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ECOLOGICAL INFRASTRUCTURE: AN EXAMINATION OF THREE CANADIAN CITIES

RICHARD PERRON AND ROB ZONNEVELD

Abstract

This paper examines the idea of ecological infrastructure within the context of three Canadian cities located in three distinct ecological regions i.e., the boreal forest (in the Precambrian Shield), the tall-grass prairie and the short-grass prairie. Each city was examined through the design studio process using a combination of GIS investigations and CAD based design iterations. The paper illustrates how design context, understood as the convergence of natural and urban systems, provides the basis for modelling urban ecological infrastructure, beginning with a macro scale long term ecological plan of the city and resolved through a series of site specific design investigations. Three approaches to designing green infrastructure are proposed: colliding infrastructures, designing for succession and regeneration, and designing for capture and inertia. Examples are presented for each approach.

Key words:
Ecological Infrastructure, research by design, colliding infrastructures, infrastructures of succession, infrastructures of capture

Introduction

The discussion that follows is based upon a methodology that treats design as research; a form of what Donald Schön would call reflective practice or knowing in action (Schön, 1987). This means paying attention to the phenomena that emerges, that is questioned, and that is tested through design inquiry. It is an approach that places as much importance to generative inquiry as it does to analytical inquiry. Following from Groat and Wang it is possible for the researcher to focus upon the design process and results both during the design activity and as a form of reflection after the fact (Groat and Wang, 2002). It is important for landscape architecture to find its own epistemological ground, balancing generative and analytical inquiry rather than following epistemological models developed for other disciplines. Landscape architecture educators should be finding new ways to exchange ideas about creative inquiry.

In the winter of 2012 students in the Department of Landscape Architecture at the University of Manitoba undertook a studio themed «Ecological Infrastructure» (Schröpfer, 2012; Shannon and Smets, 2010). As a form of generative research we were interested in questions regarding the nature and variability in how urban ecological infrastructure could be realized in different ecological/cultural contexts, with different development patterns, industrial histories and post-industrial possibilities. Each of three urban contexts would present unique problems, and design solutions would emerge in response to local sets of urban pressures and ecological potentials. As a pedagogical exercise the studio integrated macro and meso scale geographic information systems analysis with meso and micro scale design development using 3D spatial modelling applications.

The work was conducted in two phases. Phase 1 involved a study of the urban contexts and the development of large scale urban strategies based upon ecological design principles (Bullivant, 2012; Newman and Jennings, 2008). The strategies are attempts to integrate urban and ecological processes (Niemelä, 2011).

Phase 2 of the work involved meso scale design projects influenced by principles of integral urbanism (Ellin, 2006). Through our analysis we characterize approaches to designing urban infrastructure according to agencies (rather than content), which, herein, we define as colliding infrastructures, infrastructures of succession, and infrastructures of capture. Ecological infrastructure is understood in terms of landscape processes rather than objects of spatial occupation.

In the studio we began by asking «What is an urban ecological infrastructure, and, what are reasonable goals and objectives in designing and developing such an infrastructure?» Rather than working from existing definitions, we believe that designers should be seeking the definition as part of the design research inquiry. Concepts and working definitions of «ecological infrastructure» would emerge according to contextual characteristics determined by existing landscape processes.

Summary of contexts and strategies: Studio Phase 1

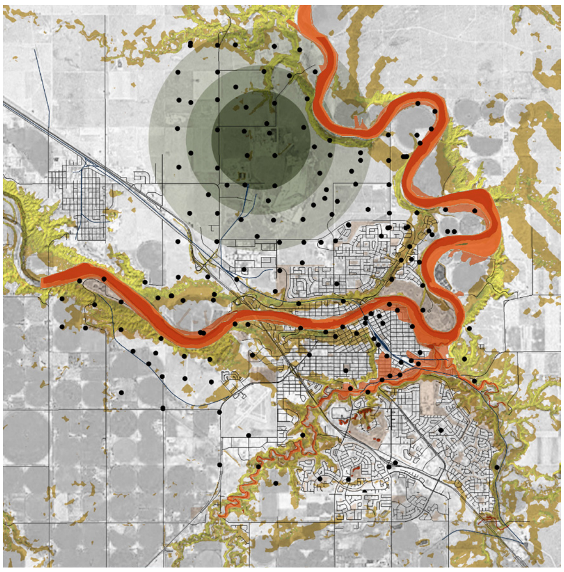
Three cities were included in the study, Winnipeg, Medicine Hat and Thompson. All three cities are located in what are called the 'Canadian Prairie Provinces', however each city is found in a unique bioregion (Lewis, 1996). All three cities could be characterized by shifts or predictable shifts from industrial to post-industrial conditions (Berger, 2008) and the emergence of wasted or liminal landscapes, or drosscapes (Berger, 2006). For each of the city's ecological infrastructure would be considered in terms of the emerging urban conditions, for Medicine Hat this meant an urban growth strategy, for Winnipeg this meant reducing ecological fragmentation, and in Thompson this would be about post-industrial revitalization.

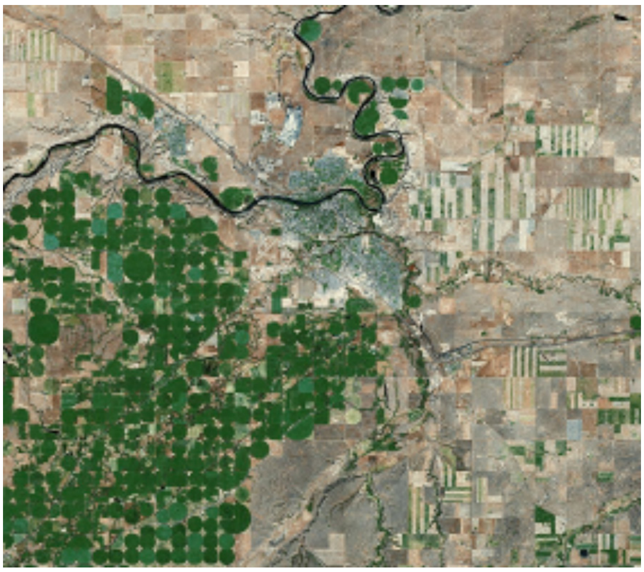
Context Medicine Hat

Medicine Hat, a small city (population 60,000) in the Province of Alberta, is situated in a short-grass prairie region. The city is characterized by dramatic river cuts (coulees) through the semi-arid short-grass prairie landscape. Medicine Hat is referred to as the «Gas City» because of a long history of natural gas extraction that has resulted in a spotty landscape mosaic with buffered gas wells distributed across the city (figure 1). Agriculture production in the region is dependent upon water drawn from channelized mountain streams. Rivers running through the city are prone to flooding due to rapid runoff of melt water in the springtime (figure 2).

Figure 1 (left)
Spotty landscape mosaic of Natural Gas wells distributed throughout the city. Large buffer to the north indicates a development boundary surrounding industrial developing fertilizer.

