 127. Print.

7 Eggebeen, Janna. “Between Two Worlds”: Robert Smithson and Aerial Art.” *Public Art Dialogue*. 1.1 (2011): 97. Web. 14 Jan. 2014.

8 Waldheim, Charles. “Landscape as Urbanism.” *The Landscape Urbanism Reader,* ed. Charles Waldheim . First. New York: Princeton Architectural Press, 2006. 8. Print.

9 Waldheim, Charles. “Landscape as Urbanism.” *The Landscape Urbanism Reader,* ed. Charles Waldheim . First. New York: Princeton Architectural Press, 2006. 11. Print.

10 Richardson, Tim. *Futurescapes: Designers for Tomorrow’s Outdoor Spaces*. New York: Thames and Hudson, 2011. 298. Print.

11 Kirkwood, Niall. *Manufactured Sites: Rethinking the Post-Industrial Landscape*. London: Spon Press, 2001. Print.

12 Corner, James. “Landscape as Urbanism.” *The Landscape Urbanism Reader,* ed. Charles Waldheim . First. New York: Princeton Architectural Press, 2006. 24. Print.

13 Corner, James. “Landscape as Urbanism.” *The Landscape Urbanism Reader,* ed. Charles Waldheim . First. New York: Princeton Architectural Press, 2006. 24. Print.

14 Mossop, Elizabeth. “Landscapes of Infrastructure”. *The Landscape Urbanism Reader,*ed. Charles Waldheim . First. New York: Princeton Architectural Press, 2006. 165. Print.

15 Schama, Simon. (1995). *Landscape and Memory.* New York: Knopff.

16 Mitchell, W.J.T. *Landscape and Power*. Chicago: University of Chicago Press, 1994. 1-2. Print.

17 Osborne, Brian S. “Landscapes, Memory, Monuments, and Commemoration: Putting Identity in its Place.” *Canadian Ethnic Studies* 33.3 (2001): 27. Web. 24 Jan. 2014.

18 Waldheim, Charles. “Landscape as Urbanism.” *The Landscape Urbanism Reader,*ed. Charles Waldheim . First. New York: Princeton Architectural Press, 2006. 43. Print.

19 Lynch as quoted in, Osborne, Brian S. “Landscapes, Memory, Monuments, and Commemoration: Putting Identity in its Place.” *Canadian Ethnic Studies* 33.3 (2001): 4. Web. 24 Jan. 2014.

20 Lynch as quoted in, Osborne, Brian S. “Landscapes, Memory, Monuments, and Commemoration: Putting Identity in its Place.” *Canadian Ethnic Studies* 33.3 (2001): 39-77. Web. 24 Jan. 2014.

21 Osborne, Brian S. “Landscapes, Memory, Monuments, and Commemoration: Putting Identity in its Place.” *Canadian Ethnic Studies* 33.3 (2001): 4. Web. 24 Jan. 2014.

Chapter 4:
Fungal Futures

Premise

Through investigating the potentials offered by new material technology, the project strives to embrace industrially damaged land, or brownfields, as inevitable and seeks to explore the positive opportunities created by it. This proposal envisions a landscaping infrastructure that ties together two seemingly different fragments: a factory producing mycobricks and a park that becomes a place for music festivals—a carefully constructed landscape that grows mushrooms to support the factory.

The main aspect of the project is the LeBreton Flats Mycofactory. Beneath the subtle, unimposing landscape lies the factory which produces bricks composed of mycelium. The building attempts to express the idea of transient architecture through its use of materiality; creating mycobricks that are transported to the yet-to-be remediated field adjacent to the site. The yet-to-be remediated site eventually becomes Festival Park Plaza resulting in a project proposal which behaves as an anti-monument. The whole park can be levelled to become an empty field as it has been all these years—consequently creating an anti-monument. At the same time, the park can be a vessel for facilitating concerts and music festivals allowing patrons to enjoy the park throughout the year. The mycobricks being produced by the factory provide the materiality for the music festivals. Festival Park Plaza is able to remain ever-changing with the mycobricks that are able to be discarded, decomposing back into the earth when not required.

Fig. 4.1 Mushroom brick. Philip Ross.

Process

The concept of a mycobrick factory facilitating remediation was largely inspired by mycologist Paul Stamets and artist Philip Ross.

Ross created a patent to produce fungus structures in 2012. As a college student studying at the San Francisco Art Institute, Ross worked part-time as hospice worker, leading him towards San Francisco's underground apothecaries. [1] His interest in mushrooms began from picking wild mushrooms by the Golden Gate Bridge and eventually flourished into him growing and experimenting with mushrooms as a full-time endeavour. He quickly created a reputation for himself in the art world as a craft mycologist—experimenting with the potential capacity of mushrooms. Now nearly three decades later, Ross has invented a way to fashion mushrooms from chairs to bricks. His method "provides a fungal substrate which could be moulded, and easily and cheaply pre-processed to precise geometric specifications".[2] His patent arrives from successfully moulding the mushrooms into bricks to create an art installation named "Mycotecture" that was made from Reishi mushroom cultures. The bricks were formed into the shape of an arch. During the exhibition, visitors had an opportunity to try tea that was made from pieces of the arch.[3]

Fig. 4.2 *Mycotecture*. Philip Ross.

For Ross, the fabrication of these bricks means that organic materials can be used in "place of plastics, urethane, and other fossil fuel dependent compounds".[4] The decreased dependence on petroleum products in the construction industry are the exceptional properties of the fungal bricks. The bricks are "nontoxic, fireproof and mold- and water-resistant, and it traps more heat than fibreglass insulation".[5] These bricks are also stronger than concrete! A claim that Ross has verified while fabricating approximately 500 bricks at his own experimental farm called Far West Fungi in Monterey, California.[6] His patent that was put forth in spring of 2012 also provides proof of this claim.[7]

Although "mycotecture"and mycobricks sound like sci-fi concepts, Ross is not the only inventor to begin thinking of fungal futures. Another company called Ecovative Design manufactures mushroom packaging in place of traditional styrofoam packaging. Because it is cost competitive and environmentally friendly, Dell Computers have recently picked up this type of packing to be used when shipping their computers.[8]

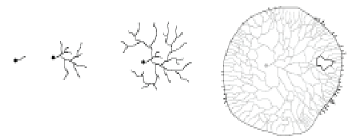


Fig. 4.3 Deriving form from mycelial root structures.

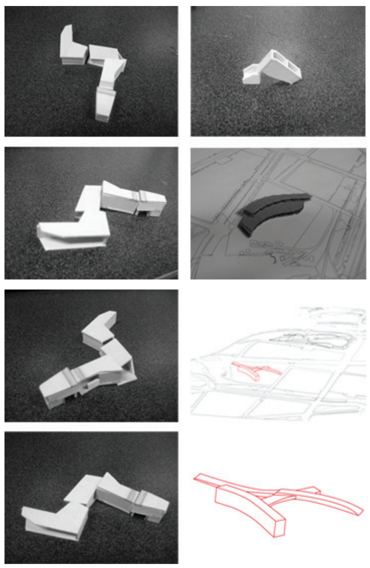


Fig. 4.4 Massing studies.

The thesis project unfolded with these exciting products and discoveries as a fulcrum for an environmentally based design. Combined with the numerous brownfield sites found in Ottawa and the emerging field of mycoremediation, a mycobrick factory became a natural conclusion. At first, the design concept utilized the visually obvious shape of mycelial structures. After a series of massing strategies that neither fit the site nor within the mycotecture context, it was clear that the notion of landscape needed to be more fully embraced. Figure 4.6 shows a design iteration where the roof dramatically conveys landscape merging with architecture. To ensure that the programmed roof surface could be utilized and did not simply become a useless lid, the next design iteration submerged the functions of the building underground so that the roof landscape could be more easily accessible for all users. The notion of accessibility has played a critical role in the conception of the building design. Accessibility in the context of this project actualized

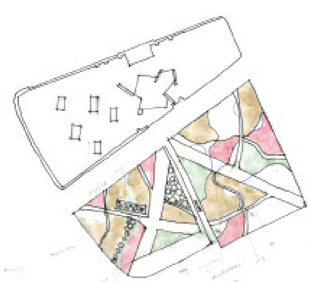


Fig. 4.5 Initial landscaping proposal.

