

**RESILIENCE THEORY/  
A FRAMEWORK FOR ENGAGING URBAN DESIGN**

**BY**

**KEVIN L. CUNNINGHAM**

**A THESIS**

submitted in partial fulfillment of the requirements for the degree

**MASTER OF LANDSCAPE ARCHITECTURE**

Department of Landscape Architecture, Regional and Community Planning  
College of Architecture, Planning + Design

**KANSAS STATE UNIVERSITY**

Manhattan, KS

**2013**

Approved by:

Major Professor  
Blake Belanger

Resilience Theory: A Framework for Engaging Urban Design

A Thesis submitted in partial fulfillment of the requirements for the degree:  
Master of Landscape Architecture

Department of Landscape Architecture, Regional + Community Planning  
College of Architecture, Planning + Design  
Kansas State University

Thesis Committee:

Blake Belanger, Assistant Professor, Dept. of LARCP

Jessica Canfield, Assistant Professor, Dept. of LARCP

Dr. Kendra McLauchlan, Dept. of Geography

Dr. Kimberly With, Division of Biology

© 2013 Kevin L. Cunningham. Kansas State University, Manhattan, KS.

All rights reserved.



LANDSCAPE ARCHITECTURE  
/ REGIONAL & COMMUNITY PLANNING  
THE COLLEGE of  
ARCHITECTURE, PLANNING & DESIGN // K-STATE

# ABSTRACT

Landscape architects are challenged with finding appropriate solutions to adequately address the dynamic nature of urban environments. In the 1970's C.S. Holling began to develop resilience theory, which is intended to provide a holistic understanding of the way socio-ecological systems change and interact across scales. Resilience theory addresses the challenges and complexities of contemporary urban environments and can serve as a theoretical basis for engaging urban design practice. To test the validity of resilience theory as a theoretical basis for urban design, this thesis is an exploration of the addition of resilience theory to current landscape architecture literature and theory through a three-part methodology: a literature review that spans a breadth of research, case study analyses, and an application of resilience theory through a design framework in two projective design experiments. The resilience framework bridges between complex theory and design goals/strategies in a holistic approach. Through the identification of key connections in the reviewed literature that situate the relevance of resilience theory to landscape architecture and the subsequent case study analysis, specific methods for applying resilience theory to urban design practice are defined within the proposed framework. These methods fit within five main categories: identify and respond to thresholds, promote diversity, develop redundancies, create multi-scale networks and connectivity, and implement adaptive planning/management/design practices. The framework is validated by the success of the projective design application in the winning 2013 ULI/Hines Urban Design Competition entry, *The Armory*. Resilience theory and the proposed design framework have the potential to continue to advance the prominence of landscape architecture as the primary leader in urban design practice.



# TABLE OF CONTENTS

|     |  |
|-----|--|
| vii | <b>List of Figures</b>                           |
| xi  | <b>Acknowledgements</b>                          |
| 1   | <b>Introduction</b>                              |
| 7   | <b>Background</b>                                |
| 20  | <b>Methodology</b>                               |
| 31  | <b>Literature Review</b>                         |
| 49  | <b>Case Study Analysis</b>                       |
| 114 | <b>Resilience Framework</b>                      |
| 125 | <b>Projective Design / Drylands Competition</b>  |
| 140 | <b>Projective Design / ULI/Hines Competition</b> |
| 168 | <b>Findings</b>                                  |
| 172 | <b>References</b>                                |
| 176 | <b>Appendix A: Definition of Terms</b>           |
| 180 | <b>Appendix B: Supplemental Material</b>         |



# LIST OF FIGURES

## **1.0 Introduction + Background**

- 1.1 - The Adaptive Cycle (Cunningham 2013, adopted from (Gunderson and Holling 2001))
- 1.2 - The Panarchy (Cunningham 2013, adopted from (Gunderson and Holling 2001))
- 1.3 - A Representative Panarchy (Cunningham 2013, adopted from (Gunderson and Holling 2001))
- 1.4 - Basins of Attraction (Cunningham 2013, adopted from (Walker et al. n.d. "Ecology and Society"))

## **2.0 Methodology**

- 2.1 - Methodology (Cunningham 2013)
- 2.2 - Framework Development (Cunningham 2013)
- 2.3 - Analysis Matrix (Cunningham 2013)

## **3.0 Literature Review**

- 3.1 - Literature Groups (Cunningham 2013)
- 3.2 - Literature Map (Cunningham 2013)

## **4.0 Case Study Analysis**

- 4.1 - Location (Cunningham 2013)
- 4.2 - Resilience Framework (Hulse and Gregory 2004)
- 4.3 - Methodology (Hulse and Gregory 2004)
- 4.4 - Opportunities + Constraints (Hulse and Gregory 2004)
- 4.5 - Results (Hulse and Gregory 2004)
- 4.6 - Analysis Matrix (Cunningham 2013)
- 4.7 - Location ([http://www.austrangesoc.com.au/site/pubs\\_newsletter.php?id=10](http://www.austrangesoc.com.au/site/pubs_newsletter.php?id=10))
- 4.8 - Resilience Framework (Cunningham 2013, adopted from (Walker and Abel 2001))
- 4.9 - Analysis Matrix (Cunningham 2013)
- 4.10 - Location (Cunningham 2013)
- 4.11 - Spatial Scales (Bonometti et al. 2010)
- 4.12 - General Concepts (Bonometti et al. 2010)
- 4.13 - Design Process (Bonometti et al. 2010)
- 4.14 - Masterplan (Bonometti et al. 2010)
- 4.15 - Site Plan (Bonometti et al. 2010)
- 4.16 - Analysis Matrix (Cunningham 2013)
- 4.17 - Location (Cunningham 2013)
- 4.18 - Resilience Framework (Barthel et al. 2010)
- 4.19 - Boundaries + Networks (Barthel et al. 2010)
- 4.20 - Design Process (Barthel et al. 2010)
- 4.21 - Masterplan (Barthel et al. 2010)
- 4.22 - Ecological Connectivity (Barthel et al. 2010)
- 4.23 - Feedback Loops (Barthel et al. 2010)
- 4.24 - Performative Building Section (Barthel et al. 2010)
- 4.25 - Active Ground (Barthel et al. 2010)
- 4.26 - Infrastructure Crossing (Barthel et al. 2010)
- 4.27 - Corridor (Barthel et al. 2010)

- 4.29 - Location (Cunningham 2013)
- 4.30 - Circuits + Flows (Czerniak 2002)
- 4.31 - Habitat Nests (Czerniak 2002)
- 4.32 - Adaptive Management (Czerniak 2002)
- 4.33 - Social Program (Czerniak 2002)
- 4.34 - Analysis Matrix (Cunningham 2013)
- 4.35 - Location (Cunningham 2013)
- 4.36 - Masterplan (Perry 2009)
- 4.37 - Metro Connections (Perry 2009)
- 4.38 - Socio-Economic Bridge (Perry 2009)
- 4.39 - Regional Connections (Perry 2009)
- 4.40 - Development Program (Perry 2009)
- 4.41 - Social Memory (Perry 2009)
- 4.42 - Analysis Matrix (Cunningham 2013)
- 4.43 - Location (Cunningham 2013)
- 4.44 - Masterplan (Archives | Urban Land Institute 2013)
- 4.45 - Goals (Archives | Urban Land Institute 2013)
- 4.46 - Connectivity (Archives | Urban Land Institute 2013)
- 4.47 - Big Box Adaptivity (Archives | Urban Land Institute 2013)
- 4.48 - Social Memory (Archives | Urban Land Institute 2013)
- 4.49 - Metro Connectivity (Archives | Urban Land Institute 2013)
- 4.50 - Water Cycle (Archives | Urban Land Institute 2013)
- 4.51 - Analysis Matrix (Cunningham 2013)
- 4.52 - Location (Cunningham 2013)
- 4.53 - Masterplan (Archives | Urban Land Institute 2013)
- 4.54 - Performance (Archives | Urban Land Institute 2013)
- 4.55 - Land Use (Archives | Urban Land Institute 2013)
- 4.56 - Architecture Typology (Archives | Urban Land Institute 2013)
- 4.57 - Social Diversity (Archives | Urban Land Institute 2013)
- 4.58 - Project Goals (Archives | Urban Land Institute 2013)
- 4.59 - Social Memory (Archives | Urban Land Institute 2013)
- 4.60 - Analysis Matrix (Cunningham 2013)
- 4.61 - Case Study Synthesis (Cunningham 2013)
- 4.62 - ULI Synthesis (Cunningham 2013)

## **5.0 Resilience Framework**

- 5.1 - Resilience Framework (Cunningham 2013)

## **6.0 Projective Design/ Drylands Design Competition**

- 6.1 - Location (Cunningham and Fagan 2011)
- 6.2 - Framework (Cunningham and Fagan 2011)
- 6.3 - Future of "Buy and Dry" (Cunningham and Fagan 2011)
- 6.4 - Recalibrate Land Types (Cunningham and Fagan 2011)
- 6.5 - Recalibrate Water Use (Cunningham and Fagan 2011)

- 6.6 - Recalibrate Agriculture (Cunningham and Fagan 2011)
- 6.7 - Modeling Process (Cunningham and Fagan 2011)
- 6.8 - Scenarios (Cunningham and Fagan 2011)
- 6.9 - EcoReserve Network (Cunningham and Fagan 2011)
- 6.10 - Social Adaptivity (Cunningham and Fagan 2011)
- 6.11 - Ecological Adaptivity (Cunningham and Fagan 2011)
- 6.12 - Economic Adaptivity (Cunningham and Fagan 2011)
- 6.13 - Analysis Matrix (Cunningam 2013)

## **7.0 Projective Design/ ULI/Hines Competition**

- 7.1 - Analysis Framework (Cunningham 2013)
- 7.2 - Location (Cunningham 2013)
- 7.3 - Design Framework (Brown et al. 2013)
- 7.4 - Panarchy Map (Cunningham 2013)
- 7.5 - Adaptive Cycle Position (Cunningham 2013)
- 7.6 - Current Basin of Attraction (Cunningham 2013)
- 7.7 - Two Basins (Cunningham 2013)
- 7.8 - Existing Site (ULI/Hines Competition Brief 2013)
- 7.9 - Masterplan (Brown et al. 2013)
- 7.10 - Land Use Diversity (Brown et al. 2013)
- 7.11 - Figure Ground (Brown et al. 2013)
- 7.12 - Transit Connectivity (Brown et al. 2013)
- 7.13 - Pedestrian Connectivity (Brown et al. 2013)
- 7.14 - Infill Strategies (Brown et al. 2013)
- 7.15 - Sustainable Strategies (Brown et al. 2013)
- 7.16 - A District Identity (Brown et al. 2013)
- 7.17 - An Adaptive Future (Brown et al. 2013)
- 7.18 - Social Diversity (Brown et al. 2013)
- 7.19 - Regional Connectivity (Brown et al. 2013)
- 7.20 - The Armory Green (Brown et al. 2013)
- 7.21 - Phasing Strategy (Brown et al. 2013)
- 7.22 - Portland Ave. (Brown et al. 2013)
- 7.23 - The Armory (Brown et al. 2013)
- 7.24 - A Resilient Future (Brown et al. 2013)
- 7.25 - Analysis Results (Cunningham 2013)
- 7.26 - Analysis Matrix (Cunningham 2013)

## **8.0 Appendices**

- 8.1 - Argumentation (Cunningham 2013)
- 8.2 - Drylands Boards (Cunningham and Fagan 2011)
- 8.3 - Drylands Boards (Cunningham and Fagan 2011)
- 8.4 - ULI/Hines Boards (Cunningham et al. 2013)
- 8.5 - ULI/Hines Narrative (Cunningham et al. 2013)
- 8.6 - ULI/Hines Pro Forma (Cunningham et al. 2013)
- 8.7 - ULI/Hines Site Plan (Cunningham et al. 2013)



# ACKNOWLEDGEMENTS

Thank you to Blake Belanger, my major professor, for believing in a project that has been more than two years in the making. It was only with your support through many discussions that this thesis became a reality. This thesis would also not have been possible without Professor Jessica Canfield, who believed in my research in resilience from the beginning. Thank you to my thesis committee members from outside the College of Architecture, Planning + Design: Kendra McLauchlan and Kimberly With. Their added perspectives from geography and landscape ecology were invaluable to adding depth and meaning to this work and are representative of the kind of interdisciplinary collaboration that resilience theory calls for.

To Derek Hoetmer, Kylie Harper, Tyler Knott, and Lauren Brown. I cannot thank you enough for the incredible work ethic, drive, passion, and talent that we pooled together to form Team 1155. The Armory would not have been possible without the unwavering support of Dr. Jason Brody - who helped realize our dream to win. It was an unforgettable experience and we should all be incredibly proud of what we accomplished through The Armory.

To all of my family: your support throughout my education has given meaning to all of my academic endeavors. I am so thankful for all the times we have had together and I look forward to many more in the future.

For E.C. - Father, Mentor, Friend.



# INTRODUCTION

Cities across the world are experiencing many challenges as urban populations continue to increase and global economic connectivity becomes ever more prominent. Landscape architects serve a unique role in solving these challenges as active agents of change through the design of built urban environments. As we continue to persist into an unpredictable future, landscape architects and urban designers will need to use new solutions and methods. Resilience theory, as developed by C.S. Holling, is a relevant and timely body of knowledge that has the potential to serve as an addendum to current landscape architecture theory by serving as a framework for engaging urban design.

This thesis responds to two primary dilemmas. The first is that current approaches to urban design inadequately address the ways in which systems interact and change over time. The second is that current landscape architecture theories of landscape urbanism and ecological urbanism are too abstract and do not provide an adequate understanding and responding to the complexity of cities. In response to these dilemmas, resilience theory addresses the challenges and complexities of contemporary urban environments and is a viable theoretical basis for engaging urban design practice.