Figure 2 (right)
Landscape characterized by patterns of irrigation; pivot irrigation green circles (west), rolling irrigation characterized by banded mosaic (east).





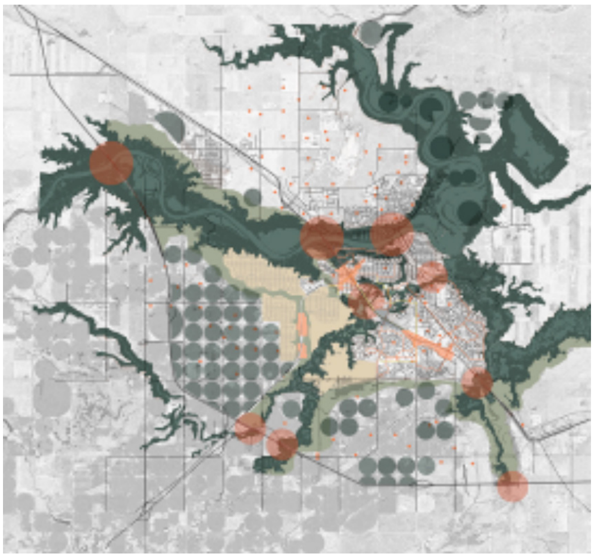
Medicine Hat Growth Strategy

An urban growth strategy should take the ecological infrastructure into account. The strategy (figure 3) for Medicine Hat includes:

- Restriction of development in the industrial zone of northwest, allowing for the establishment of a long term recombinant ecological development (Meurk, 2011);
- Expansion of a «no build area» based upon topography, soil condition, and flooding;
- Diversion of major traffic route around the city, to develop a more pedestrian and bicycle friendly environment;
- Development of a «green network» throughout the city, building upon coulees and expanding riparian zones, restricting development within the coulee network;
- Challenging the suburban mosaic by linking to green network;
- Creating didactic environmental experiences to reconnect the people to the water;
- Simulating flood conditions to assist in the propagation of native species in controlled flood plain;
- Highlighting green house production and managing water use;
- Build upon the potential of the distribution of natural gas well sites by beginning of a patchwork of urban forestry.

Figure 3 (left)
Residential development (beige) between major green corridors. Commercial development integrated into green zones, broadening of green zones.

Figure 4 (right)
Typical short grass prairie coulee condition



Context Winnipeg

Winnipeg is a mid-sized city, population 730,000, located in the Province of Manitoba. Situated in what was originally a tall-grass prairie, the City of Winnipeg may be characterized as topographically flat and prone to flooding due to the confluence of two significant waterways, the Red River and the Assiniboine River, (mitigated by major water diversions projects including the Red River Floodway[1]). The studio group focused their attention on the area bounded by the Red River and its floodway.

1 http://www.floodwayauthority.mb.ca/home.html

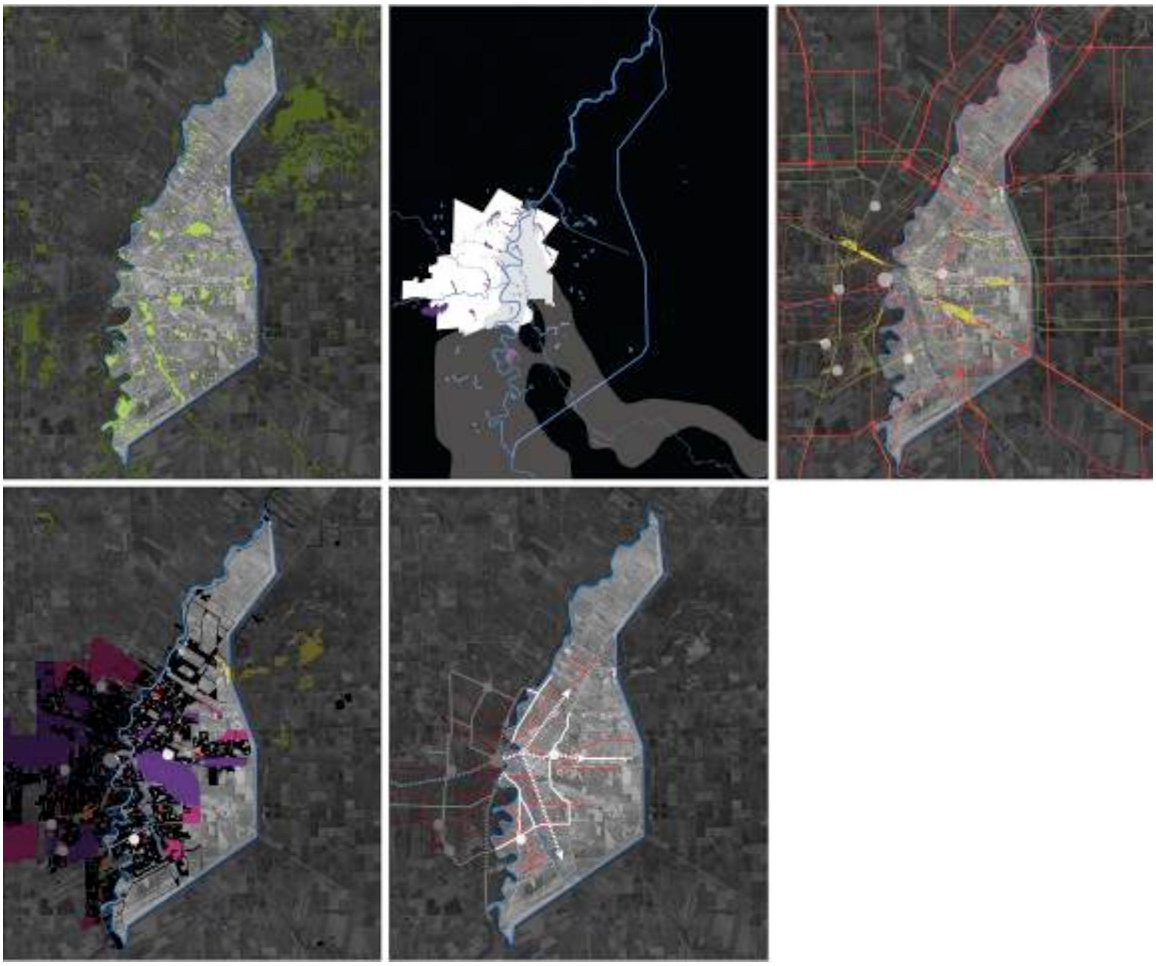


Figure 5
(top left) Winnipeg Study Site, approximately 27,500 hectares, eastern third of the City of Winnipeg; (top center) «blue infrastructure» site bounded by bounded by the Red River to the west and the floodway diversion project to the east; (top right) «Hard infrastructure», major roads, electrical ROW, rails and regional centers; (bottom right) proposed ecological infrastructure primary flow diagram; (bottom left) highlighting regional centers and residential areas.