Fig. 4.6 First design iteration.

itself through both design and programming. From a design perspective, accessibility represents itself through the extensive use of ramps where the programming revolved around the placement of the ramps. The sloping topography leads users away and towards the architecture on site. The interior circular ramp is the entrance point for both visitors and factory workers while another ramp is primarily for visitors in the exhibition space. The realization of a cultural and learning centre alongside the factory attempts to demonstrate accessibility to knowledge. Ultimately, the sloping roof structure is an integral concept acting as a spatial equilibrium between the urban landscape and an imminent social fabric.

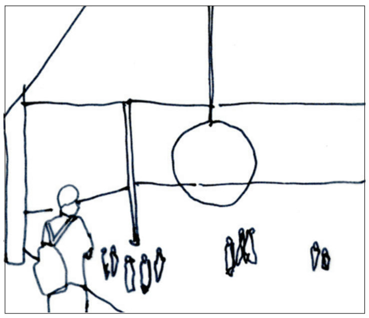


Fig. 4.7 Conceptual interior sketch of learning and exhibition centre.

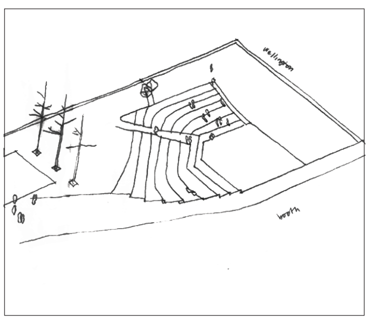


Fig. 4.8 Festival plaza conceptual sketch.

Program

The factory complex comprises of two major spaces: one that facilitates the making of the bricks, and another space that is meant as a learning centre and exhibition space for visitors to see. The section where the bricks are made includes rooms for the following procedures: making of brick molds, a clean room, substrate preparation, pasteurization, media inoculation, spawn storage, formation of bricks through pressure, drying and curing. A small reception area acts as the intermediary space between where the bricks are made to the exhibition space. The site proposal for Festival Park Plaza shows one possible

Fig. 4.9 Site plan showing showing landscape of LeBreton Flats Mycofactory along with eventual Festival Park Plaza landscape.

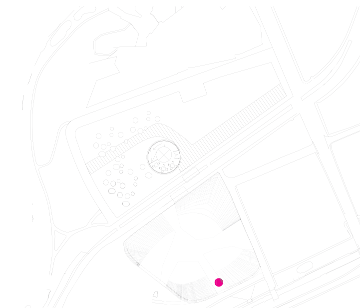


Fig. 4.10 View from Vimy Place towards the War Museum.

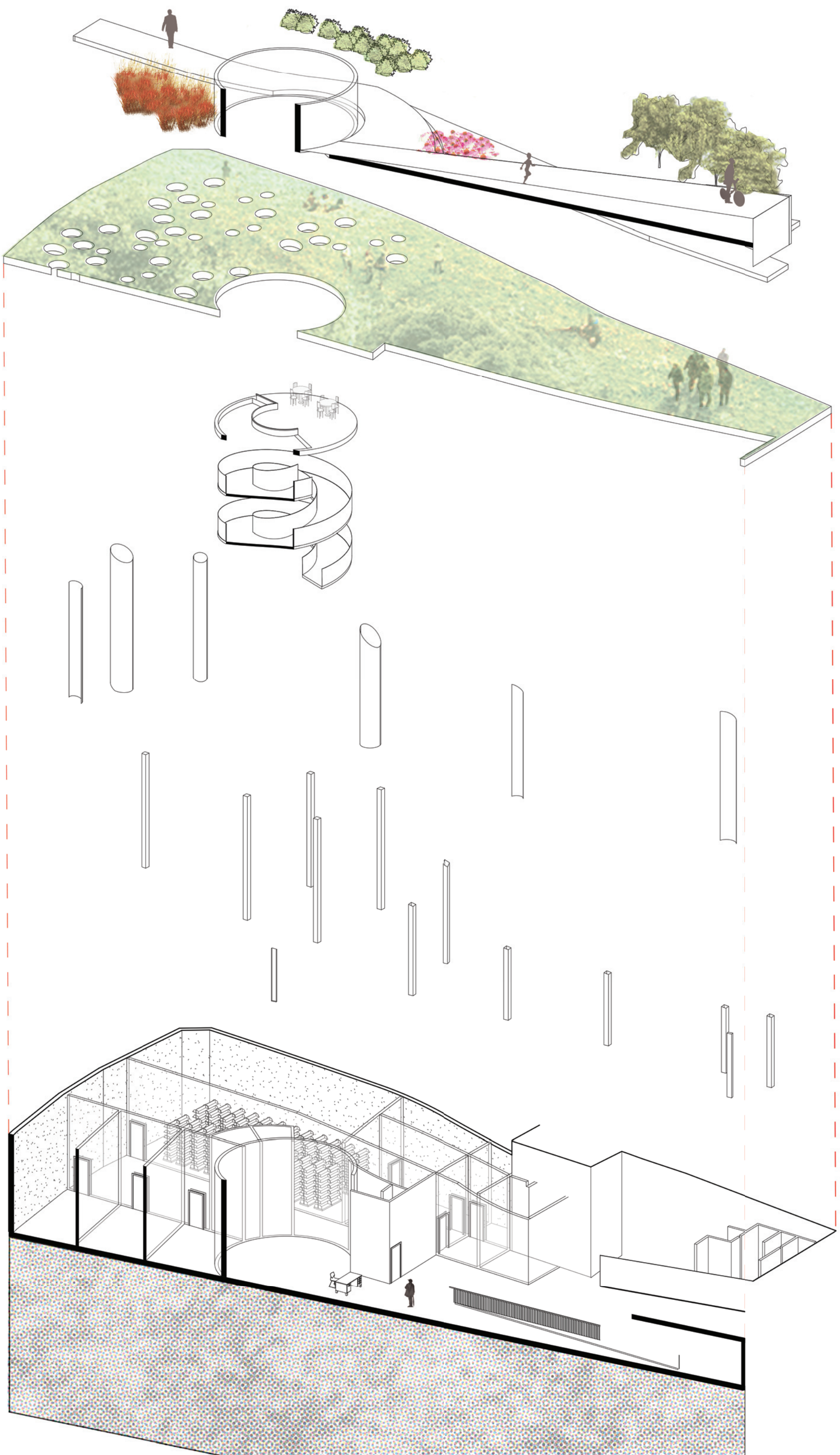
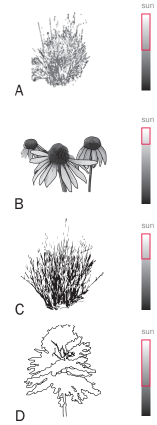


Fig. 4.11 Axonometric of building elements.

Planting Elements



Flame grass (Miscanthus purpurascens)
Bloom time: late summer, early fall, mid-fall
Height: 120-150 cm (47-59”)
Spread: 75-90 cm (29-35”)

Purple cornflower (Echinacea purpurea)
Bloom time: summer, fall
Height: 30-90 cm (12-36”)
Spread: 30-61 cm (12-24”)

Red-osier dogwood (Cornus stolonifera)
Bloom time: early summer, summer
Height: 91-200 cm (36-60”)
Spread: 305-457 cm (120-180”)

Hedge maple (Acer campestre)
Bloom time: flowers bloom in spring
Height: 15-25m (49-89 ft)
Spread: 4-8m (13-26ft)

Brick Production

Pink oyster mushrooms (Pleurotus ostreatus) colonize a substrate mold in the shape of a brick in 10 days.