## **Background**

Current landscape architecture theories, including landscape urbanism, landscape ecology, and ecological urbanism, seek to build upon the relationship between design and ecology. Landscape urbanism is an abstract theory that is supported by James Corner, Alex Wall, and Chris Reed where landscape becomes the basis for guiding urban design. Richard T.T. Forman, S.T.A. Pickett, Jack Ahern, Nina-Marie Lister, and others are primary figures in landscape ecology. They are primarily concerned with landscapes at larger scales and are more rooted in science-based research. Ecological urbanism shares some of the same players as landscape urbanism, with Mohsen Mostafavi as a prominent figure who calls for a closer integration between design and ecology with a focus on interdisciplinary collaboration. These theories share a common goal of seeking to address the complexity of changing urban environments.

Beginning in the 1970's the ecologist, C.S. Holling, sought to "develop an integrative theory to help us understand the changes occurring globally." These changes are described as "economic, ecological, social, and evolutionary. They concern rapidly unfolding processes and slowly changing ones—gradual change and episodic change, local and global changes" (Gunderson and Holling 2001, 5). This quest for a holistic understanding became resilience theory.

Resilience as defined by Holling is "the amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime—essentially retaining the same function, structure, and feedbacks" (Walker and Salt 2006, 164). The systems that resilience describes are referred to as socio-ecological. These are integrated systems that "consist of relationships between elements at a number of scales and within nested systems" (Du Plessis 2008, 3).

Resilience theory is explained through three primary concepts: the adaptive cycle, panarchy, and basins of attraction. The adaptive cycle explains the way that socio-ecological systems change through four phases within the cycle. These phases are the rapid growth phase ( $r$ ), the conservation phase ( $K$ ), the release phase ( $\Omega$ ), and the reorganization phase ( $\alpha$ ). Although all systems can be characterized by the adaptive cycle, it is important to know that “the adaptive cycle is not an absolute; it is not a fixed cycle, and many variations exist in human and natural systems” (Walker and Salt 2006, 82).

Panarchy explains the complex, cross-scale interactions between economic, ecological, and institutional systems (Gunderson 2001, 5). Within this diagrammatic concept, each system operates within its own adaptive cycle within a certain spatiotemporal scale. Panarchy describes the way that these adaptive cycles influence other cycles at larger and smaller scales over time. In describing complex adaptive systems in terms of the panarchy, it is also important to understand that “the processes that produce these panarchy patterns are in turn reinforced by those patterns—that is, the patterns and processes are self-organizing” (Walker and Salt 2006, 90).

Attraction basins are a three-dimensional representation that communicates the position of a system in terms of resilience. Resilience theory describes systems as inherently moving towards an “attractor” or stable state (Walker et al. 2011). The system is represented by a “ball” that sits within a basin. The size and shape of the basin are described by latitude, resistance, and precariousness. Depending upon these variables, it is either easier or more difficult for the ball to move out of that basin and into another. This difficulty in moving out of a basin is generally thought of as resilience.

## **Methodology**

The methodology of this thesis consists of three parts: literature review, case study analyses, and projective design. This is a mixed methods approach (Creswell 2008, 14-15) that explores the application of resilience theory as a framework for urban design. The process began with a detailed literature review that situates resilience theory into the current body of landscape architecture literature. From there, a series of case studies were explored to understand how resilience theory has been applied to current research and design. In order to conduct this analysis, a resilience framework was developed that serves as both a post-design analysis tool and as an active design/planning framework. Once the case studies were completed, a collection of methods for promoting resilience were organized to apply in a projective design using the framework, the 2013 ULI/Hines Competition. After completion, a post-design analysis was conducted that evaluated the design as well as the resilience framework.

## **Literature Review**

The literature review begins with the primary sources of resilience theory, which inform the background and basis for the research. From this category, three other categories of literature were identified: application of resilience theory, adaptation of resilience theory, and the theorization of resilience. The application of resilience theory category represents research by many of the primary source authors that directly came from the development of resilience theory in the 1970's and 1980's. The adaptation of resilience is a body of research

that applies the concepts of resilience theory to new areas, primarily urban socio-ecological systems. The final category, theorization of resilience, consists of current landscape architecture theories of landscape urbanism and ecological urbanism who loosely share the vocabulary and concepts of resilience theory but who do not apply them rigorously.

The purpose of the literature review is to situate resilience theory into the current body of landscape architecture literature. It is found that resilience theory fits within two primary groups of landscape architecture literature: the theorization of resilience and the adaptation of resilience. The first consists of landscape urbanism and ecological urban theories. Both of these theories use similar vocabulary and concepts but in loose, conceptual terms and are primed to adopt resilience theory as a relevant addendum to their approach towards urban design. The second group, adaptation of resilience theory, is a much more research-based approach to design that does not successfully merge theory and design. That being said, the research is on the right track but will require more interdisciplinary collaboration and future research. Both literature groups are necessary for landscape architecture that applies resilience theory as a basis for urban design. In order for a concrete application of the theory to design, a framework is necessary to be developed.

### **Case Study Analysis**

Through the literature review a series of case studies were identified for each of the three aforementioned categories. These case studies consist of the following:

#### Application of Resilience:

- Resilient Rangelands (Walker and Abel in *Panarchy*, 2001); Willamette River Valley (Hulse and Gregory 2004)

#### Adaptation of Resilience:

- Henna, Finland- A Resilient Socio-Ecological Urbanity (Bonometti et al. 2010); Albano Resilient Campus (Barthel et al. 2010)

#### Theorization of Resilience:

- Downsview Park / Emergent Ecologies (James Corner Field Operations 2002 in Czerniak *Downsview Park Toronto*)

Each of these case studies was analyzed using an analysis matrix that developed from a series of criteria adapted from Jack Ahern (Ahern 2011) and Brian Walker with David Salt (Walker and Salt 2006). This analysis matrix categorizes which methods for promoting resilience are used by describing them in terms of scale (regional, metropolitan, site) and system (social, ecological, economic, spatial). Beyond scale and system, each method is categorized into the adapted criteria of five areas: identify and respond to thresholds, promote diversity, develop redundancies, create multi-scale networks and connectivity, and implement adaptive planning/management strategies. Each case study analysis clearly delineates which scales, systems, and methods were focused on and identify the methods used in list form that corresponds to the matrix. Through this process, patterns can be seen between the literature categories and how much or how little methods for resilience are used.

## **Resilience Framework**

A resilience framework was formed by the author that was informed by two literature sources: Walker and Salt 2006 and Ahern 2011. Jack Ahern proposed a framework that included five categories for promoting resilience. These were a preliminary effort in applying resilience theory to urban design practice, and were cross-referenced with a similar series of categories proposed by Walker and Salt. The resulting framework has five categories: identify and respond to critical thresholds, promote diversity, develop redundancies, create multi-scale networks and connectivity, and implement adaptive planning/management strategies. It also identifies three spatial scales for each category: regional, metro, and site as well as whether it is for social, ecological, economic, or spatial systems.

The resilience framework serves in two capacities: an analysis matrix and as a design/planning framework. As an analysis matrix the resilience framework functions as a post-design tool for determining the extent to which resilience theory was applied in a project as used in the case study analysis. As an active design/planning framework it works as a way to guide decision making and to prioritize various systems, scales, and methods in terms of the overall goals per project. The framework is flexible in its ability to be applied to very specific projects that may have a more limited scope as well as holistic projects such as large masterplans that operate at larger scales. The resilience framework only reflects a project in terms of resilience and does not determine the success of a project. Filling up more cells within the matrix does not indicate that a project is more successful than if fewer cells are filled.

## **Projective Design**

This thesis contains two projective design experiments that are entries for the Drylands Design Competition and the ULI/Hines Competition. A projective design is a design project that serves as a vehicle for experimentation and research and includes a post-evaluation process (Deming and Swaffield 2011, 208-209).

The literature review and case study analysis was informed by a preliminary literature review and projective design that was completed in the fall of 2012 for the Drylands Design Competition. This project served as the foundation for the subsequent research of this thesis. The proposal, entitled *Recalibrating for Resilience: An EcoReserve Network in the South Platte River Basin*, operated at a large, regional scale and is more similar to the research efforts of other resilience scientists. In response to a critical threshold of the transfer of agricultural water rights to urban centers, this proposal seeks a resilient scenario that can adaptively manage this imminent change. A suitability analysis was conducted to identify areas of land that would be more suitable as managed EcoReserve than to continue as agricultural land. The resulting resilient scenario provides greater social, economic, and ecological adaptive capacity. Overall, the project seeks to achieve resilience at a large scale, while maintaining a balance between the targeted systems and scales. It is an exploration into how a region responds in a resilient manner to one shock or disturbance: a threshold in water supply.

After this initial projective design, the aforementioned literature review and case study analysis was conducted. Another projective design became necessary to test the

methods for promoting resilience that were identified through the case study analysis. The ULI/Hines Student Urban Design Competition was chosen as a prime opportunity to test interdisciplinary collaboration within a complex urban site. In order to better understand how resilience may have been applied to past competition entries, a series of three case study analyses were conducted – two 2009 finalists (Touch and Panorama Station) and one 2012 finalist (Bayou Commons) was chosen. The 2013 ULI/Hines Competition entry, The Armory, was produced by the author along with Team 1155.

## **Findings**

The literature review shows that there is not a systematic methodology or framework for applying resilience theory to design practice. Design is the one of the critical missing components to resilience theory, but one that landscape urbanism and ecological urbanism can begin to provide. Currently, resilience theory is too immersed in science-based research to be readily applicable to design but the concepts of resilience have the potential to serve as a beneficial framework for engaging urban environments.

The resilience framework that is proposed in this thesis as applied in the 2013 ULI/Hines Urban Design Competition is a point of departure for future research and projective design. As an analysis matrix utilized in the case study analysis and for the projective design experiments it is useful in identifying the critical systems, scales, and methods that are being employed in a project. The resilience framework is flexible in its ability to work in response to both specific thresholds or in a holistic approach to resilience.

The projective designs are successful in their application of resilience theory to design. The Drylands Competition was an initial effort that explored the complexity and challenges in applying an abstract theory to design and served as a beneficial testing ground. By winning an ASLA Central States Design Un-Built Merit Award, as well as an honorable mention in the competition it demonstrates the effectiveness of using the theory as a basis for design. The ULI/Hines Competition entry, The Armory, was a much more refined effort in applying the theory. This proposal was a highly successful urban plan that applied the abstract theory of resilience to a concrete design. The Armory was chosen with three other submissions from 149 entries as a finalist in the competition and after the finalist phase was awarded the grand prize. While there are several factors for the success of this projective design winning such a prestigious competition, it validates the resilience framework by some measure.

Resilience theory is a relevant addendum to current landscape architecture theory and urban design practice. It is not a solve-all approach but it begins to amend some of the gaps in understanding and adequately engaging urban design. While the theory itself is highly complex and comes from an ecological background, landscape urbanists and other landscape architects/urban designers are primed to adopt the theory as an addendum to their current process because of the similarities in end goals. It is particularly useful for the communication between disciplines, because of these shared concepts and ideas. If accepted as a relevant addendum, landscape urbanism and ecological urbanism would gain a more concrete approach that applies a greater rigor to their current process. This is not to completely alter or begin a new approach, but to build off of existing research and design strategies to more successfully engage urban design practice.



# BACKGROUND

## **On Integrating Ecology and Urbanism**

Over the course of the last century and a half there has been a burgeoning effort to integrate ecological and urban systems. This began with the work of Ian McHarg in the late 1960's and 70's with his research in *Design with Nature* (1969), but it has continued to develop in recent history with theories of landscape urbanism, landscape ecology, and ecological urbanism. While these theories vary in their details, they all focus on the principles of landscape serving a greater purpose in the built environment. These theories serve as a basis for landscape architecture and urban design practice in the current professional and academic realms and continue to push for a level of design that can address the complexity of an ever-changing world.

## **Landscape Urbanism**

The theory of landscape urbanism establishes landscape as infrastructure in the urban environment, and deals with the inherent complexity of cities. "New urban practices are emerging today at the intersection of geography, politics, ecology, architecture, and engineering. Among these practices, landscape urbanism in particular has acquired a privileged standing as the discipline capable of synthesizing expertise from a number of related fields" (Allen 2011, 40). This is a unique perspective, because it points to landscape architects as facilitating a role of mediation between disciplines in order to solve urban design issues. Of particular interest with landscape urbanism is their perspective on ecology, which is often a metaphor or analogy that lacks the rigor of scientific method.

James Corner is one who uses this loose analogy. "Both landscape and ecology serve as useful strategic models...they both deal with time open-endedly, often viewing a project more in terms of cultivation, staging, and setting up certain conditions rather than obsessing on fixity, finish, and completeness. Landscape and ecology understand projects as dynamic, grounded temporalities..."(Corner 2004, 2). From this perspective, landscape urbanism lies at the juncture between landscape and ecology. Corner alludes to something significant by moving the profession of landscape architecture and urban design practice away from fixed designs that imply change as being an enemy. "Much thinking on ecology and urbanism is inspired by the creative potential of contemporary scientific metaphors. Terms such as diversification, flows, complexity, instability, indeterminacy, and self-organization become influential design generators, shaping the way we consider and construct places" (Weller 2006, 874). This theme surrounding open-endedness, indeterminacy, and this type of vocabulary is consistent with what is called the non-equilibrium paradigm found in ecology, which is discussed later.

The integration of landscape, ecology, and urbanity is at the heart of landscape urbanism theory. "To see the city as an artificial ecology is not to establish a loose analogy between the city and natural systems, but rather to take advantage of ecology as a powerful model for managing the city's inherent complexity" (Allen 2011, 48). But this is the significant point, that ecology is a model within landscape urbanism. It does not act as a rigorous method for urban design and planning practice.