Winnipeg: reducing ecological fragmentation

Like many North American Cities, Winnipeg has developed in a piecemeal fashion, first as an amalgamation of a number of small communities, and later as through suburban growth designed by property developers. Coordinated spatial planning at the scale of the city was, for the most part, limited to functional zoning and transportation planning. Large scale ecological infrastructure planning has yet to be undertaken in any serious manner. This studio project began with an examination of the City's current master planning and transportation documents, and considered what an integrated ecological master plan (Shannon and Smets, 2010) based upon principles of landscape ecology (Forman, 2006; Forman and

Godron, 1986; Dramstad, Olson and Forman, 1996) might begin to entail. This is of course a complex problem and the subject of much current research (see for example Palazzo and Steiner, 2008; Newman and Jennings, 2008; Tiberghien, Desvigne and Corner, 2009).

Figure 6 (left)
Diagram indicating existing opportunities for major «green corridors» linking existing patches within the city and to the region.

Figure 7 (right)
Winter prairie at the edge of the city.

A working definition of ecological infrastructure was proposed: *Ecological Infrastructure is the organizational framework that meshes ecological processes and ecosystem services into the urban fabric*. Following from this definition a number of design goals were identified:
- Design ecological infrastructures to frame growth around regional mixed-used centres as identified by City planning documents
- Re-construct conventional infrastructures (such as road, rail and electrical right of ways) to incorporate natural processes in the city
- Identify vital ecosystem services and incorporate their functions and processes into ecological infrastructure
- Indicate areas of opportunity, where human and natural processes intersect, to allow for hybrid processes to emerge.

In pursuing these goals urban ecological fragmentation emerged as a primary concern. This fragmentation developed as a result of suburban growth patterns, and functional zoning and transportation models that, often neglected or destroyed existing ecological structures. A strategy was developed to reduce urban ecological fragmentation by:
- Reconnecting the suburban mosaic;
- Developing an «opportunistic» approach to ecological infrastructure, that takes advantage of
  - linear features that have become available through the abandonment of rail transportation routes, electrical transmission right of ways,
  - «neglected» lands that have resulted from industrialization, and
  - «day-lighting» covered riparian areas;

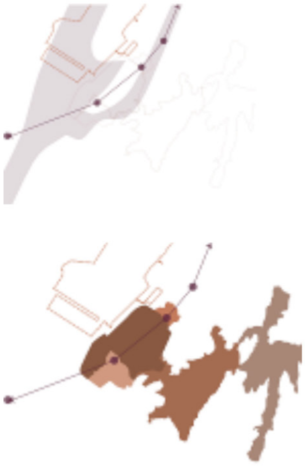
- Linking the patchwork of parks, greenways and urban forests;
- Connecting the green urban network, parks, playgrounds, forest, riparian corridors, vacant lands, etc., to the wider regional network;
- Examining the role of the residential «yard» in the green urban network;
- Considering how shifting industrial conditions may become critical to a green infrastructure, such as developing critical green nodes or green stepping-stones upon abandoned or underutilized industrial lands.

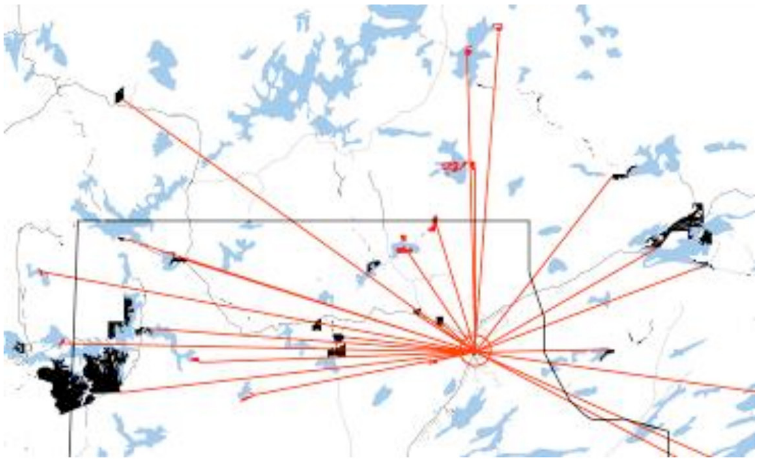
The city scale design approach that would include the establishment of a series of extended corridors (building upon the linear features described above) that would connect the inner city to the periphery. These corridors would be designed to reinforce existing ecologically sensitive urban fragments including riparian corridors, tall grass prairie patches, urban oak savannah, and prairie «parkland» forest patches.

Figure 8
Winnipeg has long been a central hub for rail transportation and is often characterized as a winter city.

Context Thompson

Thompson was conceived and later constructed as a planned community in 1957 (now with a population of 12,829) situated in the Boreal (Taiga) forest biome of northern Manitoba. The city's origin stems from the need to house and support an adjacent nickel mine and smelting operation. The urban footprint is in stark contrast with the Boreal forest (predominantly coniferous trees (particularly spruce) wetlands, granite outcrops and thousands of freshwater lakes and rivers). Mining interests have since waned and the community currently has refocused itself as a regional trade and service centre of northern Manitoba.





Thompson Post-industrial/Urban Revitalization Strategy

A strategy was proposed to consider not only the consequences of the post-industrial sites and services but to adapt the urban infrastructure to meet the current needs (Berger, 2002) of Thompson as the 'Hub of the North' and servicing the surrounding (remote) communities. The strategy, as determined by the students and the design brief, is to consider ecological infrastructure and what this means for a hinterland community. The strategy for Thompson includes:

- Adapting to the phased closure of the mining operations: smelter and refinery closed in 2015, reclaiming the mine site and remediation of the tailings pond, and, continued exploration and mining practices migrating away from the current town site;
- Expansion of the city to the north of the existing town site (and Burntwood River) integrating existing infrastructure and limitations (soil characteristics and ecological sensitivity);
- Develop a secondary commercial core along access road to airport; and proposed that new residential areas reflect the existing urban form where development radiates from institutional cores (education, medical and governmental facilities) and are connected primarily with a pedestrian pathway system;
- Development of an interconnected ecological network within the city and surrounding area by improving connections between forest patches and improving patch ecological structure and function;
- Improve connectivity (transportation) and flows between Thompson and surrounding communities with minimal obstructions to regional ecological flow.

Figure 9 (left)
The proposed strategy is staged and considers the direction of future urban growth towards abandon mine site (bottom image). Development is based upon sub surface mineral deposits (upper image) and predicted economic expansion.

Figure 10 (right)
At a regional scale Thompson performs as a regional «Hub of the North». The circle locates Thompson with First Nation communities (black colour).