With drying and growth times, one brick takes approximately 40 days to become functional.

Roughly 2880 bricks can be produced every 40 days at LeBreton Flats Mycofactory resulting in 26 280 bricks per year. This equals to 65.7 arches per year.

The bricks are used to facilitate music festivals occurring on the site adjacent to the factory. Afterwards the bricks can be left to decompose.

* Number of bricks required are based on Philip Ross's *Mycotecture*.

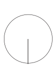


Fig. 4.12 Long section.

Legend

1. substrate chute
2. exhibition space/lecture space
3. woodshop
4. brick and mold storage
5. clean room
6. substrate preparation room
7. pasteurization room
8. steam room
9. grow room
10. pressure forming room
11. drying room
12. curing/mold removal room
13. entrance from park
14. reception
15. spawn storage
16. entrance from booth street

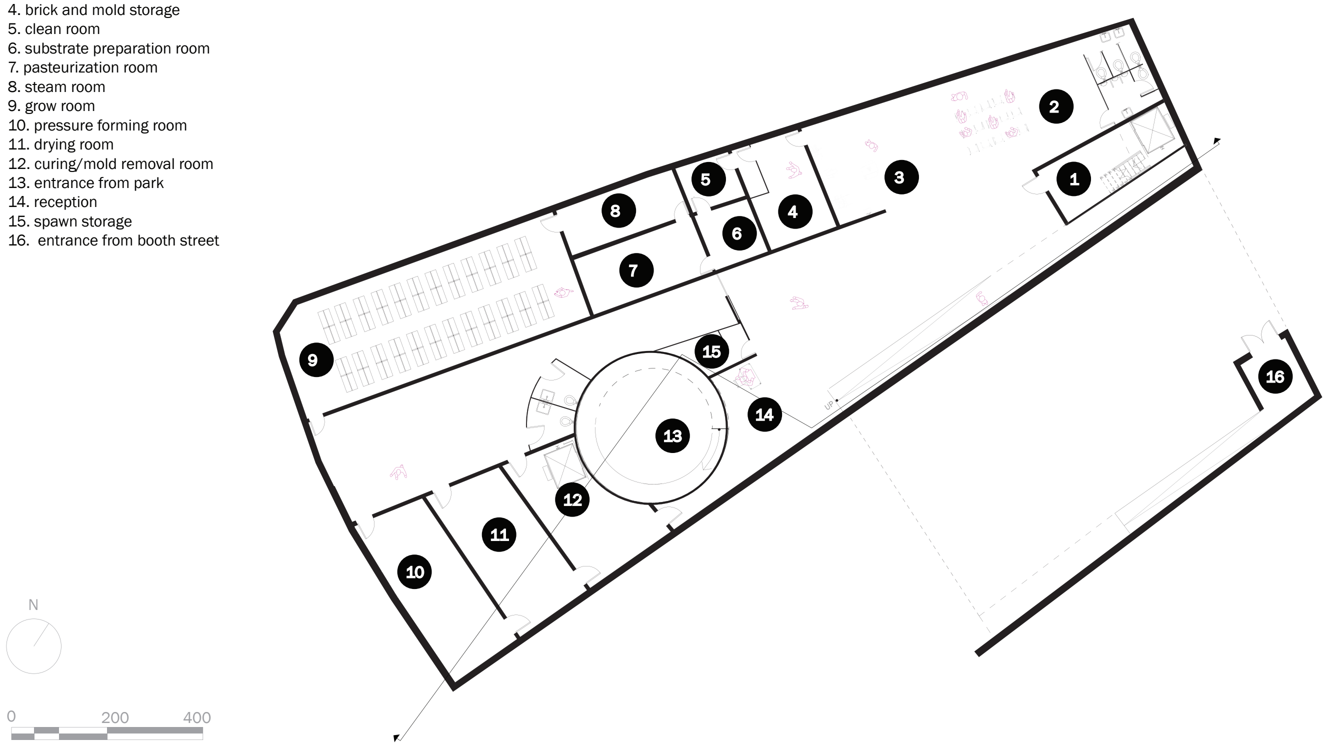


Fig. 4.13 Plan of LeBreton Flats Mycofactory.

layout that could be made from the bricks. The park is created in stages. Remediation is completed using mycoremediation, a process that would take approximately two months. Next, the park pathways are created through the layering of bricks. Performance areas emerge from the areas where there are no pathways. Trees surround the stages to help diffuse sound.

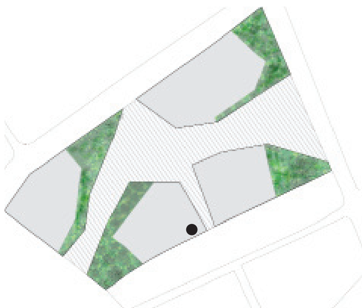


Fig. 4.14 Preliminary iteration of landscaping proposal. The site of Festival Park Plaza was made smaller.

Fig. 4.15 First vignette of Festival Park Plaza.

The landscape above the factory is composed of specific planting elements. The planting strategy is relatively simple. It comprises of grass, wildflower, shrub and tree. They are flame grass (Miscanthus purpurascens), purple cornflower (Echinacea purpurea), red-osier dogwood (Cornus stolonifera), and hedge maple (Acer campestre) respectively. Flame grass and the red-osier dogwood are especially chosen because of the visual interest they provide year round.[9] The purple coneflower is chosen for its colorful properties, its ability to withstand drought and exposure to the full sun. Purple coneflowers bloom in the spring and summer time.[10] Lastly, hedge maple is also planted for its bright leaves during the fall while during the summer it is able to provide ample amounts of shade. The hedge maple is also known for its low maintenance and ability to grow well in urban environments.[11]

Returning to the layout of the factory, the factory

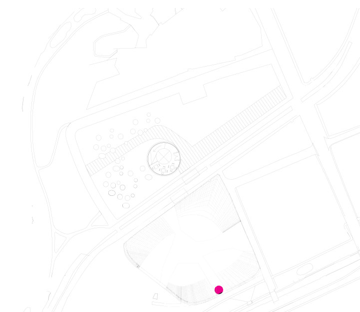


Fig. 4.16 View from Festival Park Plaza boardwalk.

Fig. 4.17 Flame grass (Miscanthus purpurascens).

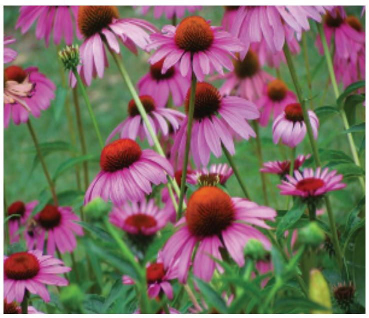


Fig. 4.18 Purple coneflowers (Echinacea purpurea)

Fig. 4.19 Red-osier dogwood (Cornus stolonifera)

Fig. 4.20 Hedge maple (Acer campestre)

program followed the requirements of a mycofarm suited to grow oyster mushrooms; the requirements and specific conditions of a mycofarm are described subsequently.