Landscape urbanism also points to landscape architecture as being an integral piece within urban design practice. “If landscape architecture has been thought of as merely an art of amelioration, of secondary significance to buildings and urban planning, then today it finds itself assuming a more relevant and active role in addressing the regional and ecological questions that face society—questions about place, time, and process” (Wall 1999, 247). This lends itself to the ability for landscape architects to communicate between disciplines and synthesize a broad range of knowledge, especially in urban design practice. It will be of equal importance to define what this significant role is as the practice continues to change over time.

### **Landscape Ecology**

The field of landscape ecology employs a more pragmatic approach to design than landscape urbanism, with the work of Richard T.T. Forman, S.T.A. Pickett, Jack Ahern, Nina-Marie Lister, and others being at the forefront. Landscape ecology is more closely allied with the sciences and has developed into a cross-disciplinary effort between design and ecology. Although it is not the focus of this thesis, Forman's work with large-scale landscapes is a prominent feature of landscape ecology. This includes the concepts of patches, edges/boundaries, corridors, and mosaics (Dramstad et al. 1996). Forman also pioneered the concept of resilience in different terms that are not included in this thesis.

One of the key concepts that developed out of ecology is the non-equilibrium paradigm, which manifested in the latter half of the 20th century and into the 21st century. “The modern era of the 20th century was arguably associated with an equilibrium or deterministic conception of nature, science and ecology” (Ahern 2011, 1). This is a significant turning point because it is a complete shift in the way that we perceive nature. Rather than ecosystems moving towards stable states known as equilibrium, they are constantly in flux. In terms of landscape ecology, this paradigm shift results in ways of thinking that accept change and adaptation as common themes within landscapes and ecosystems.

In thinking about adaptivity and designing within landscape ecology it alludes to a new way of engaging design practice, particularly in urban environments. “Design, planning, and management are all part of the same spectrum of activities in which we engage with our landscape and living ecology. The central notion of adaptive design is that if we understand that landscapes and their ecosystems are fundamentally dynamic, that they're constantly changing, this means that there is an inherent amount of uncertainty in terms of how they behave” (Lister 2011, 8). It is this change and amount of complexity within the urban environment that will ultimately need to be addressed in the field of landscape architecture in the future, and the concepts presented by landscape ecology are undoubtedly a part of the solution.

### **Ecological Urbanism**

Ecological urbanism is another theory that begins to more inclusively combine ecological ideas with the design of urban environments. Although it is different than landscape urbanism, it borrows and builds off of the theory including work by some of the same key authors. Mohsen Mostafavi is one of the primary leaders of the ecological urbanism movement. He states that “[it] is not to imply that ecological urbanism is a totally new and singular mode of design practice. Rather, it utilizes a multiplicity of old and new methods,

tools, and techniques in a cross-disciplinary and collaborative approach toward urbanism developed through the lens of ecology. These practices must address the retrofitting of existing urban conditions as well as our plans for the cities of the future” (Mostafavi 2010, 26). The collaborative nature and combination of a variety of sources validates ecological urbanism as a fitting response to the complexity and challenges presented by modern cities.

The theory of ecological urbanism tends towards a more holistic and appropriate approach toward cities. “Yet another key characteristic of ecological urbanism is its recognition of the scale and scope of the impact of ecology, which extends beyond the urban territory. The city, for all its importance, can no longer be thought of only as a physical artifact; instead, we must be aware of the dynamic relationships, both visible, and invisible, that exist among the various domains of a larger terrain of urban as well as rural ecologies” (Mostafavi 2010, 29). In terms of the way that designers engage urban challenges, this statement describes a significant role for landscape architects who are primed to operate at different scales. The perspective from which we view cities cannot be one dimensional, because the problems posed are multi-dimensional across both space and time. Ecological urbanism provides a preliminary lens through which landscape architects can advance and engage urban design.

### **Sustainability**

One of the most prevalent ideas throughout popular culture and current design practice is sustainability. In its most basic definition, sustainability refers to managing resources in a manner that provides for current necessity while not compromising the needs of the future (US EPA 2013). Among the previously described theories there is some disagreement about the significance of the concept of sustainability. In *Ecological Urbanism*, Mostafavi writes: “And yet it is relatively easy to imagine a city that is more careful in its use of resources than is currently the norm, more energy-efficient in its daily operations—like a hybrid car. But is that enough? Is it enough for architects, landscape architects, and urbanists to simply conceive of the future of their various disciplines in terms of engineering and constructing a more energy-efficient environment?” (Mostafavi 2010, 17). What is critical about this statement is the reference to increased efficiency, which is not always beneficial or even attainable.

Efficiency is a common goal, especially in terms of energy but the issues associated with obtaining it are not always the problem. “Though efficiency, per se, is not the problem, when it is applied to only a narrow range of values and a particular set of interest it sets the system on a trajectory that, due to its complex nature, leads inevitably to unwanted outcomes” (Walker and Salt 2006, 6). The pursuit of greater efficiency in terms of the way that we manage our resources is the common denominator of sustainability. “The ruling paradigm – that we can optimize components of a system in isolation of the rest of the system – is proving inadequate to deal with the dynamic complexity of the real world. Sustainable solutions to our growing resource problems need to look beyond a business as usual approach” (Walker and Salt 2006, 7). Dynamic complexity is especially present in urban areas and their future will depend on how we design and manage urban systems in the face of impending change.

Common amongst all the aforementioned theories (landscape urbanism, landscape ecology, ecological urbanism, sustainability) is that although they are getting at similar ideas, they

lack a truly holistic approach. Sustainability is the most mainstream way of thinking, but also the furthest from the mark. “What it all adds up to is that there is no sustainable “optimal” state of an ecosystem, a social system, or the world. It is an illusion, a product of the way we look at and model the world. It is unattainable; in fact... it is counterproductive, and yet it is a widely pursued goal” (Walker and Salt 2006, 7). Therefore in order to achieve a truly sustainable future, one that does not seek a stable or optimal state, there will need to be a synthesis of current theory and continuous addenda to further develop the way we think about and engage cities. Resilience theory is primed to become a strong addition to such a synthesis of current theory.

### **Resilience Theory**

Beginning in the 1970’s the ecologist, C.S. Holling, sought to “develop an integrative theory to help us understand the changes occurring globally.” These changes are described as “economic, ecological, social, and evolutionary. They concern rapidly unfolding processes and slowly changing ones—gradual change and episodic change, local and global changes” (Gunderson and Holling 2001, 5). This quest for a holistic understanding became *resilience theory*.

The process of developing resilience theory resulted from systems thinking and the shift from the equilibrium view of ecological systems to a multi-stable state, non-equilibrium perspective. In Holling’s seminal work, *Resilience and Stability of Ecological Systems*, he describes the equilibrium view of ecology as one that is “essentially static and provides little insight into the transient behavior of systems that are not near the equilibrium. Natural, undisturbed systems are likely to be continually in a transient state; they will be equally so under the influence of man” (Holling 1973, 2). The important point here is that some ecosystems are inherently drawn towards a stable or “equilibrium” but some are continually in flux, which renders the view that all ecosystems move in a linear path towards a climax state inadequate to describe their true nature.

Resilience theory embraces change as a normal aspect of life and the way systems, of which we are a part, behave (Walker and Salt 2006, 9-10). The theory describes that adaptive changes are “some of the most telling properties of ecological systems [that] emerge from the interactions between slow-moving and fast-moving processes and between processes that have large spatial reach and processes that are relatively localized” (Gunderson and Holling 2001, 9). These emergent properties are highly complex and affect a range of scales and multiple systems. Consequently, previous models for describing ecosystems “...are partial. They are too simple and lack an integrative framework that bridges disciplines and scales” (Gunderson and Holling 2001, 8). It is this complexity that resilience theory seeks to understand.

### **The Properties of Systems**

Resilience is “the amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime—essentially retaining the same function, structure, and feedbacks” (Walker and Salt 2006, 164). The concept of resilience refers to what are called socio-ecological systems that are “linked systems of people and nature” (Walker and Salt 2006, 164). Socio-ecological systems are also “one

integrated system that spans matter, life, and human social and cultural phenomena (or mind)" and "consists of relationships between elements at a number of scales and within nested systems"(Du Plessis 2008, 3).

These socio-ecological systems undergo a process known as the adaptive cycle. The adaptive cycle is "a way of describing the progression of social-ecological systems through various phases of organization and function. Four phases are identified: rapid growth, conservation, release, and reorganization. The manner in which the system behaves is different from one phase to the next with changes in the strength of the system's internal connections, its flexibility, and its resilience" (Walker and Salt 2006, 163). When a system undergoes a major change, causing the system to shift into another phase of the adaptive cycle, it is said to undergo a disturbance.

Disturbance can be classified as "actual change...triggered by agents of disturbance, such as wind, fire, disease, insect outbreak, and drought" (Holling 2001, 394). Within the urban environment, disturbances may be social, ecological, or economic and can include from changes in institutional management, floods, social fads, housing crises, and migration.

The way in which adaptive cycles relate to each other across scales is called *panarchy*, which evolved from hierarchy. Panarchy "is the term we use to describe a concept that explains the evolving nature of complex adaptive systems. Panarchy is the hierarchical structure in which systems of nature (for example, forests, grasslands, lakes, rivers, and seas), and humans (for example, structures of governance, settlements, and cultures), as well as combined human-nature systems (for example, agencies that control natural resource use) (Gunderson and others 1995) and social-ecological systems (for instance, co-evolved systems of management) (Folke and others 1998), are interlinked in never-ending adaptive cycles of growth, accumulation, restructuring, and renewal. These transformational cycles take place in nested sets at scales ranging from a leaf to the biosphere over periods from days to geologic epochs, and from the scales of a family to a socio-political region over periods from years to centuries" (Holling 2001, 392). To summarize, resilience relates to socio-ecological systems, which dynamically change through the adaptive cycle, which in series are related through the panarchy.

Holling also redefines the meaning of sustainability, claiming that true sustainability "requires both change and persistence" (Holling 2001, 403). Sustainability is also "the capacity to create, test, and maintain adaptive capability. Development is the process of creating, testing, and maintaining opportunity. The phrase that combines the two, "sustainable development," therefore refers to the goal of fostering adaptive capabilities while simultaneously creating opportunities. It is therefore not an oxymoron but a term that describes a logical partnership" (Holling 2001, 399). This definition of sustainability includes the tenets of resilience and adequately takes into account the way in which systems actually behave.

When dealing with systems there are some other key terms that are necessary to understand. The first relates to the way systems work in terms of variables. Variables are separated into two categories: controlling and fast/slow. Controlling variables in a

system determine the levels of other variables. In terms of the urban environment, these might be the street network, government institutions, or regional ecologies. Fast and slow variables operate at short, rapid time scales or very slowly. Slow variables tend to be ecological, institutional, or cultural, while fast variables might be social fads, daily economic shifts, or extreme weather events (Walker and Salt 2006, 165).

The way in which variables interact and affect each other is called feedback. Feedback is important because it is a signal for when certain events are occurring such as gas prices signalling a fluctuation in the market or that there is a scarcity of oil. Therefore feedbacks are “the secondary effects of a direct effect of one variable on another, they cause a change in the magnitude of that effect. A positive feedback enhances the effect; a negative feedback dampens it” (Walker and Salt 2006, 164).

Systems also tend to be thought of in terms of having redundancies and diversity. Both are important but there is a fine balance between having too many redundancies and not enough diversity. Redundancies are “systems designed with multiple nodes to ensure that failure of one component does not cause the entire system to fail” (Fleischhauer 2010, 277). In general, it is about putting all of one’s eggs in one basket without planning for failure. It is better to have more baskets with eggs, but not to a point where efficiency is lost.

Conversely, diversity refers to “the different kinds of components that make up a system. In respect to resilience there are two types of diversity that are particularly important.” The first of these is functional diversity, which refers to the range of functional groups that a system depends on. For an ecological system this might include groups of different kinds of species like trees, grasses, deer, wolves, and soil. Functional diversity underpins the performance of a system. The second is response diversity, which is the range of different response types existing within a functional group. Resilience is enhanced by increased response diversity within a functional group” (Walker and Salt 2006, 164). Resilience is related to the way that systems respond to disturbance, either in an adaptive and transformative manner, or resulting in catastrophic change. Identifying feedbacks, developing redundancies, and promoting diversity are a few of the ways that resilience can be enhanced in systems.

Resilience theory is based upon three concepts: the adaptive cycle, panarchy, and basins of attraction.

### **The Adaptive Cycle**

The adaptive cycle describes how systems change. There are (Fig. 1.1) four different phases within the cycle: the rapid growth phase ( $r$ ), the conservation phase ( $K$ ), the release phase ( $\Omega$ ), and the reorganization phase ( $\alpha$ ). These phases are within an infinite loop, where each phase can move into the next without going in any particular order, although the reorganization phase cannot go directly to the conservation phase (Walker and Salt 2006, 83). The adaptive cycle “aggregates resources and periodically restructures to create opportunities for innovation that is a fundamental unit for understanding complex systems, from cells to ecosystems to societies to cultures” (Holling 2001, 403). Although all systems can be characterized by the adaptive cycle, it is important to know that “the

adaptive cycle is not an absolute; it is not a fixed cycle, and many variations exist in human and natural systems" (Walker and Salt 2006, 82).