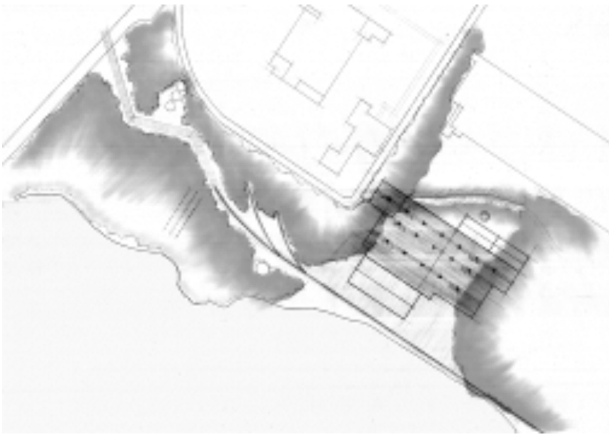


Figure 11 (left)
Photograph of mining operation. Modified image from: http://www.findthe postalcode.com/location.php?province =MB&location=Thompson

Figure 12 (right)
Illustration of natural corridor passing through mining site as part of a post-industrial design scenario.

Ecological Infrastructure at a meso scale: Studio Phase 2

In the examples that follow a number of design approaches to ecological infrastructure have been developed. Through the work, three design approaches have emerged that characterize the foci of the projects: colliding infrastructure, design for succession, and systems of capture. The approaches are described briefly below with examples drawn from each of the cities under investigation. The design has taken into consideration qualities of hybridity, connectivity, porosity, authenticity and vulnerability. These qualities, as described by Nan Ellin, are meant to serve as «guideposts» for developing an integral urbanism (Ellin, 2006).

Colliding infrastructures

Perhaps the greatest impediments to the urban ecological infrastructure are other conventional infrastructures such as roadways, buildings, etc. Conventional infrastructures may be developed directly on the landscape, or as sub-surface conditions and even as above surface phenomena. But in each case these infrastructures may restrict or impede flow of organisms; and are resistant to natural landscape dynamics due to ongoing management practices. These conventional urban infrastructures are usually linear in nature but can occasionally take on patch like or matrix like patterns.

The long linear nature of roadways and railways, systems designed for the movement of water, systems of electrification or natural gas may all limit and determine, in different ways, ecological design possibilities. The corridor like nature of these infrastructures is what allows them to work while also contributing to their potential for limiting other activities. Conventional infrastructure corridors share some functional similarities with ecological corridors of serving as habitat, conduit, filter, barrier, source and sink.[2] For example, conventional freeway and rail corridors are primarily designed as conduits of materials or machines (often machines that carry people and materials). As conduits they usually consist of inorganic materials and systems of movement that filter out or-

2 Douglas, I. and Sadler, J.P., *Urban Wildlife Corridors: Conduits for movement or linear habitat*. The Routledge Handbook of Urban Ecology. New York: Routledge, 2011, p. 278–279.

ganisms or act as barriers that prevent the movement of organisms. But, the design of ecological urban infrastructures may be thought as ways of mitigating the impacts of these other movement systems, of reducing barrier effects, of increasing the porosity of linear systems, and of acting as strategic sources of organisms and materials for serving a wider hybrid urban ecology. As linear systems, ecological infrastructure may be thought of as colliding with other infrastructure networks, and the challenge for landscape architects has to do with finding opportunities in such collisions.

The colliding infrastructure approach is illustrated in three different design studio examples described below. The first example describes conventional infrastructure in the linear form. The second example examines a patch like industrial infrastructure. In the third example the conventional infrastructure (covers a large area through industrial processes and takes on the form of a small matrix (or extensive patch). In each case ecological impediments are mitigated and ecological opportunities are considered in terms of their design potential.

Corridors: transportation and barriers to flow
(student Dustin Dilts)

The City of Winnipeg, Manitoba, was established as a result of the development of the railway and the rail transport continues to act as a determinant of ecological flow within the city. Winnipeg is home to two major railway yards (the CP (Canadian Pacific) Yards and the CN (Canadian National) Symmington Yards) that separate the city between north and south. Large railways yards are often adjacent to industrial developments and, or, sites of low lands due to excavation required for the building up of the rail beds. These railway yards often act as barriers of flow for human and non-human organisms fragmenting the city according to functional industrial desires.

Connection

Conversely, railways and roadways may act as «through» corridors[3] for species movement due to their width, the associated buffers and the irregularity of their usage. Since these corridors are human-made they are unnatural habitats, however their maintenance and disturbance regimes may be considered as landscape ecology design problems. Although highly managed, rail corridors often act as contiguous linear features of open space in a city. Railway corridors may be the only places where native grasslands persist.[4] In a tall grass prairie region like Winnipeg railways may be considered as potential corridors connecting remnant prairie patches.

The linear nature of rail corridors provide less opportunity for *convoluted* boundary conditions and may limit energy exchanges between the corridor and its surroundings. Design consideration involving rail

3 Through Corridors include roads, power lines, gas lines, railroads, dikes, livestock routes, horseback trails, walking paths and animal paths (Forman, 2006, p. 159).

4 Forman, 2006, p. 172.

and road corridors should take into account the shape and nature of the adjacent landscapes where rail corridors and adjacent land work together modifying the shape attributes of corridors and patches.

One of the most dramatic instances of the restriction of ecological flow occurs when rail infrastructure intersects major roadways. Major intersections between railways and roadways are often resolved using underpasses or overpasses. But the intersections of unnatural corridors should also be considered in terms of the contiguous flow of organisms. The intersections of railways and roadways may be thought of in terms of the intersection of ecological corridors, as nodes forcing the diversion of flow, or as possible sinks for organisms.

In this design proposal the focus was upon the intersection of railway and roadway corridors. Lowlands adjacent to rail-yards are treated as an important part of the urban wildlife habitat. Berms along the rail-yards are designed to limit the impact of the rail activity on the wetland, while providing a viewing area for the passer-by to experience the rail-yard activities. A proposed land bridge and associated earth works project limits corridor fragmentation by directing the flow of organisms over the roadway along the rail corridor.

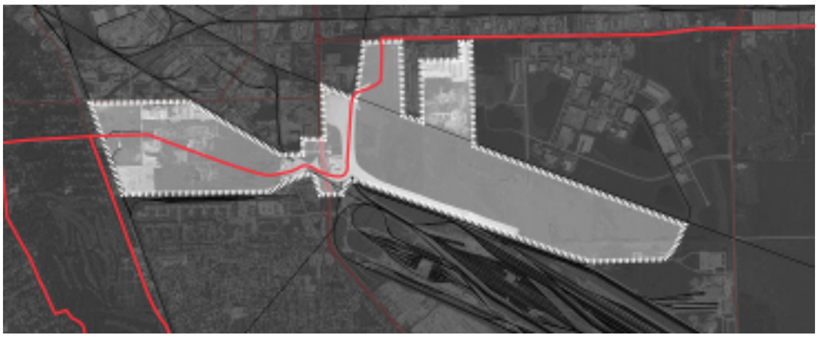


Figure 13 (left)
Greenway crossing major highway and railway. Vacant land associated with rail yard development used for the expanded greenway.