Mycofarm Requirements

Oyster mushrooms are generally found in temperate forests and (sometimes in tropical ones) growing on dead logs and in relatively moist environments under dim lighting conditions. In Canada, wild mushroom varieties are typically found in "cool, northern forests."[12] The oyster mushroom is rarely found in the wild in Canada but when found; it is growing in shelving clusters on deciduous trees.[13] In artificial conditions, they have adapted the capacity to grow on: corncobs, cottonseed hulls, sugarcane bagasse, coffee waste, palm leaves, soy pulp, cereal straws and other materials comprising of lignin and cellulose.[14] The least expensive option for substrate is straw yet coffee pulp is best for growing oyster mushrooms.[15] Stamets states that an oyster mushroom and a coffee farm are complimentary industries demonstrating that "mushroom cultivation is the missing link in the integration of complex systems of human enterprises within a sustainable environment."[16]

There are a variety of techniques that can be used

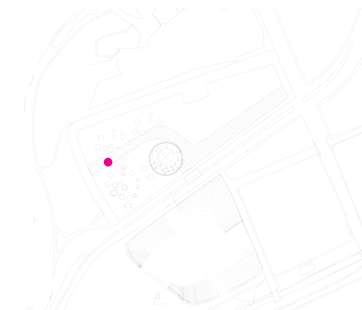
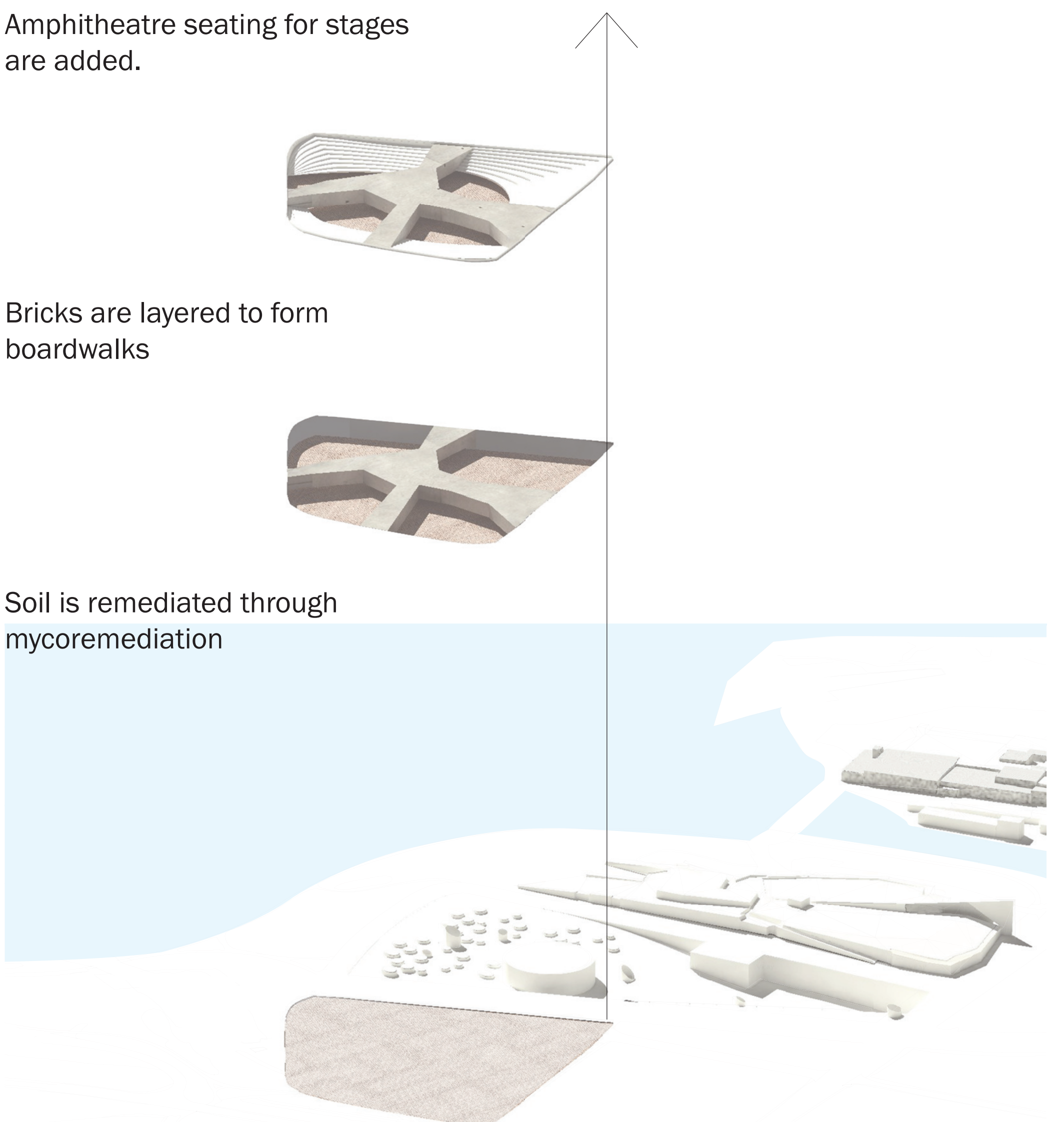


Fig. 4.21 View from Vimy Place towards Booth street.

Fig. 4.22 Axonometric showing the process of Festival Park Plaza.



for the cultivation of mushrooms. The container in which the mushrooms grow (cropping container) relies on several variables: the type of mushroom, the cultivator, and the equipment/space available. [17] The types of cropping containers used are: tray culture, vertical wall culture, bag culture, slanted wall or a-frame culture, column culture, or bottle culture.

In Stamet's opinion, oyster mushrooms grow best vertically, in columns or in bags. Oyster mushrooms need a robust amount of light otherwise they grow to be "unnatural-looking" and "trumpet shaped."[18] Since the main reason for the growth of the oyster mushrooms is for bioremediation purposes and the creation of mycobricks, their aesthetics are not vital. Consequently, it was deemed appropriate for the mushrooms to grow under mostly darkened and dense conditions. Combining the methodology of Ross, the mycobrick factory utilizes the bag culture and vertical wall culture method.

Bag culture is inexpensive, portable and uses disposable containers.[19] There is a potential for a niche market to exist for a "biodegradable, heat-tolerant, and breathable plastic for bag culture."[20] It is ironic then, that cultivators using the bag culture method are so heavily reliant on plastics. It is particularly ironic that the bag culture method is used for a factory producing sustainable building materials. Moreover, the building requires heavy use of cement to combat the effects of humidity required for growing the mushrooms. To rival the heavy usage of plastics, recycled bags are used, therefore increasing the size and requirements of sterilization immensely.

The vertical wall culture method evolves from the traditional tray culture method. The tray method

Fig. 4.23 Image of grow room using vertical bag method.

involves using trays (as the name suggests) that are approximately 0.6 m x 1.0 m x 0.15 deep (2 feet x 3 feet x 6 inches deep). In the vertical method, the trays are turned vertically so that there is more opportunity for the mushrooms to grow; that is they can fruit from both sides.[21] In between the growing medium lies perforated plastic and wire mesh, allowing for the "formation and development of mushrooms while retaining moisture."[22] Optimum rack width is between 0.3-0.4 m (12-16 inches). Frames that range between 1.2m x 1.2m (4 foot by 4 foot) to 1.2m by 2.4m (4 foot by 8 foot) allow for the implementation of continuous mushroom walls.[23] Using this method, it is theoretically possible to grow a mushroom wall.

Another mycologist, Ralph Kurtzman, has also written a book on ideal conditions and set-up requirements for mushroom growing facilities. According to Kurtzman, the following components are required for oyster mushrooms growing in a building: a temperature of 15˚C to 20˚C; humidity of 80% to 90%; extremely sanitary conditions; light; and ventilation.

Since it is vital that temperature and humidity are kept constant—as mentioned previously, the choice of building materials are reduced to concrete and plastic. If materials that are too porous are used (such as wood or bamboo), then there is a higher chance of attracting and keeping pests within the structure of the building. Sanitation is considered to be the most important aspect of a mushroom growing facility and must meet the following conditions: a way to filter air in; screen or air filters at the exits; a foot bath; air tight exits; air-lock changing room.