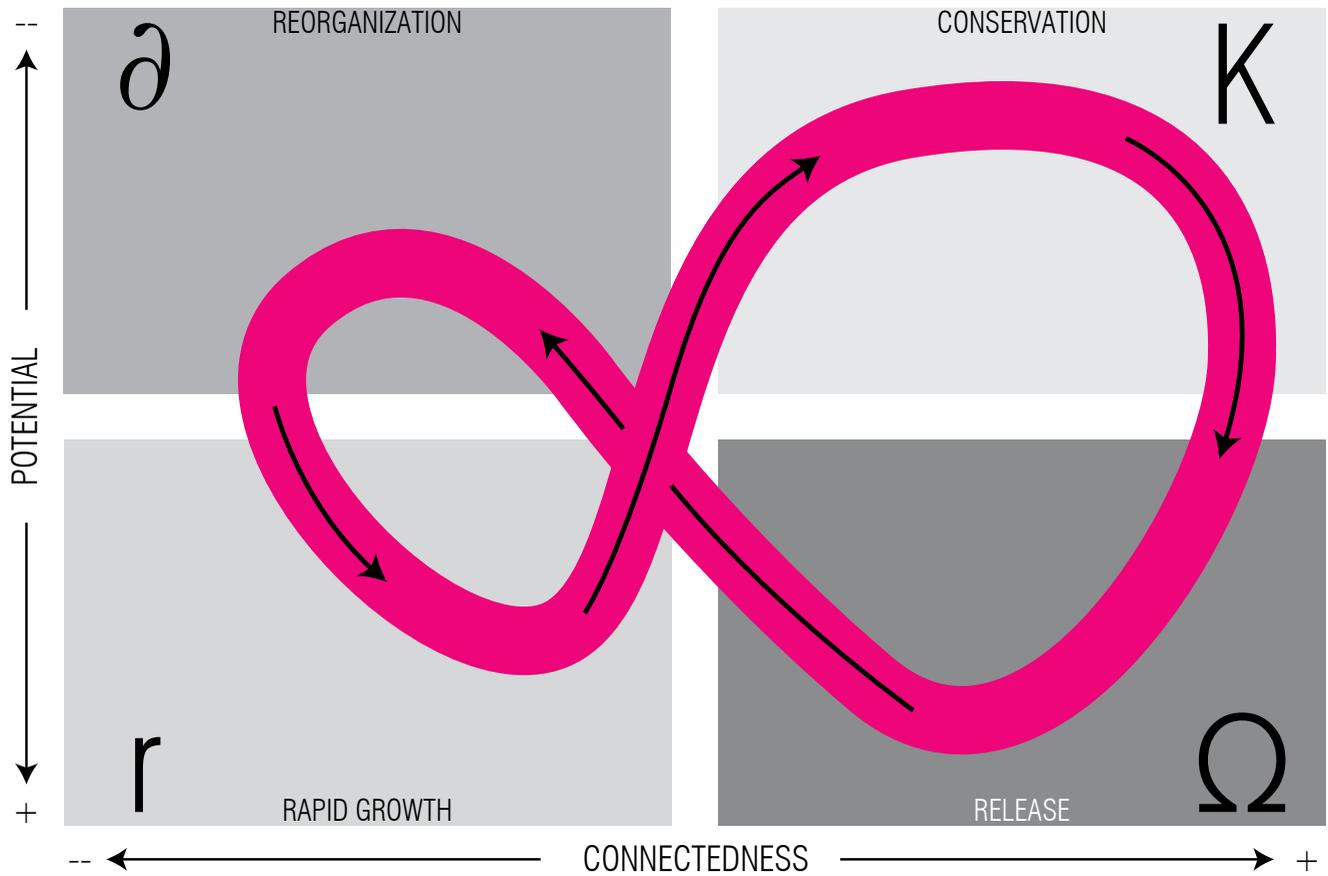
Breaking down the adaptive cycle into four phases is simple, but the interactions between phases are extraordinarily complex. The *rapid growth phase* is explanatory in its title; growth occurs very quickly. This is the stage where species are "able to prosper under high environmental variation and tend to operate over short timeframes. What characterizes this stage in ecosystems are pioneer species and those that thrive in disturbed areas; this is the phase of opportunity and innovation (Walker and Salt 2006, 76).

The *conservation phase (K phase)* focuses on carrying capacity where the survivors "live longer and are more conservative and efficient in their use of resources. They operate across larger spatial scales and over longer time periods. They are strong competitors" (Walker and Salt 2006, 77). The K phase is also where resources become increasingly tighter and the system as a whole is less flexible, it is locked into a stratified set of processes (Walker et al. 2004, 2).

The path between the later stages of the K phase are often times the most crucial: "Capital doesn't accrue in the late K phase either, and the likelihood of a major collapse is high. So if the system is in a late K, the first question is how to undo some of the constraints. Any release phase is costly and unpleasant and involves the loss of capital (social, economic, and natural), so if a release seems inevitable, then the question becomes: How can we navigate a graceful passage through the back loop?" (Walker and Salt 2006, 87). This is significant because it begins to point to what is important for decision making in terms of managing for resilience.

The *release phase* is where the system becomes undone. "The longer the conservation phase persists the smaller the shock needed to end it" (Walker and Salt 2006, 77). The following *reorganization phase* is marked by chaos and uncertainty. "Small, chance events have the opportunity to powerfully shape the future" (Walker and Salt 2006, 78). Usually systems move in the order of the phases presented here, but this can vary depending on the system. With systems moving through these adaptive cycles, and systems interacting with a variety of other systems, it becomes quickly apparent at how complex these relationships are.

When using the adaptive cycle as a visual descriptor of resilience, it is important to understand that "the cycle is too general to be viewed as a testable hypothesis. Its value is as a metaphor to classify systems, order events, and suggest specific questions and testable hypotheses that are relevant for... understanding transformations in linked systems of people and nature" (*Panarchy*, 49). The adaptive cycle is therefore a tool that is beneficial in helping us understand resilience and the cycles that systems experience, but not an absolute.



### 1.1 The Adaptive Cycle

The adaptive cycle describes the way that systems travel through phases in an infinite loop. Four phases characterize this process: rapid growth, conservation, release, and reorganization. This representation is, however, only a metaphor for understanding the changes that systems go through. It is not meant to quantitatively measure resilience or represent an absolute. There are many variations of the adaptive cycle that systems go through, but this diagram provides the basis for understanding complex adaptive systems.

### Panarchy

Resilience theory revolves around the concept of *panarchy* (Figs. 1.2, 1.3) which by definition explains the complex, cross-scale interactions between economic, ecological, and institutional systems (Gunderson 2001, 5). This concept evolved from hierarchy, which is insufficient in describing the systems being studied that shift across a variety of scales. "Because of cross-scale interactions, the resilience of a system at a particular focal scale will depend on the influences from states and dynamics at scales above and below. For example, external oppressive politics, invasions, market shifts, or global climate change can trigger local surprises and regime shifts" (Walker et al. 2004, 3). In other words, hierarchy does not adequately describe the complexity of the interaction of systems, because each system acts independently in its own adaptive cycle but interacts with other systems above and below.

The concept of panarchy is what separates this theory from previous models, because it addresses the aforementioned properties that "emerge from the interactions between slow-moving and fast-moving processes and between processes that have large spatial reach and processes that are relatively localized" (Gunderson and Holling 2001, 9). In describing complex adaptive systems in terms of the panarchy, it is also important to understand that "the processes that produce these panarchy patterns are in turn reinforced by those patterns—that is, the patterns and processes are self-organizing" (Walker and Salt 2006, 90).

## **Attraction Basins**

The concept of basins of attraction is a three-dimensional diagram that communicates the position of a system. In *Resilience, Adaptability, and Transformability in Social-ecological Systems*, Walker et al. describe systems as inherently moving towards an “attractor,” or stable state. Systems tend to have multiple basins of attraction, with one main attractor and sometimes several alternates (Fig. 1.4).

In describing the position of a system in three dimensions, there are three key terms: latitude, resistance, and precariousness. Latitude describes the width of the basin, which is the maximum change a system can withstand without losing the ability to recover. Resistance is the depth of the basin, and represents the amount of difficulty of changing the system. Precariousness represents the current trajectory of the system and how close it is to a critical threshold between basins of attraction; the closer a system is to a threshold, the easier it is to be pushed over (Walker et al 2004, 6; Walker and Salt 2006, 63). Within the context of this three-dimensional representation, resilience is staying in the same basin of attraction—which is intended to be the desirable stable state (Walker et al. 2004, 6). The attraction basins themselves are continuously changing shape due to external factors, but the system is constantly attracted to the bottom of the basin (Walker and Salt 2006, 54).

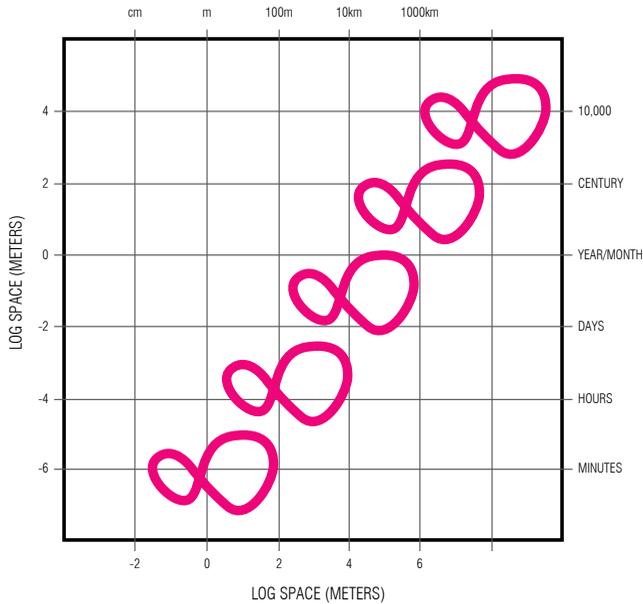
Panarchy is an important concept that ties into basins of attraction. Systems at finer scales can influence the position of larger systems within their basin of attraction and vice versa. Influencing resilience at one scale fundamentally results in a loss of resilience at another scale, therefore it becomes important to prioritize resilience at various scales from a management perspective (Walker et al. 2004, 4-5).

When thinking of resilience in terms of this three dimensional approach, several questions arise that reoccur throughout this literature: What is the desired stable state or basin of attraction, and who defines what this is? Is it desired for a system to be able to move between two or more basins of attraction, and if so, what is the level of resilience required to facilitate this oscillation between stable states?

One example of an attraction basin is the case of surface parking lots in an urban context. Surface parking lots tend to be highly resilient socio-economic systems because the parking is based upon convenience and low prices. They are also steady cash flow generators for owners, where it is more profitable for them to keep the parcels as surface parking rather than develop them. Here, these systems are highly resistant to change. If a developer were to push the ball out of the basin, they would leverage a large sum of money which would be the catalyst for change and move the ball into a basin that is organized around mixed-use development or some other use that is more desirable.

## **Current Research**

There are several research efforts related to the development of resilience theory over the last decade. The two of note are the Resilience Alliance and the Stockholm Resilience Center. The Resilience Alliance was founded in 1999 and consists of scientists and professionals from a variety of disciplines who collaboratively approach research in

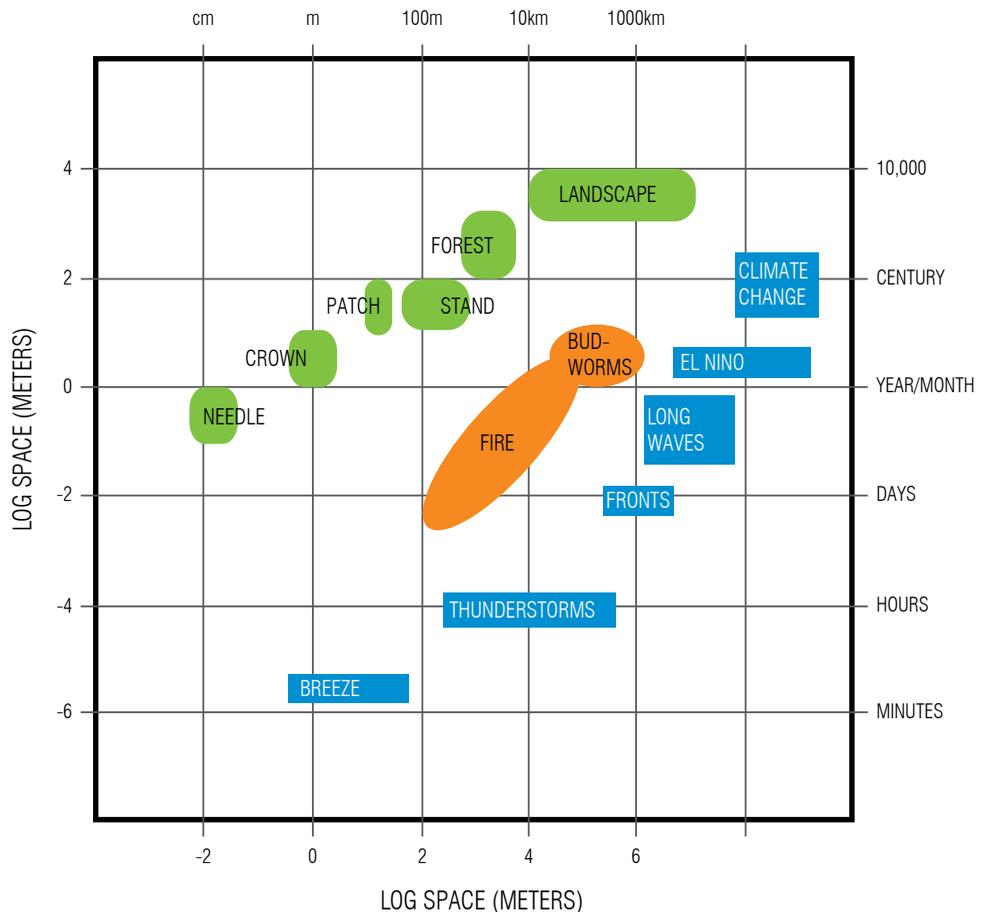


## 1.2 The Panarchy

A panarchy is a nested set of adaptive cycles that represent the cross-scale interaction between complex systems. At the lower left are small scale processes that occur both spatially and temporally. Larger scale processes occur much more slowly but have greater implications for what occurs at scales below. Conversely, small scale adaptive cycles influence larger scales.