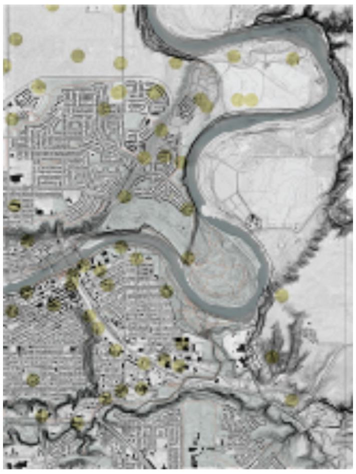
Figure 14 (right)
Fibre-reinforces plastic (FRP) honeycomb structures (inset) have been used in highway bridge decks. New composite materials and honeycomb structures for infrastructure is an ongoing area of engineering research.

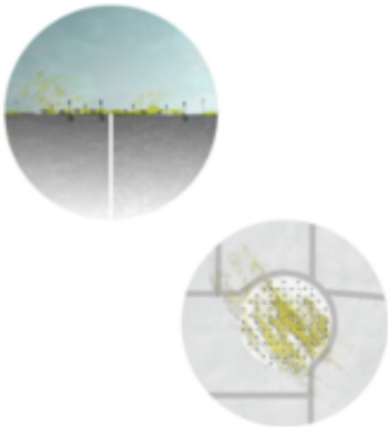
Patches: industry sources of opportunity

(student Kristen Struthers)

The City of Medicine Hat, Alberta is often referred to as the «Gas City» because of its long history as a source of «sweet (low in sulphur)» natural gas. The extraction of natural gas in the City itself has resulted in a patchwork of gas wells distributed throughout the region (figure 1). Due to the nature of the gas extraction process, 100 meter protective buffers have been established associated with each of the approximately 1500 gas wells distributed throughout the city. This has resulted in a regular shaped mosaic of «green» patches of varying quality distributed «randomly» according to the subsurface geology. As a surface condition, theses patches provide unique opportunities for a distributed system of protected natural environments.

In this design proposal entitled «Capture and Disperse», a mechanical seed dispersion system on the sites distribute seed mixtures (vary according to specific soil conditions) as a deliberate response to the release of methane gas occurring as a result of the gas extraction process. Tree and shrub planting occurs in the buffered areas to contain the dispersed seeds and structure the site (plantings vary according to soil and other conditions, so for example, Shubert Chokecherry and Green Ash are planted in highly urbanized areas). On the one hand the act of seeding serves as a commentary to the negative impacts of industrialization, while increasing the likelihood of maintaining what might otherwise become an isolated patch condition. It is anticipated that over time the plant material would extend beyond the patch itself. Seed mixtures vary according to a number of site specific details such as soil condition, aridity, and urban micro-climatic considerations.





In this scenario the patch is treated as hybrid ecological/industrial artefact that *collides* with its adjacent urban setting (commercial areas, suburbs, dense urban features, etc.). The fact that the natural gas extraction occurs in an urban setting allows for the establishment of unique, albeit potentially isolated patches to emerge. Forman indicates that the five corridor functions «are exactly the same as the five functions performed by patch boundaries or edges» (Forman, 2006, p. 155). The individual patches are designed to respond to a number of conditions such as the intensity of urbanization, whether it is found in a coulee or a short-grass prairie, area, the soil type, etc. Each set of conditions offers unique possibilities for the patch agency as source, sink, habitat, filter or barrier. So for example, the patch may act as a barrier to urban growth, and a sink for invasive species, a xeric habitat, or a filter of human activities. Since these unique patches are designed to artificially self-seed they become the source of organisms that could be encouraged to spread into the greater urban ecological matrix.

Figure 15 (left)
Seed dispersal mechanisms attached to methane extraction systems.

Figure 16 (Middle)
The city of Medicine Hat is built on a variety of different soil conditions. As the buffers are apparent throughout the city, the diversity of soil conditions and the possibilities each soil type affords should be evident in the design intervention.

Figure 17 (right)
Typical plan and section with sandy area with loam soils, low moisture retention and high erosion potential, seed mix is drawn from local short grass prairie varieties.

New matrix: post-industrial restoration
(student Marie Levesque)

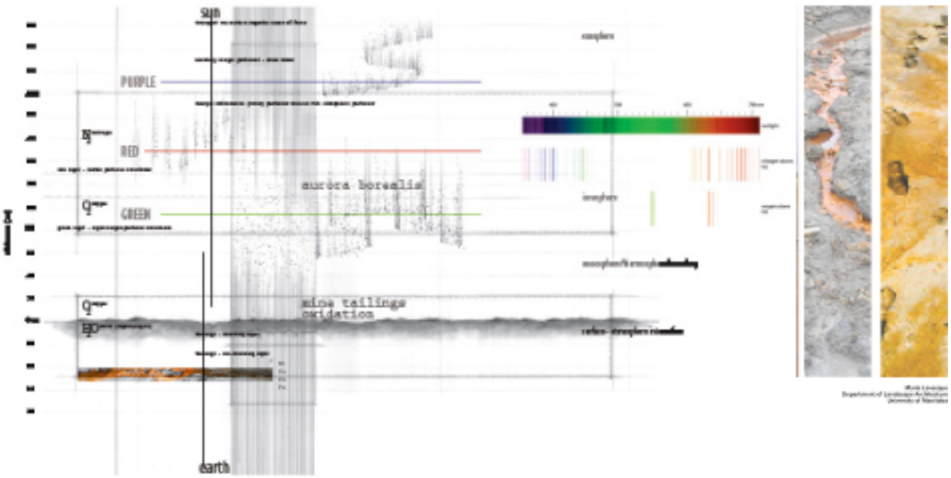
Thompson, Manitoba, is a northern community developed around the mining industry. Located within the boreal forest, the surrounding landscape is characterized by primarily deciduous forests and rocky outcrops. Mining activities in the area have played a significant role in reshaping the landscape. Large industrial processes like mining may be though of as redefining the underlying landscape matrix[5]. Forman defines the matrix as «the background ecosystem or land-use type in a mosaic, characterized by extensive cover, high connectivity, and/or major control over dynamics» (Forman, 2006, p. 39). In the case of mine site the surface area coverage of the disturbance is larger than the City itself. These are human-made unnatural habitats that have a significant control over the local landscape dynamics.

5 In this case matrix is considered to be a relative term. Within the context of the boreal forest the area that we are considering may be thought of as a large disturbance patch in the more expansive forest matrix. Within the context of the city itself the same disturbance patch becomes a dominant (relative to the size of the adjacent city) part of the urban matrix.

Figure 18
Mine Tailings.

The mine site includes three large unique landscape formations that are the result of the mining process: large open pits, slag piles, the obsolete manufacturing infrastructure, and the tailings ponds. As a form of ecological design inquiry on post-industrial sites such as this one, we are concerned with either re-integrating the post-industrial landscape into the boreal forest matrix, or examining the new potentials of the reshaped landscape. In the first project (examining the tailings pond) the emphasis was on the latter approach.