Kurtzman also suggests three environments for the cultivation of mushrooms which are the following:

1. Substrate initial preparation area: this is a space that is normally outside where the substrate is made moist and the ingredients are mixed.

2. Final preparation area: The wet substrate is pasteurized at temperatures no higher and between 55˚C to 60˚C for roughly 30 minutes. Afterwards, the substrate must be allowed to cool down and be protected from contaminants for at least 16 to 20 hours.

Sterilization means that there is equipment that can assure that the all the substrate is able to be maintained at 250˚C for about 15 minutes. This occurs in a pressurized container which also ensures that no other microorganisms can contaminate the substrate.

3. A spawning facility: here, the substrate is pasteurized and sterilized and requires greater

sanitary conditions than the place where the mushrooms are grown. In this space, the mushrooms are spawned, meaning they are prepared so that more mushrooms can be reproduced.

Based on these requirements, parts of the mushroom growing facility will be subjected to: high temperatures, extremely high levels of humidity leading to the corrosive impact of water and the use of chemicals.[24] Humidity and temperature changes depend on the cultivation stage of the mushroom so the area where the mushrooms are growing will be subjected to changing conditions. Growing mushrooms requires that the organisms which help mushrooms grow are enhanced while at the same time organisms that halt growth must be suppressed. In order for these conditions to be met, a strictly climate-controlled environment must be maintained.

Pasteurization involves heating a substance to a high degree so that the bacteria within are destroyed. If the mushrooms grown have used a compost substrate, then pasteurizing the mushrooms is sufficient. Sterilization is required if the mushrooms have been grown through fibrous wood material. Sterilization is an intense purification process. Conventional steam is utilized at extremely high temperatures to obliterate any harmful bacteria in the mixture. In the past, large ovens were commonly used. Today, organic sterilization is favoured through the use of hydrogen peroxide.[25] Inoculation is the process of impregnating the growing medium with the desired species of mushrooms wished to be grown. The growing medium is usually injected with “juvenile mushroom mycelium” that is typically called spawn. The more spawn that is used during the inoculation process, the faster the mycelia will grow and the quicker that mushrooms will begin to sprout. Cultivation is where the mushroom grower uses the inoculated medium to foster maximum mycelial growth. Temperature and carbon dioxide levels are manipulated to encourage mycelial maturation and to induce fruiting of the mushrooms. The mycelium growing below the layer of added soil doesn’t colonize but is better able to produce fruiting bodies. After casing, mushroom bodies begin to appear about 3 weeks later and should be promptly picked (also referred to as flushing).

Production

The ability for mushroom varieties to create mushrooms from substrate material is called biological efficiency. A basic formula derived from the White Button mushroom industry is as follows: “1 pound of fresh mushrooms grown from 1 pound of dry substrate is 100% biological efficiency.”[26]

Stamets believes that a good grower can operate within the 75-125% range. The biological efficiency of oyster mushrooms is sometimes greater than 100%.[27]

In the production of oyster mushrooms, there are three disadvantages: they spoil quickly, the spores from the oyster mushroom can be potentially hazardous to workers, and the mushrooms attract a large number of flies. There are a number of strains of oyster mushrooms that could be chosen for production in the LeBreton Flats Mycofactory.

Ultimately, the pink oyster mushroom was selected for the speed at which it grows. It can also adapt easily to growing on many different types of substrate and grows aggressively, even on unpasteurized bulk substrates.[28] Stamets has recorded growing a strain of the pink oyster mushroom in a little as 10 days “after inoculation onto pasteurized wheat straw.”[29] The suggested cropping containers are: polyethylene bags or columns, trays or racks. The biological efficiency of this type of mushroom is 75-150% and requires between 750-1500 lux.[30] The amount of lux or light intensity required is equivalent to that of a well-lit office.[31] The development of the fruit bodies takes anywhere from 3-5 days.[32]

The brick making procedure is based on Ross’ process during the making of “Mycotecture”.

“Mycotecture” required 400 bricks in order to build a 1.8 meter (six feet) wide arch. The following steps were utilized in the fabrication of “Mycotecture” and have been adapted accordingly for LeBreton Flats Mycofactory.

1. Wooden molds are created
2. Substrate (sawdust) is put into airtight plastic bags. Plastic bags are placed into the steam room for several hours.
3. Bags are left in wooden molds where the humidity enclosed in the bags allows the mycelium to grow and then begins to digest the sawdust substrate. The pink oyster mushroom is predicted to take up to 10 days to fully digest the sawdust substrate, resulting in the creation of solid block.
4. Once the mycelium has completely colonized the sawdust bags, the tops of the plastic bags are cut off and shifted to a growing room with high humidity conditions.
5. Afterwards, the bricks are removed from the plastic bags and left to dry for one month. Once this process is complete, the bricks are functional.[33]

In the growing rooms, each rack is able to grow 24 bricks and with 120 racks in the growing room, approximately 2880 bricks can be grown every 40 days. This amounts to the estimated yearly production of 26 280 bricks which equates to 64.7 “Mycotecture” arches.

How long do the bricks take to break down?

The decomposability of the bricks is variable depending on: weather conditions and if/and how the bricks are coated (which change their performance significantly).[34] Without any finishing, and any contact with the earth, the bricks have survived the East Coast winter for several years, changing “in consistency and quality, swelling and shrinking in the weather, but still fully functional when dried out”.[35] Conversely, if the bricks are in contact with the ground, they can decompose in approximately six weeks, depending on soil humidity and insect activity. The bricks behave in a manner similar to untreated softwood.[36]

How do the bricks bond to each other?

If the bricks are left live (meaning the mycelial network is not pasteurized), they can be “coaxed” into growing in such a way that the mycelium grows to bridge the gaps between the bricks.[37] A more precise method involves using pegs to join the bricks or inserting connecting elements while the brick is forming.[38]

Conclusion

Growing mushrooms requires various types of knowledge. Moreover, the production of mycobricks on a large scale is yet to be determined. Accordingly, the LeBreton Flats Mycofactory would be a highly experimental place. Knowledge derived from experiments would showcased and taught in the learning centre. The exhibits would display different joining techniques, behavioral properties of mycobricks in different condition as well as artistic and design experiments such as furniture made from mushrooms. Architecturally, learning and making are connected through the gradual ascent of the ramps. Skylights or groundholes, depending on how they are viewed, provide light into workshop. The architecture attempts to connect the acts of making and learning through the use of light, ramps and programming. In its introduction of culture and arts to the damaged landscape, the LeBreton Flats Mycofactory and park weaves juxtaposition of old and new, creating a post-industrial landscape that merges stewardship with a cultural landmark for the city of Ottawa.