## 1.3 A Representative Panarchy

The diagram at right describes the panarchy in ecological terms. The small scale goes all the way down to how a breeze is a disturbance to the needle of a pine tree, and goes all the way up to how entire landscapes react to slow-moving processes like climate change. Fast-moving disturbances such as fire have implications at a range of scales both spatially and temporally. Conceptually this diagram can be conceived as a nested set of adaptive cycles, where systems interact across scales. Additional layers can also be included that are not represented here, such as social and economic systems.



socio-ecological systems. They primarily focus on topics of resource management, terrestrial and aquatic regional research, exploring interdisciplinary collaboration, and the application of resilience theory to develop guidelines and frameworks for sustainable development. This effort is led by C.S. Holling and Brian Walker, among others who originally developed resilience theory (resalliance.org).

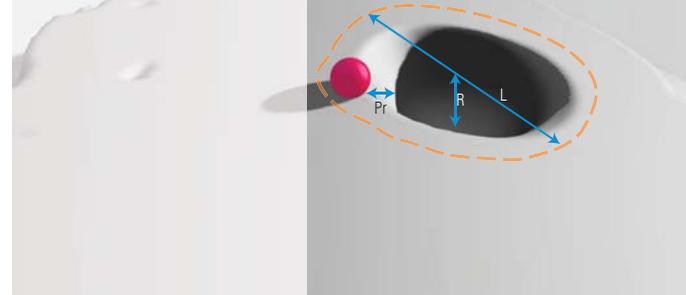
The Stockholm Resilience Center was founded in 2006 by a grant from the Foundation for Strategic Environmental Research. Their mission is to be a world-leading collaborative research center that advances the knowledge and understanding of socio-ecological systems in terms of development management and governance practices. Extensive research has been conducted by the Center in the following themes: freshwater, food, and ecosystem services; global and cross-scale dynamics; governance of coastal and marine systems; adaptive governance, networks, and learning; regime shifts; urban socio-ecological systems; and Baltic Sea ecosystem management (stockholmresilience.org).

Other research efforts have focused on resilience in urban areas in relation to peak oil, climate change, and other critical thresholds (e.g. *Resilient Cities* by Newman, Beatley, and Boyer). While these issues are timely and of importance, they are not the focus of this research and do not directly relate to resilience theory as developed by C.S. Holling.

### The Goals of Resilience

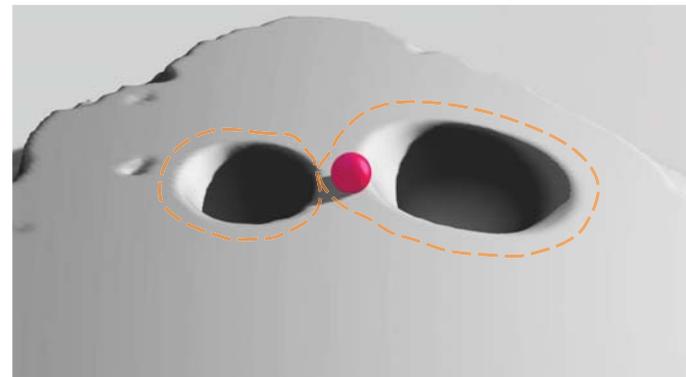
Generally speaking, the goal of resilience theory is in the definition of the term according to Holling and other resilience scientists associated with his theory: to withstand change while still retaining the system's structure, identity, function, and feedbacks (Walker and Salt 2006, 154). In terms of a diagrammatic, three dimensional approach the goal is to remain within the same basin of attraction that is constantly experiencing external disturbances. The ability to remain within a desirable basin of attraction, of which there may be more than one, refers to the concept of stability. There are two distinct ways of viewing stability: one focuses on maintaining efficiency of function, while the other focuses on the existence of function (Gunderson and

### 1.4 Basins of Attraction



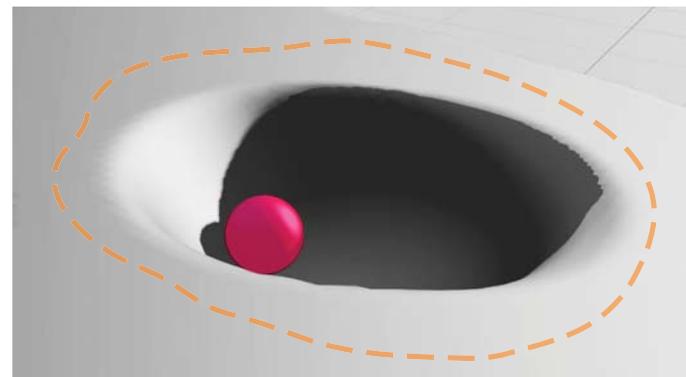
A visual description of a basin of attraction. The system, represented by the ball, is sitting on the edge of a new basin or stable state. The distance from the basin is

precariousness ( $Pr$ ), the depth of the basin is resistance ( $R$ ) and the width of the basin is latitude ( $L$ ). See text for further definition of these terms.



A representation of two basins of attraction. A system may have multiple stable states that can be equally resilient, but not always desirable. Here, the system is in

neither and these situations are where adaptive management and planning can help to move the system into a desired stable state before it moves into the opposite.



A depiction of the system within a basin of attraction. The level of resilience that this system has to various disturbances determines how long it will remain in this

stable state. This may be a desired or undesired effect, and it is therefore important to determine which thresholds are most significant for resilience.

Holling 2001, 28). The research presented in this thesis looks at the latter, which is associated with the non-equilibrium paradigm. Contrastingly, to maintain efficiency of function seeks to control and optimize system performance which creates rigid, homogeneous, and precarious systems—concepts that fundamentally inhibit resilience.

Resilience is also not always a desirable characteristic. A socio-ecological system that is in an undesirable state (such as a post-industrial site, a turbid lake system, an urban surface parking lot, or a channelized urban stream corridor) may also demonstrate highly resilient features that are resistant to efforts to change the stable state (Walker and Salt 2006, 37). Related to this is the formation of rigidity traps and poverty traps within the panarchy. A *poverty trap* occurs when the adaptive cycle collapses due to external or internal forces, resulting in low connectedness, potential, and resilience. A *rigidity trap* results from maladaptive conditions that facilitate high potential, connectedness, and resilience (Gunderson and Holling 2001, 95). Neither of these scenarios represents a desirable stable state but is frequently found in socio-ecological systems. Poverty traps include slums, degraded urban conditions such as post-auto industry collapse Detroit, and parts of rural America. Rigidity traps include suburban development, bureaucratic structure (i.e. monarchies, the caste system), early American plantations, and extremely degraded watersheds due to heavy industrial development.

Often times, resilience is thought of as “bouncing back” to an original state. This is contradictory to what resilience theory describes which is to retain the *ability* to return to a desired stable state (Walker and Salt 2006, 63). Resilience is about responding to change as a normal occurrence, rather than being a victim of its effects.

A significant question when thinking of resilience is: what are we trying to be resilient to? “The notion of general resilience—that is, ecosystems that are resilient in the face of any and all disturbances for all purposes (production, species diversity, aesthetic value, and so on)—is not achievable, and the quest for it clouds understanding” (Walker and Abel in *Panarchy*, 295). Because general resilience is not achievable, it is necessary to identify and prioritize thresholds and disturbances that different systems need to be resilient to. This also raises the issue of what spatial and temporal scales are most relevant in terms of resilience. Are the most critical issues at regional spatial scales and across centuries? Or is it about resilience within a home during a decade? “Specification of time scale must accompany any discussion of resilience. Without it, disagreements will arise between a geomorphologist, who thinks the last ice age has just ended, and an economist, who thinks thirty years is a long run” (Walker and Abel in *Panarchy*, 295).

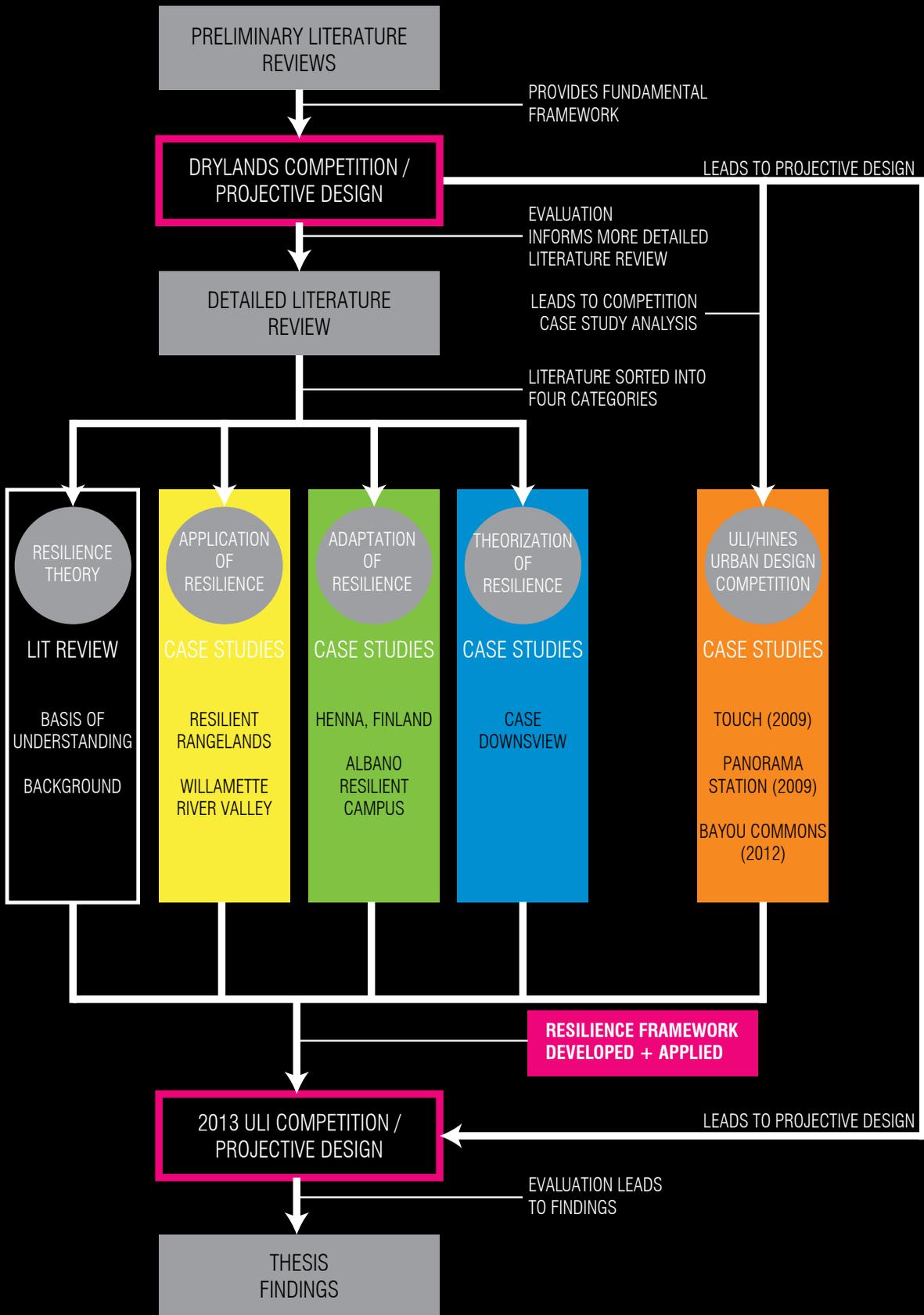
Resilience at varying scales also influences resilience at other scales above and below. “... resilience can be achieved in one time period at the expense of the future, and at one scale at the expense of a broader scale (Carpenter et al., 2001) “(Alberti and Marzluff 2004, 250). With this in mind, it becomes evident that decisions need to be made that prioritize different systems, thresholds, and scales.

Who makes these decisions will inherently play a critical role in attempting to design for a resilient future. The following chapters explore how landscape architects are positioned to be the leaders in using resilience theory as a framework for engaging urban design practice, synthesizing a range of systems, scales, disciplines, and issues to produce well-developed and effective design decisions.

# METHODOLOGY

The methodology for this thesis focuses on three primary methods: literature review, case study analyses, and projective design. A mixed methods approach is utilized to holistically explore resilience theory and its applicability to landscape architecture and urban design practice (Creswell 2009, 15). This exploration developed in a linear process and has been the product of almost two years of work through seminars, thesis research, competition entries and design studios. The resulting thesis is a culmination of research, literature review, and projective design that is structured into a cohesive methodology.

A preliminary literature review and seminar paper informed the framework for the first projective design- *Recalibrating for Resilience: An EcoReserve Network in the South Platte River Basin*. The results from this first projective design experiment led to a subsequent literature review that went into more depth and breadth. The analyzed literature for this review was categorized into four groups: primary sources, application of resilience, adaptation of resilience, and theorization of resilience. From this categorization, case studies were identified to analyze for methods that promote resilience. The resilience framework was developed as an analysis tool for the case studies as well as a method for applying the theory to (projective) design. Another projective design experiment was identified to test the methods derived through the case study analyses and used in the resilience framework. The ULI/Gerald D. Hines Urban Design Competition was chosen as this projective design, and an analysis of three case studies from previous competitions were conducted to understand how the principles of resilience have been applied thus far in the competition. Once the 2013 ULI/Hines Competition was completed as a projective design, the results from the application of the framework were synthesized into findings.