The City of Thompson has a direct physical relationship to the mine site and may be able to take advantage of the emerging landscape condition. Although common mining practice involves the restoration of mined lands, wherever possible, the post-industrial condition may be treated as a rare opportunity for the creation of an unique or hybrid «ecology».



In the project the student became fascinated with an «alien» surface condition that emerges from the mine tailings. She would «equate» this emergent landscape with the material assemblages of the Aurora Borealis, a process about the coalescence of minerals and the optical potentials. In the creation of this hybrid ecology, a new electrical and hydrological infrastructure would be embedded into the emergent landscape as the industrial process reaches its conclusion. These conduits of light and steam sit within the mine tailings to celebrate a new beginning.

Figure 19
Mine tailing and Aurora Borealis association study. Several forms taken by the northern lights have been used to guide the intentions of the site choreography, including both steam and light as the instruments. Aurora rays, homogeneous bands and arcs, horizon glow, suspended patches, rayed arcs, and rayed bands are some of the most recognizable forms of atmospheric displays of the northern lights.

Succession and regeneration

The complexity of urban systems, the human competition for resources and the extent of disturbances within the urban setting gives cause for considering urban ecological infrastructure as a means of dealing with shifting mosaics, and the events or agents associated with changes of patches, corridors and species populations. In the dense urban settings of the studio investigations the shifting mosaics appear to be characte-

Figure 20
Pressurized and heated water will be forced through tiny perforations in the expandable pipes, positioned at grade with the existing tailings surface. As more tailings are generated and disposed of on the site, the pipes will be covered, allowing for steam-atmosphere mixing at and just above the surface of the tailings.

rized by remnant patches, regenerated patches, introduced patches and disturbance patches. Remnant, regenerated and introduced patches can be susceptible to relatively rapid change with rapid succession, whereas disturbance in the form of landscape management will slow down the rate of succession. When such disturbances are removed the rate of succession will likely accelerate (Forman and Godron, 1986).

Cities by their very nature involve ecological disturbances. Most notably are disturbances caused through human interventions. As land uses change, new opportunities to increase the rate of the shifting mosaic may emerge. In urban environments ecological infrastructure may be thought of in terms of potentials for supporting landscape succession, of directing change and of influencing a shifting mosaic. In the examples that follow, three design proposals were developed based upon principles of designing for cyclic succession, heterotrophic succession (primary energy source is non-photosynthetic organic matter), and point succession.[6]

6 The discussion of succession should not be limited to patches since corridors and matrices will also be subject to succession.

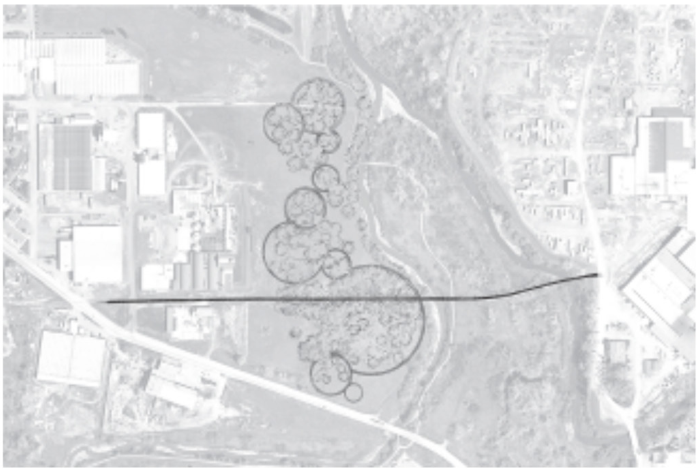
Figure 21
Succession in the boreal forest.

Cyclic succession: Of Clay and Water

(student Amy Whitmore)

Probably the most easily understood means of succession is cyclic succession. (see Forman and Godron, 1986, pp. 64–65). To design ecological infrastructure that encourages cyclic succession may mean that we are engaged in designing ways of deliberately affecting landscape processes, influencing the agencies of place.

In the project «Of Clay and Water» the designer recognized that changes in the hydrological regime act as limits to the cycles of succession. By stopping the possibility of flooding we have inadvertently inhibited the regeneration of the cottonwood, thus causing a break in the successional cycle. The design includes the development of artificial retention ponds along with integrated irrigation systems to artificially induce flooding into the cycle of succession.



Point succession: Vestige Metamorphosis

(student Vincent Hosein)

«In point succession the climax community is a mosaic containing patches with species of earlier successional stages.» (Forman and Godron, 1986, p. 65) Expansive linear corridors such as Winnipeg's hydro electric right of ways cut through a wide swaths of landscape intersecting several «green» patches and may provide the basis for building off of a point succession mosaic. These corridors have had limited urban impact, although they have been under a regular management regime and serve as informal pedestrian pathways. Still, these corridors continue to provide remnants of endangered species (www.livingprairie.ca) such as those found in the original tall-grass prairie mosaic.

Figure 22
Top left, maps of flood plain and Cotton wood tree stands; top right, plan of water control system; below, rendering of the cottonwood park and retention ponds during a dry period.

Figure 23
Typical prairie vegetation, from left to right, Prairie dropseed (*Sporobolus heterolepis*), Paper birch (*Betula papyrifera*), Western prairie fringe orchid (*Platanthera praeclara*), Big Blue Stem grass (*Andropogon gerardii*).

The project Vestige Metamorphosis, is a design for an existing urban electrical corridor that is about to be decommissioned. The design brings about a new hybridity taking advantages of human made vestiges of the hydro-electric towers, but also vestiges of ecological communities. The design reinforces woodland, tall-grass prairie, fescue prairie, wetlands and aspen parklands, while recycling the materials of the towers by creating a series of ecozone specific follies along the newly created greenway.

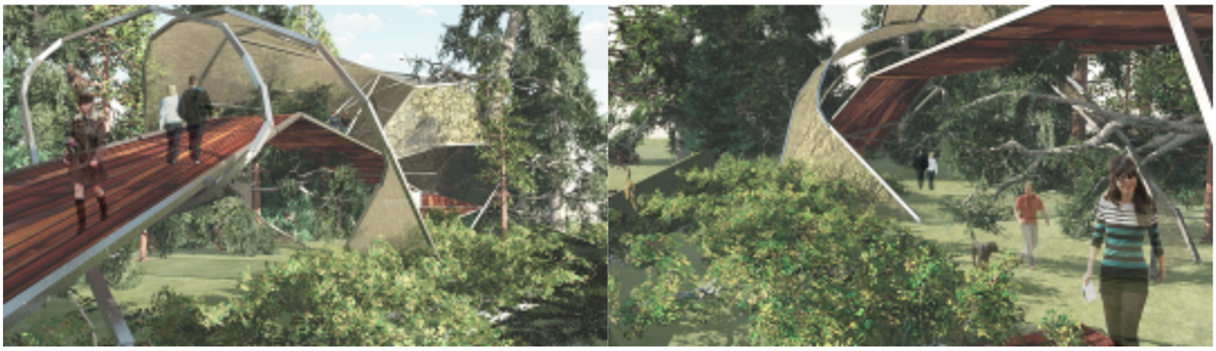


Figure 24
Computer rendering of hybrid landscape.