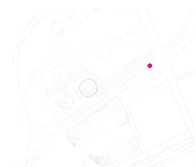
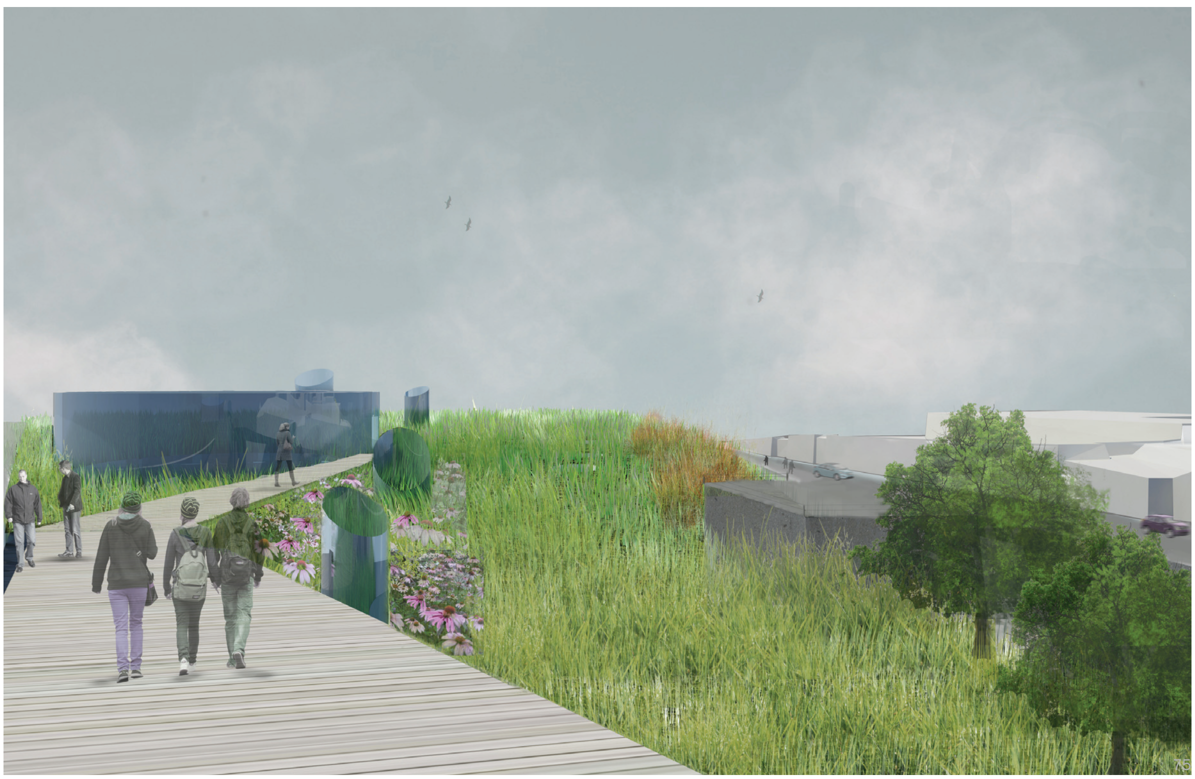


Fig. 4.24 View from from Booth Street towards boardwalk.



Notes

1 Thomas, Greg. “Phil Ross Grows Furniture Out of Mushrooms.” *Motherboard*. Vice Media Inc., 12 Dec 2012. Web. 30 Mar. 2014. <http://motherboard.vice.com/blog/houses-of-the-future-grown-out-of-mushrooms>.

2 Ross, Philip. “Method for Producing Fungus Structures.” Patent US20120135504A1. 31 May 2012.

3 Mok, Kimberley. “Mycotecture: Building with Mushrooms? This Inventor Says Yes.” *Treehugger*. MNN Holding Company, LLC., 26 Sep 2012. Web. 30 Mar. 2014. http://www.treehugger.com/green-architecture/mycotecture-mushroom-bricks-philip-ross.html

4 Ross, Philip. “Method for Producing Fungus Structures.” Patent US20120135504A1. 31 May 2012.

5 Fisher, Adam. “Industrial-Strength Fungus.” *Time Magazine*. 8 Feb 2010: n. page. Web. 1 Apr. 2014. <http://content.time.com/time/magazine/article/0,9171,1957474,00.html>.

6 Fisher, Adam. “Industrial-Strength Fungus.” *Time Magazine*. 8 Feb 2010: n. page. Web. 1 Apr. 2014. <http://content.time.com/time/magazine/article/0,9171,1957474,00.html>.

7 Ross, Philip. “Method for Producing Fungus Structures.” Patent US20120135504A1. 31 May 2012.

8 “Mushroom Packaging.” *Ecovative Design*. N.p., n.d. Web. 31 Apr. 2014.

9 “Seasonal Flow.” *Canadian Wildlife Federation*. Canadian Wildlife Federation. Web. 20 Mar 2014. <http://cwf-fcf.org/en/discover-wildlife/gardening/gardening101/design-and-garden-planning/seasonal-flow.html>.

10 “Coneflowers.” *The Old Farmer’s Almanac*. Landscape Ontario Horticultural Trades Association. Web. 20 Mar 2014. <http://www.almanac.com/plant/coneflowers>.

11 “Hedge Maple.” *Landscape Ontario*. Landscape Ontario Horticultural Trades Association. Web. 20 March 2014. <http://landscapeontario.com/acer-campestre-hedge-maple>.

12 Government of Canada. Agriculture and Agri-food Canada. *Canadian Mushrooms*. Web. 8 Mar. 2014.

13 Government of Canada. Agriculture Canada. *Edible and Poisonous Mushrooms of Canada*. Web. 8. Mar. 2014.

14 Stamets, Paul. *Growing Gourmet and Medicinal Mushrooms.* New York: Ten Speed Press, 1993. 202. Ebook.

15 Ibid.

16 Ibid.

17 Ibid, 215.

18 Ibid, 215.

19 Ibid, 217.

20 Ibid, 217.

21 Ibid, 217.

22 Ibid, 217.

23 Ibid, 217.

24 “Balex Metal-We Build Together.” *Mushroom Farms: Technical Information*. Web. 20 Feb. 2014. <http://www.balex.eu/en/mushroom-farm>.

25 Gush, Rick. “Mushroom Farming.” *Hobby Farms*. I-5 Publishing, LLC, n.d. Web. 30 Mar 2014. <http://www.hobbyfarms.com/crops-and-gardening/mushroom-farming-14815.aspx>.

26 Stamets, Paul. *Growing Gourmet and Medicinal Mushrooms.* New York: Ten Speed Press, 1993. 84. Ebook

27 Ibid, 300.

28 Ibid, 309.

29 Ibid, 311.

30 Ibid, 311.

31 “Lux, Lumens and Watts.” *Green Business Light*. N.p.. Web. 10 Apr 2014. <http://www.greenbusinesslight.com/page/119/Lux-lumens-and-watts>.

32 Stamets, Paul. *Growing Gourmet and Medicinal Mushrooms.* New York: Ten Speed Press, 1993. 311. Ebook.

33 Ross, Philip. “Mycotecture.” *Philip Ross*. N.p.. Web. 10 Apr 2014.

34 Ross, Philip. “biodegradable architecture.” Message to Munira Karimjee. 02 Apr 2014. E-mail.

35 Ross, Philip. “biodegradable architecture.” Message to Munira Karimjee. 02 Apr 2014. E-mail.

36 Ross, Philip. “biodegradable architecture.” Message to Munira Karimjee. 02 Apr 2014. E-mail.

37 “Real Art Ways Intimate Science Exhibition: Phil Ross and Mushroom Bricks.” *The 3 Foragers*. N.p., 26 Mar

2013. Web. 10 Apr 2014. <http://the3foragers.blogspot.ca/2013/03/real-art-ways-intimate-science.html>.

38 Ross, Philip. "Method for Producing Fungus Structures." Patent US20120135504A1. 31 May 2012.

Conclusion

After my cousin and I kicked the anthill, after I watched all the dead ants hosed away from her, we were chastised for attempting to make friends with ants. More importantly, for destroying their colony—it would be an understatement to say that their colony was irreparable by human hands. Ants are in every part of the world; similar to humans, they are able to thrive in almost every type of ecosystem. Unlike ants, however, humans are not as eco-effective[1] with their construction.

With a better understanding as well as a better method of making mycobricks means that there is an incredible amount of potential for building construction. It would also be a revolutionary step in the way environmental architecture is understood and practiced. Mycoremediation and mycobrick fabrication, both being a relatively new fields, hold exciting potential. Additionally, the combination of these fields is a great opportunity for the merging of disciplines between landscape, geography, biology, and architecture. This type of interdisciplinary discourse is not a new thought and is a concept that has been propelled by many other architects and theorists in the past. Even so, it is an idea that persists—it is fuelled by dismantling the notion that environmental stewardship is an inconvenient chore.