2.1  
Methodology

## **Preliminary Literature Review + Drylands Projective Design**

The preliminary literature review consisted of primary sources of the development of resilience theory. Key authors explored included Holling, Gunderson, Abel, Hulse, and the work of the Resilience Alliance. This body of literature was the focus mostly to gain familiarity with the tenets of resilience theory and to understand how it has been applied in the field of ecology. This literature review was conducted in anticipation of the 2012 Drylands Design Competition.

Gunderson and Holling 2001 was used as the primary source of literature for an overview of resilience theory and the concepts supporting the theory. More specifically, Gunderson and Holling in *Panarchy* 2001, was used as the basis for understanding the goals of resilience theory and why it is a relevant topic. Holling 1973 provided the background for the earliest stages of the development of resilience theory, while Holling 2001 provided a more current understanding of resilience research as it relates to socio-ecological systems. Hulse and Gregory 2004 served as a case study for the application of resilience theory to a design/planning oriented project and was the main example for how the theory might be applied to the Drylands Competition.

The Drylands Design Competition focused on water scarcity in the American West, defined by all land west of the 100th meridian. Climate change, a decreasing water supply, water quality, access, and treatment were the drivers for the creation of the competition. There were four competition objectives: the water-energy nexus, scarcity and variability, localized resources, and social equity. Coupled with these objectives was the concept of variability of scale with local, regional, and global contexts being addressed by the design proposals. The requirements for the design proposals were open-ended, with the only guidelines being the final board size and either an architectural or community based approach. The competition was also not site-specific beyond being west of the 100th meridian.

As part of the LAR 648 specialization studio course under Assistant Professor Jessica Canfield and in collaboration with fellow Master of Landscape Architecture student, Elise Fagan, a submission for the Drylands Design Competition was completed. The South Platte River Basin in Eastern Colorado was chosen as a site of study for the project. From the beginning it was clear that the Basin presented an opportunity for an exploration in the application of resilience theory to design because of several factors present. These factors included a diversity of land type (agriculture, rangeland, urban, riparian), critical thresholds (water use, an aging rural population, climate change), a range of scales (regional, local, site), and a clear presence of social, ecological, and economic systems. Resilience theory was used to understand the systems interacting across scales within the South Platte River Basin, and the use of the theory as a framework for design was explored. The results from this exploration led to a need for more literature review and a deeper understanding of the subject of resilience theory. This initial projective design was a pioneering effort, a first attempt at applying resilience theory to landscape architecture practice. The project was successful in receiving an honorable mention, which is a testament to the success of this initial endeavor.

## Detailed Literature Review

In seeking to apply resilience theory to urban design practice, it became necessary to conduct a more detailed literature review than the aforementioned. The purpose of this literature review was also to situate resilience theory into the current body of landscape architecture literature to understand its relevance to the field. In situating the theory's relevance, literature was categorized into four groups. These groups are: *primary sources*, *application of resilience*, *adaptation of resilience*, and *theorization of resilience*.

The first category, *primary sources*, represents the body of literature that is the basis of resilience theory itself. These sources focus on the core development of resilience theory and include key authors such as C.S. Holling, Lance Gunderson, Bryan Walker, and David Salt. The literature in this category is more focused has fewer sources than the other categories. The group that is most closely related is the application of resilience theory, which consists of many of the same authors who have applied resilience theory to further research.

The *application of resilience theory* stems directly from the development of resilience theory and its application to planning and research efforts. Two key contributors in this category are the Resilience Alliance and the Stockholm Resilience Center, which are institutions that direct research efforts in wake of the development of resilience theory in the 1970's and 80's. The primary authors in this category have backgrounds in ecology and science-based professions with the majority of their efforts being outside of the United States. Also specific to this category are the research efforts on spatial resilience through the work of Graeme Cumming and Mark Fleischhauer.

The *adaptation of resilience theory* represents a body of research that has applied the concepts of resilience theory to new areas, mainly urban socio-ecological systems. The researchers here are more associated with the design professions, including landscape ecology. They are, however, not practicing landscape architects or planners but are professors and researchers at academic institutions including Marina Alberti at University of Washington, Jack Ahern at University of Massachusetts at Amherst, Nina-Marie Lister at Ryerson University, and Chrisna Du Plessis at the University of Pretoria. An overarching concept that is common amongst this literature is the view of cities as coupled socio-ecological systems.

The final category is the *theorization of resilience*, which consists of the current landscape architecture theories of landscape urbanism and ecological urbanism. The literature in these sources does not explicitly cite the work of Holling and resilience theory specifically, but utilizes much of the same vocabulary and general concepts including indeterminacy, emergence, resilience, diversity, and redundancy. Chief among these authors are James Corner, Alex Wall, Richard Weller, and Mohsen Mostafavi. This category represents the highly abstract end of the spectrum, with the grounded principles of resilience theory on the other. It is a category not rooted in science, but in the general association of landscape architecture with ecological systems.

## Case Study Analyses

A series of case studies were identified through the categorization of the literature to represent projects and research conducted around resilience theory that embodies the tenets of the three categories where the theory was used: application of resilience, adaptation of resilience, and theorizing resilience. Each case study was also identified based upon the availability of data and information to ensure a viable analysis. Reference Fig. 2.1 for a list of the case studies under each category.

The case study analysis uses a universal analysis matrix (Fig. 2.3) to provide a common ground to compare results. Through combined concepts identified in the literature, the matrix was developed as an analytical tool for evaluating the methods employed in each case study. The matrix uses five categories of potential methods: identify and respond to thresholds, promote diversity, develop redundancies, create multi-scale networks and connectivity, and implement adaptive planning and management strategies. These categories were defined by the author and combined/rearranged methods from two different sources, the first being *Resilience Thinking* which is a primary source for resilience theory, and the second being *From Fail-Safe to Safe-to-Fail: Sustainability and Resilience in the New Urban World* (Fig. 2.2).

Walker and Salt propose nine strategies for moving towards a resilient world at the conclusion of their book, *Resilience Thinking*. These strategies are diversity, ecological variability, modularity, acknowledging slow variables, tight feedbacks, social capital, innovation, overlap in governance, and ecosystem services (Walker and Salt 2006, 145-148). In thinking ahead to apply these methods to design of the built environment, it became clear that some of these are more active and some more passive. Passive methods include slow variables, social capital, tight feedbacks, innovation, and ecosystem services. It also became apparent that some of these passive methods could be encapsulated by the active ones, because they function more as secondary effects of the active methods. For instance *ecosystem services* can be protected and promoted through creating a *diversity* of spaces that accommodate stormwater runoff on a site. Similarly, feedback loops can be tightened in terms of creating redundancies in energy production for a group of buildings, i.e. geothermal, passive solar, fossil fuels, and wind. Ultimately, these nine methods proposed by Walker and Salt were consolidated and then combined with the methods proposed by Jack Ahern.

The methodology developed by Ahern was used as a basis for achieving the goals and strategies proposed by Walker and Salt with a few modifications. Walker and Salt are primary authors of resilience theory while Ahern is one who has adapted the theory to an urban design application. Therefore when using Ahern's framework it was cross-referenced with Walker and Salt to make sure that all of ideas were adequately represented. Ahern proposes five urban planning and design strategies for building resilience in the urban environment: multifunctionality, redundancy and modularization, (bio and social) diversity, multi-scale networks and connectivity, and adaptive planning and design (Ahern 2011, 4). In comparison to the methods proposed by Walker and Salt, there are some similarities and differences. Walker and Salt come from the approach that as a human entity, we generally need to change our understanding of the world and the way systems behave if we are to find a resilient future. Ahern's methods are more active and are design strategies that we can adopt to implement in the way we think about and engage urban design practice. The final strategies used in the case study analysis matrix for this thesis are:

## AHERN

(Ahern 2011)

1. MULTIFUNCTIONALITY
2. REDUNDANCY + MODULARIZATION
3. (BIO + SOCIAL) DIVERSITY
4. MULTI-SCALE NETWORKS + CONNECTIVITY
5. ADAPTIVE PLANNING + DESIGN

## RESILIENCE FRAMEWORK

1. IDENTIFY AND RESPOND TO CRITICAL THRESHOLDS
2. PROMOTE DIVERSITY
3. DEVELOP REDUNDANCIES
4. CREATE MULTI-SCALE NETWORKS AND CONNECTIVITY
5. IMPLEMENT ADAPTIVE PLANNING/MANAGEMENT STRATEGIES

## WALKER + SALT

(Walker and Salt 2006)

1. DIVERSITY
2. ECOLOGICAL VARIABILITY
3. MODULARITY
4. ACKNOWLEDGING SLOW VARIABLES
5. TIGHT FEEDBACKS
6. SOCIAL CAPITAL
7. INNOVATION
8. OVERLAP IN GOVERNANCE
9. ECOSYSTEM SERVICES

## 2.2 Framework Development

The five categories for the development of a resilience theory framework come from two sources. Ahern serves as the starting point which was cross referenced with the goals outlined by Walker and Salt.

identify and respond to thresholds, promote diversity, develop redundancies, create multi-scale networks and connectivity, and implement adaptive planning and management strategies.

### Identify and Respond to Thresholds

This strategy was identified as being of great importance and encompasses several ideas of Walker and Salt. They identified the acknowledgement of slow variables, tighter feedback loops, and innovation as being key ideas. In analyzing these ideas, it became apparent that they all relate to how we think about and identify critical thresholds. By acknowledging slow variables "that configure a social-ecological system, and the thresholds that lie along them, we have a greater capacity to manage the resilience of a system" (Walker and Salt 2006, 146). Similarly, by tightening feedback loops it "allow(s) us to detect thresholds before we cross them" (Walker and Salt 2006, 146). Innovation is more of a response to the critical thresholds that are identified; it is a strategy for how we engage and address them. These topics fit broadly under identifying and responding to thresholds, and this is not something addressed by Ahern in his strategies. It was included here because it is a key subject within resilience theory and focuses on how to increase adaptive capacity in response to these thresholds.

### Promote Diversity

Diversity is covered by both Walker and Salt and Ahern. It is critical to promoting resilience both in terms of ecological and social systems (Ahern 2011, 5). Diversity "is a major source of future options and a system's capacity to respond to change and disturbance in different ways" (Walker and Salt 2006, 145). The concept of diversity can also be thought of in terms of economic systems, land use, architecture, and animal species. The idea is to not put all of one's eggs in a single basket. For instance if an economic condition in a certain area within a city is based completely upon the cash flow generated by surface parking, that is not a very diverse situation. Such an instance would be highly susceptible to shocks such as the discontinuation of the automobile or increased gas prices curtailing automobile use.

### **Develop Redundancies**

This strategy combines three concepts proposed by Walker and Salt and Ahern. Walker and Salt discuss modularity, while Ahern looks to multi-functionality and redundancy and modularization as separate methods. Each of these three (modularity, multi-functionality and redundancy, and modularization) address the same idea. In its most basic form this idea is “to avoid putting ‘all your eggs in one basket’ and for preparing and pre-planning for when (not if) a system fails” (Ahern 2011, 5). Redundancies also work to reduce over-connectivity within systems, and with one example being decentralized water treatment cycles. Generally, systems that are dependent upon a centralized input, it is more vulnerable to failure after a disturbance.

### **Create Multi-Scale Networks and Connectivity**

This method comes directly from Ahern and relates to the spatial connectivity of the urban landscape. “In urban environments, connectivity of built systems is generally robust but in natural systems is typically greatly reduced, often resulting in fragmentation—the separation and isolation of urban landscape elements with significant impacts on specific ecological processes that require connectivity” (Ahern 2011, 7). Other forms of connectivity refer to transportation systems, street networks, hydrological processes, and green networks. “Multi-scale connectivity is important when planning for functions that operate at multiple scales” which is critical when addressing the way different systems connect across scales e.g. walking trails linking with bus routes and urban drainage systems linking with low-order streams (Ahern 2011, 6).

### **Implement Adaptive Planning/Management Strategies**

This final category relates to institutional management and the intangible aspects of promoting resilience. It comes from both Walker and Salt and Ahern, and deals with the difficulties in “making decisions with imperfect knowledge about change and uncertain disturbances as an ‘opportunity’ to ‘learn-by-doing’ (Holling, 1978)” (Ahern 2011, 7). This idea also directly relates to Walker and Salt’s concept of social capital in that resilience is “strongly connected to the capacity of the people in that system to respond, together and effectively, to change and disturbance. Trust, strong networks, and leadership are all important factors in making sure this can happen” (Walker and Salt 2006, 147). These networks of governance, both formal and informal, dictate the manifestation of resilience in the urban environment. This also applies to ownership of land where “overlapping rights and a mix of common and private property rights can enhance the resilience of linked social-ecological systems (Dietz et al. 2009)” (Walker and Salt 2006, 148).

### **Scales and Systems**

Resilience theory provides an understanding for the cross-scale dynamic interactions between systems. In this case study analysis it was of great importance to provide a category in the analysis matrix that addressed scales and systems. Scale is in both spatial and temporal terms while the systems are social, ecological, and economic. Each of the above five categories for methods are cross-referenced with three scales (regional, metro, and site) and systems (social, ecological, and economic).