The point succession approach to design is meant to strengthen nodes along the path in strategic locations encouraging interconnectivity of the corridor acting like a spine through the city. The follies serve as both attractors to the nodes as well as ways of protecting sensitive habitat.

Heterotrophic succession

(student Curtis Krul)

In heterotrophic succession «the primary energy source is non-photosynthetic organic matter», much of which can be found in the organic human and non-human animal waste or in the vegetative biomass such as a fallen log in the forest. In the project *City Center*, heterotrophic succession underpins a new urban park design. This project is meant to be a subtly didactic exposition of urban energy flow while facilitating the conversion of human waste. Working from the classic ecology text *Energy Basis for Man and Nature* by Howard and Elizabeth Odum, the designer develops a model and

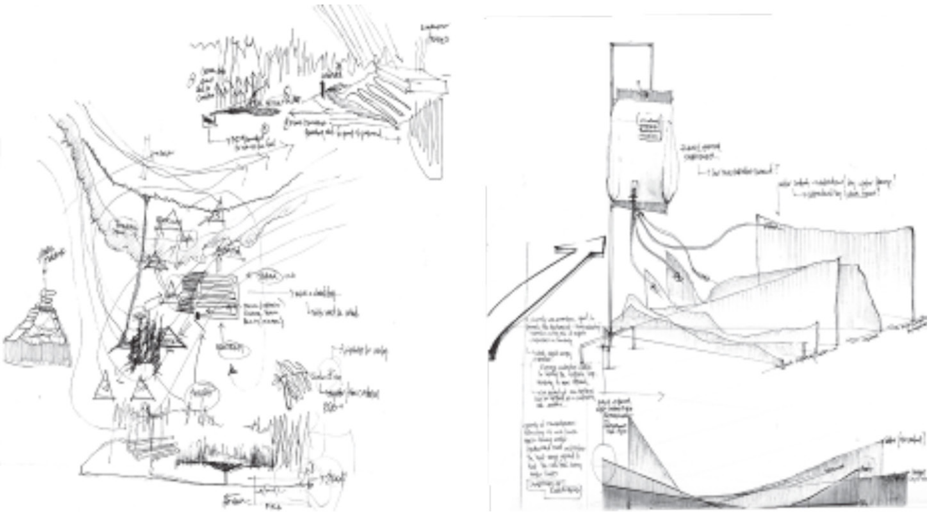


Figure 25
Sketch studies modelling the energy flow of heterotrophic succession design.

structures a design that maps the heterotrophic processes (hydrolysis, acidodegisis, acetogenesis, methanogenesis, digestion, symbiotic photosynthesis, etc.) to the physical infrastructure that supports it. In their discussion on succession Odum and Odum state that species «collectively maintain soils, establish nutrient storages, set up pathways of processes, store information for inheritance, etc. In general, where succession starts with a low initial state there is a period of mass growth with low diversity, followed by diversification and great variety.» (Odum and Odum, 1981, p. 111) Following from this the work concentrates on the growth of one of nature's basic infrastructures, and a fundamental building block of the boreal forest, lichen.

Capture... inertia

The final three examples of designing ecological infrastructure come from approaches that can be characterized as being about deliberate accumulation, gathering, capturing or to put it another way, of engaging and playing with the principle of inertia (from the Latin meaning idle or lazy). Design for inertia («the resistance of any physical object to a change in its state of motion or rest, or the tendency of an object to resist any change in its motion»[7]) is thought of as finding ways to limit system functioning and/or the rate of change in a system. This may be, for example, about increasing biomass accumulation, or concentrating and containing system materials. Inertia may be about the regulation of affect, the regulation of system characteristics that increase frequencies, rates of flow, rates of change, or even momentum within a system (i.e. population size times rate of population growth). Inertia may also be considered in terms of other assemblages, of for example, the accumulation of a cultural past, and a slowing down of our frenetic urban tendencies. Design for inertia may be slowing down one function so that another function can take root. Design for inertia may be about introducing disturbances that are strong enough to slow things down so that new functions may become established.

7 http://en.wikipedia.org/wiki/Inertia, also «inertia» may refer to an object's «amount of resistance to change in velocity» (which is quantified by its mass), or sometimes to its momentum, depending on the context. (momentum = mass x velocity).

Design for inertia, may be about resetting systems within a metastable context, or it may be about deliberately invoking system instability, causing the system to find its own new metastable equilibrium (Forman and Godron, 1986, p. 431). The infrastructure for this kind of design will vary vastly, but may be best characterized as interfering with or deliberately destabilizing system functioning.

Filter, the industrial watershed
(student Taylor LaRocque)

This project is a response to pollution in the South Saskatchewan River attributable to a number of sources including: agricultural and municipal return flows, surface runoff, pesticides, phosphorous, sedimentation, and the accumulation of nitrogen. Infrastructure was designed that not only captured sediment for phytoremediation but would also serve as a collector for people to reconnect to the wetland to other areas of Medicine Hat, and to make the area not only a destination, but part of the community's life.

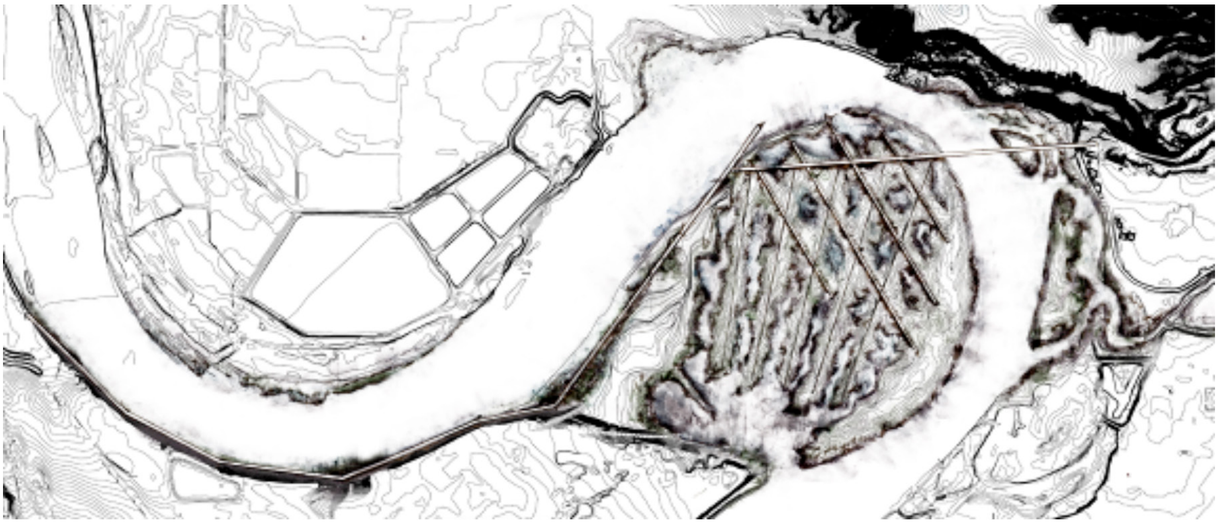


Figure 26. More than just a functional wetland, the River Walk is a reminder that the river is important to the vitality of the city and the province, and it is a resource that should be not only drawn from, but also celebrated and protected.[8]