Biodegradable architecture explores the possibility of building technology that enables convenient solutions. For instance, biodegradable architecture could explore a housing typology that has a life cycle appropriate to its users, as well as to its environment; it allows for as minimal impact as possible in the [re]design of the landscape. It would also make a tremendous impact on the construction industry, alleviating the use of petroleum in the fabrication of buildings.

If biodegradable housing were to become a mainstream way of life, it could also mitigate a lot of financial burden on the Canadian population by allowing just about anyone to become a home builder. What is more, homeowners could potentially build for the amount of time that they'd like to live in their home for. Currently, as it stands, the Canadian housing market has been unstable for quite some time.[2] Despite this, the Canadian Mortgage and Housing Company (CMHC) argue otherwise. The CMHC reports a stable housing market in the fourth quarter of 2013 that continues forward into 2014, therefore supporting the housing market.[3] This stability is somewhat jeopardized by elevating household debts, leaving the economy susceptible to economic shock.[4] An article by the CBC News, “Rethinking the Home Ownership Dream” states that the notion of owning a home as an ideal investment simply doesn’t make sense anymore—especially if, according to CMHC statistics, homeowners are spending half their income on their mortgages.[5] The same article quotes urban critic Richard Florida who claims that “the best investments people can make are in their own human capital and development training, knowledge and education.”[6]

The same type of training, knowledge and education can be applied to the way brownfields are viewed. Brownfield remediation and development parallel landscape urbanism in an extremely interesting way. That is, both remediation and development of brownfields are gradually but surely shifting the way landscape urbanism is viewed as well as significantly increasing its importance. The project proposal sought to humbly convey this shift and to demonstrate an intersection between many disciplines. The project acts as an interface between ecology, design and landscape—helping to create a healthy interrelationship between the environment and the economy. In between these interrelationships, we can begin to experience modernity through a planetary lens.

Notes

1 McDonough and Braungart elaborate on their concept of eco-effectiveness in *Cradle to Cradle.* To summarize quickly, eco-effectiveness is a focus on product development where the subsequent life cycle of the product maintains or improves the quality of the environment.

McDonough, William, and Michael Braungart. “Eco-Effectiveness.” *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press, 2002.68-91. Print.

2 Babad, Michael. “Why are so many people saying nasty things about Canada’s housing market?.” *Globe and Mail* [Ottawa] 15 01 2014, n. pag. Web. 3 Feb. 2014. <http://www.theglobeandmail.com/report-on-business/top-business-stories/why-are-so-many-people-saying-nasty-things-about-canadas-housing-market/article16347044/>.

3 Canadian Government. Canadian Housing and Mortgage Company. *Housing Market Outlook*. 2013. Web. 3 Feb. 2014. <http://www.cmhc-schl.gc.ca/odpub/esub/61500/61500_2013_Q04.pdf?fr=1391445506848>.

4 Canadian Government. Canadian Housing and Mortgage Company. *Housing Market Outlook*. 2013. Web. 3 Feb. 2014. <http://www.cmhc-schl.gc.ca/odpub/esub/61500/61500_2013_Q04.pdf?fr=1391445506848>.

5 Smith , Alison. “Rethinking the Home Ownership Dream.” *CBC News* [Ottawa] 31 01 2014. Web. 3 Feb. 2014. <http://www.cbc.ca/news/business/rethinking-the-home-ownership-dream-1.2519201>.

6 Smith , Alison. “Rethinking the Home Ownership Dream.” *CBC News* [Ottawa] 31 01 2014. Web. 3 Feb. 2014. <http://www.cbc.ca/news/business/rethinking-the-home-ownership-dream-1.2519201>.

List of Illustrations

Chapter 1

Fig. 1.8 Soil contaminants: petroleum hydrocarbons, volatile organic compounds, polyscyclic aromatic hydrocarbons. <*http://www.ncc-ccn.gc.ca/sites/default/files/pubs/2.00_-_2012-p79e-board-remediation_of_lebreton_north.pdf*>. Map reproduced by Karimjee, Munira Z. 2014.

Fig. 1.9 NCC's proposal for 2017. <*http://www.nccccn.gc.ca/sites/default/files/pubs/2.00_-_2012-p79e-board remediation_of_lebreton_north.pdf*>. Map reproduced by Karimjee, Munira Z. 2014.

Fig. 1.10 Levels of remediation on LeBreton Flats. <*http://www.ncc-ccn.gc.ca/sites/default/files/pubs/2.00_-_2012-p79e-board-remediation_of_lebreton_north.pdf*>. Map reproduced by Karimjee, Munira Z. 2014.

Chapter 2

Fig. 2.1 Overview of Remediation Technology. *http://www.clu-in.org/download/remed/nairt_2000.pdf*. Reproduced by Karimjee, Munira Z. 2014

Fig. 2.2 Overview of Physical/Chemical Remediation Technology. Reproduced from: *http://www.clu-in.org/download/remed/nairt_2000.pdf.* Reproduced by Karimjee, Munira Z. 2014

Fig. 2.3 Overview of Biological Remediation Technology. Reproduced from: *http://www.clu-in.org/download/remed/nairt_2000.pdf*. Reproduced by Karimjee, Munira Z. 2014.

Fig. 2.4 Remediation Technology. Graph. Stamets, Paul. Mycellium Running. First. New York: Random House, 2005. 91. Print.

Fig 2.5 Parts of a Mushroom. <*http://www.education.com/reference/article/examining-fungus/*>. Image Reproduced by Karimjee, Munira Z. 2014.

Fig 2.6 Mycelium expansion. N.d <*http://www.anbg.gov.au/fungi/mycelium.html*>. Web. 24 March 2014.

Fig. 2.7 Mirabella Joe. Oyster mushrooms (Pleurotus ostreatus). Photograph. 2009. <*http://snapflash.net/oyster-mushrooms/*>. Web. 13 March 2014.

Fig. 2.8 Maitake (Grifola frondosa). N.d <*http://mossyskull.com/images/maitake2.jpg*>. Web. 13 March 2014.

Fig. 2.9 Turkey tail (Trametes versicolor). N.d <*http://www.fcps.edu/islandcreekes/ecology/turkey_tail.htm*>. Web. 13 March 2014.
Fig. 2.10 Reishi (Ganoderma lucidum). N.d <*http://sporeology.com/wp/wp-content/uploads/2014/01/reishi.jpg*>. Web. 13 March 2014.

Fig. 2.11 Artist conk (Ganoderma applanatum). N.d <*http://magickcanoe.com/fungi/big-artists-conk-1-large.jpg*>. Web. 13 March 2014.

Figure 2.12 Oyster mushrooms growing on contaminated soil. Photograph. P.Stamets. *Mycellium Running*. First. New York: Random House, 2005. 91. Print.

Figure 2.13 Regreened pile of formerly contaminated soil.Photograph. P.Stamets. *Mycellium Running*. First. New York: Random House, 2005. 91. Print.

Chapter 3

Fig. 3.1 Eisenman's Wexner Centre. N.d. Photograph.
<*http://archinect.com/features/article/49090085/still-ugly-after-all-these-years-a-close-reading-of-peter-eisenman-s-wexner-center*>. Web. 24 March 2014.

Fig. 3.2 Robert Smithson. *Dallas-Fort Worth Regional Airport Layout Plan: Wandering Earth Mounds and Gravel Paths*, 1967. Image. <*http://moca.org/landart/*>. Web. 24 March 2014.

Fig. 3.3 Martha Schwartz Partners project in London, UK. St. Mary's Churchyard Park. 2007. Image. < *http://www.marthaschwartz.com/projects/parks_stmarys.php#*>. Web. 23 March 2014.

Chapter 4

Works Cited

Arora, Dilip. *Fungal Biotechnology in Agriculture, Food and Environmental Applications*. New York: Marcel Dekker, 2004. Print.