2.3

Analysis Matrix

SPATIAL  
SCALE

REGIONAL



METRO



SITE



|                |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |
|----------------|------------|-----|------|------|-------|--------|
| THRESHOLDS     | SOCIAL     |     |      |      |       |        |
|                | ECOLOGICAL |     |      |      |       |        |
|                | ECONOMIC   |     |      |      |       |        |
| DIVERSITY      | SOCIAL     |     |      |      |       |        |
|                | ECOLOGICAL |     |      |      |       |        |
|                | ECONOMIC   |     |      |      |       |        |
|                | SPATIAL    |     |      |      |       |        |
| REDUNDANCY     | SOCIAL     |     |      |      |       |        |
|                | ECOLOGICAL |     |      |      |       |        |
|                | ECONOMIC   |     |      |      |       |        |
|                | SPATIAL    |     |      |      |       |        |
| CONNECTIVITY   | SOCIAL     |     |      |      |       |        |
|                | ECOLOGICAL |     |      |      |       |        |
|                | ECONOMIC   |     |      |      |       |        |
| PLANNING       | ECOLOGICAL |     |      |      |       |        |
|                | ECONOMIC   |     |      |      |       |        |
| TEMPORAL SCALE |            |     |      |      |       |        |

These spatial scales are flexible depending on the project. Generally the case studies are within an urban environment, so the regional scale looks at how the city fits into the context within a network of cities, the metro scale is associated with the city itself, and the site scale is anything from a single acre to approximately 30 acres. It was not considered to be of great importance to define these spatial scales with specific dimensions because of the variety of project type within the case studies. What is more important is understanding what the focus of the project was, whether the primary objective was to create solutions at large scales, small scales, or somewhere in between. The project as a whole is identified on one time scale—how long is the plan, research, project supposed to last or what was the extent of the time scale addressed in the case study.

The systems analyzed are generally social, ecological, and economic with a few exceptions. The redundancy and diversity categories have a spatial component because it was important to differentiate whether the methods were focused primarily on socio-ecological systems (in terms of diversity this might be demographics or habitat type) or spatial (creating a spatial hierarchy or size of infrastructure). The connectivity category does not have a spatial component because it inherently embodies the idea of space in terms of social, ecological, and economic systems. Adaptive planning and management does not have a social component because it became apparent that all of the planning/management strategies are socially based, but either have an ecological or an economic focus which is the main differentiator here.

## **Analysis**

Each case study was analyzed for the aforementioned methods in terms of scales and systems. The documents and information provided was read thoroughly and as a method was identified, it was plugged into the appropriate cell within the matrix. Some cells have multiple methods that fit that category, system, and scale. The matrix allows for a clear visualization of which systems, scales, and methods were emphasized more or less in each case study. This analysis is subjective based upon the author's previous knowledge and understanding of design and resilience theory. It is simply a way to create some formal organization to generate a base knowledge to move future research efforts forward. After the analysis was completed, the extracted methods were used in an application to another projective design experiment.

## **Gerald D. Hines/Urban Land Institute Projective Design**

The Gerald D. Hines/ULI Student Urban Design Competition is an annual graduate-level design competition that facilitates interdisciplinary collaboration. The design competition focuses on large-scale, real urban sites that are typical of current urban design practice. Each team develops an urban masterplan and financial feasibility study of the site, which requires close collaboration between the design and financial disciplines. The teams are made up of five students, with three disciplines represented including one from a non-design field (typically finance or real estate). Over a period of two weeks, each team generates drawings, diagrams, and other visual explanation of the design. After this first round, the jury chooses four finalist teams who work for another month on a refined submission that may include other criteria the finalist brief calls for. The finalist round culminates in each team presenting their submissions to the jury in the selected city, where one winning entry is chosen (<http://www.uli.org/programs/awards-competitions/hines-student-design-competition/>).

The competition represents a truly interdisciplinary approach to design and development problems: academia meets the professional world; design meets economic viability; architects, landscape architects, urban planners, financiers, and developers come together. This presents a prime opportunity to test the application of resilience theory to urban design, especially in regards to working with a diverse group of disciplines. Interdisciplinary collaboration is an important component in much of the literature that is reviewed as a part of this thesis. "... ecologists, social scientists, planners, and designers will need to work collaboratively to develop interdisciplinary approaches for understanding the effects of long-term changes in urban spatial patterns, landscapes, and environmental quality. Landscape architects, urban planners, and urban designers will need to be able to utilize such interdisciplinary information in the development of sustainable human settlements" (Musacchio and Wu 2004, 175). An important point that is missing from Musacchio and Wu in their commentary on emerging trends in urban design is the inclusion of economics, which is a main component of the ULI/Hines Competition. Generally speaking, urban design competitions are design-centric and do not contain a component that assesses the financial feasibility for the project to actually get built. This is especially true in student competitions. What the ULI/Hines Competition facilitates is an exploration of the nexus between social, ecological, and economic systems within a single site.

Mohsen Mostafavi echoes this growing need for multiple disciplines coming together to create holistic urban design solutions: "This is not to imply that ecological urbanism is a totally new and singular mode of design practice. Rather, it utilizes a multiplicity of old and new methods, tools, and techniques in a cross-disciplinary and collaborative approach toward urbanism developed through the lens of ecology. These practices must address the retrofitting of existing urban conditions as well as our plans for the cities of the future" (Mostafavi 2010, 26). The application of resilience theory as a framework for engaging urban design is perhaps one of the "new methods" that Mostafavi is looking for. The competition itself serves as a testing ground for his call in addressing the complexity of urban conditions in order to create "cities of the future." Resilience theory takes Mostafavi's concept of a "lens of ecology" much further, and provides a framework for understanding the dynamic interaction of the multiple disciplines taking part in the competition.

The extracted methods from the case study analysis provided the theoretical framework for the approach to the 2013 ULI/Hines Competition entry by Team 1155. This team consists of three Master of Landscape Architecture students from Kansas State University (Kevin Cunningham, Derek Hoetmer, and Kylie Harper), a Master of Architecture student from the University of Kansas (Lauren Brown) and a Master of Business Administration student from the University of Missouri – Kansas City (Tyler Knott). Team 1155 is a diverse group of individuals, with multiple schools, backgrounds, genders, ages, and professions being represented.

The purpose of participating in the ULI/Hines Competition was to test the identified methods for promoting resilience in urban design practice through a multi-disciplinary approach. It combined the theory with a grounded application through financial feasibility, which tested the identified methods to see how effective they are. The intent was to see if resilience theory provides a well-defined and viable approach that holistically understands the complex systems and issues inherent to the competition site and result in an effective design. The interdisciplinary nature of the team mimicked the design team structure of real-world situations, and served as a case study for future endeavors into resilience research.



# LITERATURE REVIEW

## Literature Groups

This literature review is a synthesis of key sources that span a breadth of topics associated with ecology, systems, and urbanism – all through the lens of resilience. The literature is grouped into four categories: resilience theory, application of resilience theory, adaptation of resilience theory, and the theorization of resilience (see Fig. 3.1). Each of these categories views the concepts of resilience in a different way but have commonalities throughout. These commonalities and relationships between literature sources situate resilience as a relevant addition to current theory on landscape architecture and urban design practice (see Fig. 3.2). By establishing key connections between groups of literature, resilience theory contributes to the direction of the design professions rather than inventing new theoretical approaches to design. The first category, resilience theory, is fundamentally the primary sources of literature. These sources focus on the core development of resilience theory and include key authors such as C.S. Holling, Lance Gunderson, Bryan Walker, and David Salt. The sources focus on the development of the theory, primarily in terms of large, regional scales and in socio-ecological systems.

The next category, application of resilience theory, stems directly from the development of resilience theory and its application to planning and research efforts. Two key sources in this category are the Resilience Alliance and the Stockholm Resilience Center, which are institutions that direct research efforts in wake of the development of resilience theory in the 1970's and 80's. The primary authors in this category have backgrounds in ecology and science-based professions with the majority of their efforts being outside of the United States. Also specific to this category is the research effort into spatial resilience through the work of Graeme Cumming and Mark Fleischhauer.

The adaptation of resilience theory represents a body of research that has applied the concepts of resilience theory to new areas, mainly urban socio-ecological systems. The researchers here are more associated with the design professions, including landscape ecology. They are, however, not practicing landscape architects or planners but are professors and researchers at design schools including Marina Alberti at University of Washington, Jack Ahern at University of Massachusetts at Amherst, Nina-Marie Lister at Ryerson University, and Chrisna Du Plessis at the University of Pretoria. An overarching concept that is common amongst this literature is the view of cities as coupled socio-ecological systems.

The final category is the theorization of resilience, which consists of the current landscape architecture theories of landscape urbanism and ecological urbanism. The literature in these sources does not explicitly cite the work of Holling and resilience theory, but utilizes much of the same vocabulary and general concepts including indeterminacy, emergence, resilience, diversity, and redundancy. Chief among these authors are James Corner, Alex Wall, Richard Weller, and Mohsen Mostafavi. This category represents the opposite end of the spectrum, with resilience theory on the other. It is a category not rooted in science, but in the general association of landscape architecture with ecological systems.

## PRIMARY SOURCES

C. S. Holling: Resilience and Stability of Ecological Systems  
- The seminal work of resilience theory, this document is the theory in its infancy

Holling: Understanding Complexity of Economic, Ecological, and Social Systems  
- Explores the adaptive cycle, panarchy, and how they describe economic, ecological, and social systems.

## APPLICATION OF RESILIENCE THEORY

Allen, Peter: Complexity: the Integrating Framework for Models of Urban and Regional Systems  
- This work does not mention resilience theory specifically, but it introduces the significance of computer modeling as a method for understanding the complexity of emergent urban systems.

Anderies, John: Fifteen Weddings and a Funeral: Case Studies and Resilience-based Management  
- This work establishes the importance of developing case studies in order to generate policy for socio-ecological systems. It is a possible method for the application of resilience theory.

Cumming, Graeme: Spatial Resilience in Social-Ecological Systems  
- A seminal work in the application of the theory to the new form of spatial resilience, which holds possibilities for methods and further development into the implications for resilient spatial organizations and designs.

Feischhauer, Mark: The Role of Spatial Planning in Strengthening Urban Resilience  
- Expands on some of the thinking of spatial organization playing a part in resilience, specifically in responding to hazards/shocks within the urban environment.

ResAlliance: Urban Resilience Research Prospectus  
- Develops a methodology and focus into the research efforts for exploring resilience theory as applied to urban environments and studies.

Walker, Brian and Nick Abel: Resilient Rangelands- Adaptation in Complex Systems  
- A case study analysis of the application of resilience theory in rangelands. Develops a framework for the management and planning of this complex, dynamic landscape typology.

Woodward, Joan: Envisioning Resilience in Volatile Los Angeles Landscapes  
- Loosely applies the definition of resilience and the theory as a basis for understanding harsh landscapes in LA and specific design responses intended to increase landscape resilience.

Hulse: Integrating Resilience into Floodplain Research  
- Develops a methodology based upon computer modeling techniques to apply the tenets of resilience theory to the restoration of parts of the Willamette River floodplain in Oregon.

## ADAPTATION OF

Ahern, Jack: From fail-safe to safe-to-fail: sustainability and resilience in the new urban world  
- The most direct application of specifically Holling's theory to the design disciplines of landscape architecture and planning. It is very loose and does not go beyond the point of suggestion.

Alberti, Marina: Ecological resilience in urban ecosystems: Linking urban patterns to human and ecological functions  
- Alberti is one of the seminal figures in linking ecology to urban spatial patterns and development. She references resilience theory but does not go into great detail on the application of theory to design.

Barthel, Stephan: Innovative Memory and Resilient Cities: Echoes from Ancient Constantinople  
- Barthel applies the tenets of resilience theory as a method for understanding the "resilience" of the ancient city of Constantinople. He does not explore the implications of the findings for design, only an analysis of the case study.

Du Plessis, Chrisna: Understanding Cities as Social-Ecological Systems  
- The author proposes a conceptual framework for understanding cities as SES's through interpretation of complex thinking and resilience theory. Displays the relevance of this thinking towards an urban design approach.

Deppisch, Sonja and Mareike Schaeftli: Given the Complexity of Large Cities, Can Urban Resilience Be Attained at All?  
- A critique on current approaches to research in urban resilience, the limitations of the application of the theory, and suggestions for carrying forward in the future.

Lang, Thilo: Urban Resilience and New Institutional Theory- A Happy Couple for Urban and Regional Studies?  
- Explores the tenets of resilience theory as applied to urban systems and how institutional management can potentially influence urban resilience.

Musacchio, Laura and Jiangu Wu: Emerging Trends in Urban and Regional Ecology  
- Generates a commentary on the current trends of ecological thinking in planning, including resilience theory. Critiques such people as Alberti and Martzluft, Nassauer.

### 3.1

## Literature Groups

Walker, Brian et al: Ecology and Society: Resilience, Adaptability and Transformability in Social-ecological Systems  
- Describes the concepts of resilience theory and covers the concept of attraction basins, defining key vocabulary.

Holling and Brian Walker: Regime Shifts, Resilience, and Biodiversity in Ecosystem Management  
- Explores regime shifts in terrestrial and aquatic environments in relation to resilient complex adaptive systems and how biological diversity plays a role in this context.

## RESILIENCE THEORY

Holling: Toward an Urban Ecology  
- Interprets the relevance of ecology to urban systems and how they are interrelated.

Alberti, Marina: Integrating Humans into Ecology: Opportunities and Challenges for Studying Urban Ecosystems  
- This work is widely referenced for integrating humans into ecology. Resilience theory itself is not a large part of this work, but concepts of complexity, dynamic states, and interface of systems/scales is highly relevant. Alberti describes humans as no different than other species, with little reference to institution.

Ernstson, Henrik: Urban Transitions: On Urban Resilience and Human-Dominated Ecosystems  
- Generates a dialogue about the policy implications of resilience thinking on urban environments. Challenges the application of resilience theory to human-dominated ecosystems which stray from what the theory was originally developed for.

Lister, Nina-Marie: Sustainable Large Parks  
- Explicitly addresses resilience theory as a seminal explanation for the end of stable-state thinking towards dynamic systems. Does not go into detail on direct application to design, however several case studies could be derived from this article.

Lister, Nina-Marie: ASLA Dirt Interview  
- Explicitly addresses resilience theory and how it has influenced the basis for design in safe-to-fail landscapes. Not a theoretical approach, but very pragmatic and succinct.