The treatment wetland incorporates several of methods of wetland design described by (France, 2003)[9], while catering to the specific conditions of the South Saskatchewan River in Medicine Hat. The design considers the transition of the wetland through the year, from low levels during the early spring and fall, to the highest levels during the month of June. The wetland is designed to withstand this seasonal flooding, as well as abnormal flood events. It consists of an inlet, sedimentation forebay, interior segmented channels, a micro pool and outlet. The wetland serves to remove contaminants such as phosphorous and nitrogen, as well as various sediments. By targeting various types of river water pollution, the treatment wetland both improves water quality and educates the public about the quality of their river. By exposing the process of water treatment, citizens of Medicine Hat can approach the river and observe

8 Laroque, Taylor, Medicine Hat Studio Book, Draft Version, p. 159 (unpublished).
9 Robert L. France, 2003. Wetland Design: Principles and Practices for Landscape Architects and Land-Use Planners.

the treatment cycle firsthand. At certain times of the year, the wetland can even be entered for a more immersive experience.

Assemble and Disperse: Infrastructural Hybridity
(student Trent Workman)

Each spring the City of Winnipeg collects approximately 5,000 truckloads of grit from the streets of the city in the form of sand, salt and debris. Over the winter months this grit helps to add traction to roads but by spring it is collected and deposited in the landfill. This design proposal posits the re-use of sediment in combination with over-flow water from the combined sewer and drain system on a site adjacent to the Red River, beneath a vehicular overpass.

Combined sewers and drains have a tendency to over-flow approximately eighteen times per season in Winnipeg. The design exposes the drainage hydrology in the form of bioswales designed as a system which integrates a regional trailway, the railroad and hydro corridor allowing excess water to flow to this under-utilized site. The collection of these

Figure 27
Models simulating soil build up and visualization of steam in park.

elements is imagined as a process of land-forming through a cause and effect relationship. This relationship is explained as a process of primary, secondary and tertiary settings based on three forms of operation: assembly, accumulation and aggregation. Each operation has implications upon further settings affecting the way in which subsequent settings react to their new situation. This project maps the cause and effect relationship of a landscape in process.[10]

10 Workman, Trent, *Ecological Infrastructure Studio Book*, Draft version, p. 159 (unpublished).

The living inertia of an abandoned mine
(student Noman Syed)

The last example illustrates the idea of the cultural potential that can be found through the play with industrial inertia. In each of the three examples the students engage the potential of abandoned mine site through the re-invention of the by-products of industrialization. In the design revisits and decomposes the mining process and gathers the memories of the industrial process through a series of symbolic gardens. Here is the memory of the industrial infrastructure itself that is captured and celebrated.

Figure 28
Metaphors of the mining process, clockwise from top left, milling, bedrock profile, mining waste, nickel product.

Discussion

The examination of designing with ecological infrastructure in three Canadian cities located in three separate ecological regions has revealed three primary insights. First is the ambivalence of understanding ecological infrastructure. The necessity of framing perception and intentions at various scales, in this case at macro and meso scales as well as locating the urban patch (or patch work) in a specific landscape matrix affects our understanding of how we perceive, design for and use ecological infrastructure. Ambivalence is understandable as the convergence of natural and urban systems, along with intentionally hybrid systems, is complex and associated with ambiguities of the relationships between humans (and their built world) and nature.

The second insight is the recognition of three design approaches emerging from the student work: colliding infrastructure, design for succession, and systems of capture and inertia. The collision between urban infrastructure (including ecological infrastructure), ecological processes or systems and human activities is evident in the student inquiries into corridors and patches. Accepting new ways of perceiving existing and hybrid conditions are necessary for encouraging new urban ecologies. Without new perceptions the conventional and less inspiring systems remain. The idea of succession has also been reconsidered to acknowledge principles of cyclic, heterotrophic and point succession. This opens design opportunities to provide affect (ecological and cultural) in otherwise conventional circumstances. Design interventions become more responsive to otherwise hidden or neglected natural processes. Students also considered challenging inertia by 'interfering with or deliberately destabilizing system functioning'. This was accomplished through recognizing existing systems and creating interventions that assist in naturally occurring (or previously existing) functioning systems such as a constructed 'industrial' wetland; in constructed human systems as exemplified by redirecting road grit from landfills into an engaging hybrid landscape; and celebrating industrial by-products, slag piles, open pits, and abandoned buildings which otherwise are covered over, removed, or ignored.

The third insight is pedagogical. An investigation into urban ecologies of three separate cases using surfacing definitions is challenging. Exploring the ambivalence of human and natural ecologies as well as learning new analytical and graphic software (GIS and 3D graphics) occasionally pushed students (and staff) outside of normal comfort levels. However, this process resulted in urban design solutions that challenge (unproven) convention and reconsider the relationships between natural and human ecologies. In the end, new ways of perceiving ecological infrastructure adds to the discourse, ultimately improving, culturally and ecologically, the urban situation.

Acknowledgement

The work described herein was the result of one term of studio work in the Department of Landscape Architecture, University of Manitoba. Three cities were investigated and proposals were developed at a macro scale by small groups of students. Individual students then developed meso scale design proposals. Students working on Medicine Hat, Alberta, included Kevin Handkamer, Taylor LaRocque, Kristen Struthers, Amy Whitmore and Megan Wilson. Students working on the study of Thompson, Manitoba, included Amanda Blick, Sara Brundin, Curtis Krul, Marie Levesque, Stephanie McKichan, Sarah Mitchell, Leah Rampton, Kajsa Strom and Noman Syed. Students who worked on the City of Winnipeg projects included Lia Abolit, Dustin Dilts, Vincent Hosein, Shannon Loewen and Trent Workman. The authors are indebted to the students for their insights and their design contributions as illustrated throughout the paper. All images are from the authors or students. The only exception is figure 11 which is a modified image from the public website: List of Postal codes in Thompson, Manitoba (http://www.findthepostalcode.com/location.php?province=MB&location=Thompson).

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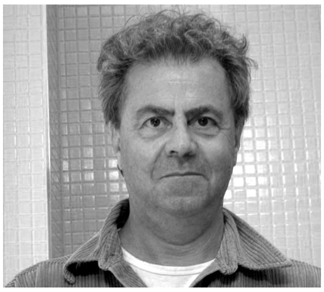

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