Ausubel, Kenny, and J.P Harpignies. *Nature's Operating Instructions: The True Biotechnologies*. San Francisco: Sierra Club Books, 2004. Print.

Babad, Michael. "Why are so many people saying nasty things about Canada's housing market?." *Globe and Mail* [Ottawa] 15 01 2014, n. pag. Web. 3 Feb. 2014. <http://www.theglobeandmail.com/report-on-business/top-business-stories/why-are-so-many-people-saying-nasty-things-about-canadas-housing-market/article16347044/>.

Benyus, Jane. "Biomimcry." *Nature's Operating Instructions: The true biotechnologies*. San Francisco: Sierra Club Books, 2004. Print.

Canadian Government. Canadian Housing and Mortgage Company. *Housing Market Outlook*. 2013. Web. 25 Feb. 2014. <http://www.cmhcschl.gc.ca/odpub/esub/61500/61500_2013_Q04.pdf?fr=1391445506848>.

Capitale. *LeBreton Flats Revitalization*. Web. 25 Feb. 2014. <http://www.canadascapital.gc.ca/planning/master-plans/lebreton-flats-revitalization>.

Collins, Chris. "Implementing Phytoremediation of Petroleum Hydrocarbons." Neil Willey. *Phytoremediation:Methods and Reviews*. Totowa: Humana Press, 2007. 99-109. Print.

Corner, James. "Landscape as Urbanism." *The Landscape Urbanism Reader,*ed. Charles Waldheim. First. New York: Princeton Architectural Press, 2006. 21-35. Print.

De Sousa, Christopher. *Brownfields Redevelopment and the Quest For Sustainability*. Amsterdam:

Elsevier, 2008. Print.

De Sousa, Christopher. "Assessing the Effect of Publicly Assisted Brownfield Redevelopment on Surrounding Property Values." *Economic Development Quarterly*. 2.23 (2009): 95-110. Print.

"Mushroom Packaging." *Ecovative Design*. N.p., n.d. Web. 31 Mar. 2014.

Eggebeen, Janna. "Between Two Worlds": Robert Smithson and Aerial Art." *Public Art Dialogue*. 1.1 (2011): 87-111. Web. 14 Jan. 2014. <http://www.tandfonline.com/doi/abs/10.1080/21502552.2011.536712#.UzX1svm-2HY>.

Fisher, Adam. "Industrial-Strength Fungus." *Time Magazine*. 8 Feb 2010: n. page. Web. 1 Apr. 2014. <http://content.time.com/time/magazine/article/0,9171,1957474,00.html>.

Gehl, Jan. *Life Between Buildings: Using Public Space*. Washington: Island Press, 2011. 12. Print.

Hawken, Paul. "Natural Capitalism: Brother, Can You Spare a Paradigm?" *Nature's Operating Instructions: The True Biotechnologies*. San Francisco: Sierra Club Books, 2004. 147-160. Print.

Kirkwood, Niall. *Manufactured Sites: Rethinking the Post-Industrial Landscape*. London: Spon Press, 2001. Print.

Krinke, Rebecca. "Overview: design practice and manufactured sites." Trans. Array *Manufactured Sites: Rethinking the Post-Industrial Landscape*. London: Spon Press, 2001. Print.

Kurtzman, Ralph. "Mushroom Cultivation."*http://oystermushrooms.net/*. N.p.. Web. 19 Feb 2014. <http://www.oystermushrooms.net/chap1.pdf>

Lapointe, François, Fred Gaspar, and Eric Soulard. "LeBreton Flats Remediation and Infrastructure Project." *NCC-CCN*. NCC, 13 11 2012. Web. 10 Feb 2014. <http://www.ncc-ccn.gc.ca/sites/default/files/pubs/2.00_-_2012-p79e-board-remediation_of_lebreton_north.pdf>.

Ley, Justin. "Mycoremediation." *Bioremediation*. Wikispaces. Web. 3 Mar 2014. <http://bioremediation123.wikispaces.com/Mycoremediation>.

McDonough, William, and Michael Braungart. *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press, 2002. Print.

---. *The Upcycle*. First. New York: North Point Press, 2013. Print.

McMillan Binch LLP. *Brownfield Tool Kit*. 2005. Web. 17 Feb. 2014. <http://www.mcmillan.ca/Files/Brownfield_Toolkit_0405.pdf/>.

Mitchell, W.J.T. *Landscape and Power*. Chicago: University of Chicago Press, 1994. Print.

Mostafavi, Mohsen , and David Leatherbarrow. *On Weathering: The Life of Buildings in Time*. London: MIT Press, 1993. Print.

Mossop, Elizabeth. "Landscapes of Infrastructure". *The Landscape Urbanism Reader,*ed. Charles Waldheim. First. New York: Princeton Architectural Press, 2006. 163-179. Print.

NCC Watch. Web. 6 Feb. 2014. <http://www.nccwatch.org/blunders/lebreton.htm>.

Government of Canada. National Round Table on the Environment and Economy. *Cleaning Up the Past, Building the Future*. Ottawa. 2003. Web. 4 Feb. 2014. <http://www.collectionscanada.gc.ca/webarchives/20061207104153/http://www.nrtee-trnee.ca/publications/pdf/sod_brownfield-strategy_e.pdf/>.

Osborne, Brian S. "Landscapes, Memory, Monuments, and Commemoration: Putting Identity in its Place." *Canadian Ethnic Studies* 33.3 (2001): 39-77. Web. 24 Jan. 2014.

Ousley, Mark. "Capital Brownfields: An Assessment of Brownfield Planning Policy in the City of Ottawa, Ontario." University of Waterloo, April 2013. Web. 10 Feb 2014. <https://uwspace.uwaterloo.ca/bitstream/handle/10012/7545/Ouseley_Mark.pdf

Pacific Northwest National Laboratory. U.S Department of Energy, n.d. Web. 7 Feb. 2014. <http://www.pnnl.gov/about/>.

Richardson, Tim. *Futurescapes: Designers for Tomorrow's Outdoor Spaces*. New York: Thames and Hudson, 2011. Print.

Rogers, Jean. " Industrial Evolution: prevention of remediation through design " *Manufactured Sites: Rethinking the Post-Industrial Landscape*. London: Spon Press, 2001. Print.

Sarni, William. *Greening Brownfields.*New York: McGraw-Hill, 2010. eBook.

Schama, Simon. *Landscape and Memory.* New York: Knopff, 1995.

Smith, Alison. "Rethinking the Home Ownership Dream." *CBC News* [Ottawa] 31 01 2014. Web. 3 Feb. 2014. <http://www.cbc.ca/news/business/rethinking-the-home-ownership-dream-1.2519201>.

Stamets, Paul. *Mycellium Running*. First. New York: Random House, 2005. Print.

---. *Growing Gourmet and Medicinal Mushrooms.* New York: Ten Speed Press, 1993. Ebook.

Till, Jeremy. *Architecture Depends*. Cambridge: The MIT Press, 2009. Print.

United States Environmental Protection Agency. *Brownfields and Land Revitalization*. 2012. Web. <http://www.epa.gov/brownfields/overview/anat_bf_redev_101106.pdf>.

Waldheim, Charles. "Landscape as Urbanism." *The Landscape Urbanism Reader,*ed. Charles Waldheim. First. New York: Princeton Architectural Press, 2006. 35-53. Print.

Willing, J. *Cost of Cleaning up Contaminated Soil at Ottawa's LeBreton Flats Could Top $71 million, National Capital Commission says*. *Ottawa Sun,* 22 Dec. 2012 Web. 14 Feb. 2014. <http://www.ottawasun.com/2012/12/22/cost-of-cleaning-up-contaminated-soil-at-ottawas-lebreton-flats-could-top-71-million-national-capital-commission-says>.