Steiner, Frederick: Urban Human Ecology  
- Argues that cities are human ecosystems based upon eight primary concepts: systems thinking; language, culture, and technology; structure, function, and change; edges boundaries, and ecotones; interaction, integration, and institution; diversity; adaptation; and holism.

## THEORIZING RESILIENCE

Allen, Stan: Urbanisms in the Plural  
- Discussion of the complexity of the urban environment, calls for new methods that look to ecology beyond metaphor, cites landscape ecology as a key connection to urban design practice.

Corner, James: Not Unlike Life Itself  
- In this article, Corner directly references the term resilience as well as some of the vocabulary associated with the theory including complexity, systems thinking, adaptation, robustness. He does not directly apply it to a design strategy, but theorizes about the implications for a general design approach.

Muller, Bernhard: Urban and Regional Resilience- A New Catchword or a Consistent Concept for Research and Practice  
- Assesses the validity of the concept of resilience thinking to urban and regional planning.

Berrizbeitia, Anita: Scales of Undecidability  
- Commentary on designs proposed by OMA, Corner + Allen, and others and how they address frameworks, adaptivity, and emergence. Concepts relate directly to resilience theory but it is not mentioned explicitly.

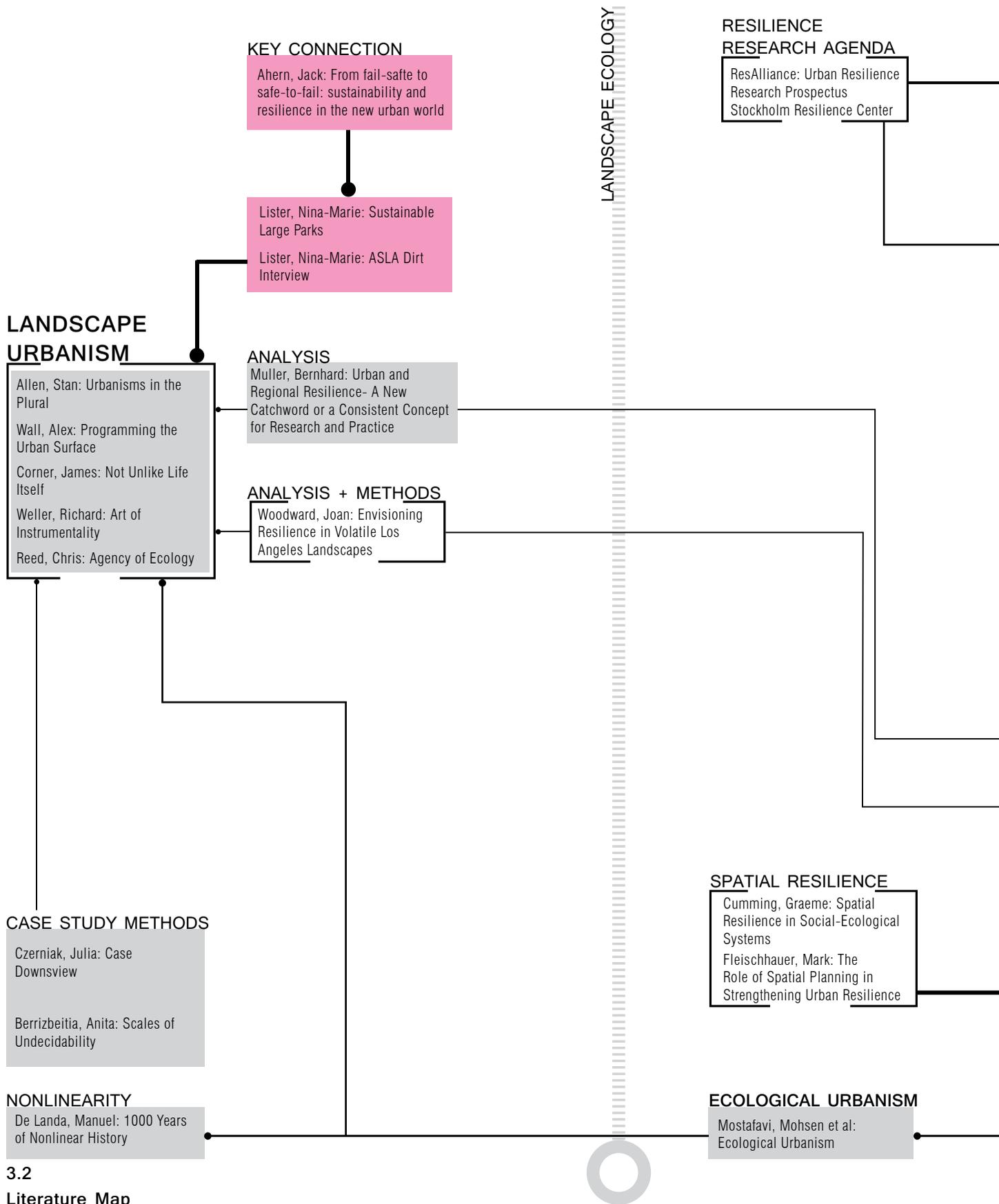
Weller, Richard: Art of Instrumentality  
- Speaks of landscape architecture and its approach to design as highly metaphorical/abstract/conceptual/pseudo-artistic. References ecology and socio-ecology as a basis for design, but not the direct application of a science-based theory like resilience.

Reed, Chris: Agency of Ecology  
- Speaks loosely about terms of emergence, adaptation, ecology, systems, and complexity as parts of approach to design. Uses many concepts found in resilience theory, but it is much more metaphorical than those who explicitly address the theory.

Czerniak, Julia: Case Downview  
- Commentary on a case study that is a great summary of many of the tenets of this literature category. Frameworks, emergence, adaptation, and implied resilience.

Wall, Alex: Programming the Urban Surface  
- Describes the changing views of landscape and urbanism, and landscape architecture's position to become interdisciplinary leaders.

De Landa, Manuel: 1000 Years of Nonlinear History  
- Maps the flows, changes, and bifurcations of matter that have occurred over the last 1000 years. Moves away from an anthropocentric view and describes the way systems interact across scales.



3.2  
Literature Map

THEORY EVOLUTION

PRIMARY SOURCES

C. S. Holling: Resilience and Stability of Ecological Systems  
Holling: Understanding Complexity of Economic, Ecological, and Social Systems

Holling and Walker: Regime Shifts, Resilience, and Biodiversity in Ecosystem Management

Walker, Bryan et al: Ecology and Society: Resilience, Adaptability and Transformability in Social-ecological Systems

Ernstson, Henrik: Urban Transitions: On Urban Resilience and Human-Dominated Ecosystems

Lang, Thilo: Urban Resilience and New Institutional Theory- A Happy Couple for Urban and Regional Studies?

ECOLOGICAL ANALYSIS

Du Plessis, Chrisna: Understanding Cities as Social-Ecological Systems  
Wu, Musacchio: Emerging Trends in Urban and Regional Ecology

APPLICATION METHODS

Walker, Brian and Nick Abel: Resilient Rangelands- Adaptation in Complex Systems  
Allen, Peter: Complexity: the Integrating Framework for Models of Urban and Regional Systems  
Anderies, John: Fifteen Weddings and a Funeral: Case Studies and Resilience-based Management  
Hulse: Integrating resilience into floodplain research  
Albano Resilient Campus

ECOLOGY

Holling: Toward an Urban Ecology  
Steiner, Frederick: Urban Human Ecology  
Alberti, Marina: Integrating Humans into Ecology: Opportunities and Challenges for Studying Urban Ecosystems  
Alberti, Marina: Ecological resilience in urban ecosystems: Linking urban patterns to human and ecological functions  
Barthel, Stephan: Innovative Memory and Resilient Cities: Echoes from Ancient Constantinople

URBAN RESILIENCE ANALYSIS

Deppisch: Given the Complexity of Large Cities, Can Urban Resilience be Attained at All?

## **Primary Sources**

Resilience theory has undergone an evolutionary process that began with the work of C.S. Holling in the 1970's. Holling has remained the prominent head of this theory, but others have joined him as resilience has continued to develop. The primary source for resilience theory is in Holling's "Resilience and Stability of Ecological Systems" published in 1973. In this source, Holling comes from the perspective of resource ecology, and assesses the current state of thinking and theory. Most of this is completely ecologically based, and has little to do with human dominated systems or sociology, which would become more prominent in Holling's future research. He focuses mainly on the stability of ecosystems and equilibrium states, with specific examples being referenced in terms of relationships between species diversity, extinction, and adaptability. The most significant piece from this article is Holling's first definition of resilience which is: "Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist. In this definition resilience is the property of the system and persistence or probability of extinction is the result. Stability, on the other hand, is the ability of a system to return to an equilibrium state after a temporary disturbance" (Holling 1973, 17). This definition of resilience would serve as the point of departure for the development of resilience theory.

After the initial efforts of conceptualizing resilience, it began to evolve as a theory. Later, Holling and other resilience experts reflected upon the reasons for developing the theory. They point to the dated thinking about stable state systems, the incomplete nature of other theories that explore dynamic adaptive systems, and the general lack of a holistic approach to sustainability and other mainstream worldviews. "The problem with them (worldviews) is that they are partial. They are too simple and lack an integrative framework that bridges disciplines and scales" (Gunderson et al. 2001, 8). Really the purpose for investigating a theory of resilience is simple as "to develop an integrative theory to help us understand the changes occurring globally...such changes are economic, ecological, social, and evolutionary" (Gunderson et al. 2001, 5). This approach strategically defines the overall intentions of resilience theory. The theory is a method of understanding that informs better decision making that moves away from static, rigid solutions. The authors also point out the inextricable connection between human and ecological systems, which is a common relationship among all the literature in this review.

## **Application of Resilience Theory**

As resilience continued to develop, the ideas and application of the theory became more refined and focused in terms of application. Central to this application is the work of the Resilience Alliance, specifically with their initial *Research Prospectus for Urban Resilience* which was later taken on by the efforts of the Stockholm Resilience Centre. The research agenda of the prospectus focuses on four main ideas: metabolic flows (production and consumption chains), governance networks (institutional management and organization), social dynamics (demographics, human capital), and the built environment (ecosystem services in urban landscapes). While the document itself does not provide conclusive results, it lends direction to the kind of application that resilience theory can have within the urban environment in future research efforts.

The *Research Prospectus* does identify key concepts that are illustrated later in the case study analysis of this thesis and especially the projective designs. These concepts pertain to the way that cities manifest in physical form, of which landscape architects and urban designers play a central role. "By analyzing urban form, we suggest opportunities will arise for investigating new ways of changing the built environment in line with the changing needs and requirements of urban populations" (*A Research Prospectus* 2007, 18). These urban populations often times exhibit common properties in terms of social systems. "What we also see in urban areas is considerable social stratification and inequity. Many housing developments these days are built to specific price ranges, creating income homogeneity within neighborhoods, and fostering income inequality across metropolitan areas" (*A Research Prospectus* 2007, 14). This is one example of how designers and landscape architects might begin to amend the issues with the urban environment while using resilience theory as a framework for understanding and engaging cities.

The idea of the role of space in the influence of resilience is an area of literature that refers to spatial resilience as developed by Graeme Cumming. Most of his research focuses on ecologically dominated systems, but also looks at the management strategies of human-dominated systems. Cumming provides a comprehensive but practical approach to resilience as he states that the theory is not a "solve-all" solution but rather provides a method of understanding. "Broadly speaking, spatial resilience refers to the ways in which spatial variation-including such things as spatial location, context, connectivity, and dispersal- influences (and is influenced by) the resilience of an SES or other complex system" (Cumming 2011, 4). This definition of spatial resilience implies a complex and rigorous approach to planning and design that is in all likelihood unachievable by solely landscape architects and urban designers. This is because such planning and design efforts require the expert knowledge of the disciplines allied with design such as ecology, economics, real estate, sociology, and geography.

Cumming highlights a couple important notions within his research that are relevant to the efforts of this thesis. The first is the "fact that 'resilience' is not always a good thing. Systems may become locked in to regimes that are undesirable from a human perspective; in these instances, achieving positive system change may be impossible without reducing the resilience of the current state. For example, poverty can create a resilient regime for a household" (Cumming 2011, 17). Knowing that systems and spatially referenced areas can organize themselves around states that are highly resilient but undesirable highlights the role that landscape architects can facilitate as actors of positive change. One method of that change is "...spatial variation, both within and between communities and habitats, provid[ing] opportunities for population persistence that generally do not exist if a community is well-mixed and homogeneous" (Cumming 2011, 100). This by no means is the only method, but is an example of the type of solutions that can work towards resilience and specifically, spatial resilience.

Spatial resilience also relates to spatial planning and the methods of developing resilience to hazards as outlined by Mark Fleischhauer. Spatial planning in terms of resilience to disturbances created by natural disasters is not the focus of this thesis, but the spatial planning aspects of this research area is worth mentioning. There is a point

made by Fleischhauer that is incongruent with the thoughts of landscape architects and designers in general which is that “spatially non-relevant hazards occur more or less anywhere. For example, murder, drug abuse or road accidents definitely belong to the main risks in Western societies. However, risks like these do not have any specific spatial relation, which means that their occurrence is not limited to some exclusive areas” (Fleischhauer n.d., 280). Urban designers and landscape architects would disagree with this claim because situations like vehicle accidents, murder, and drug abuse do occur in space. While it is not an easy task, the role of spatial planning and design in relation to these social disturbances is an important role in urban design and landscape architecture practice.

Spatial planning also plays a significant role in planning for natural disasters and hazards. “Spatial planning action is especially important in the area of prevention which aims at a reduction of damages to people, property, and resources before a disaster strikes” (Fleischhauer n.d., 293). Therefore spatial planning in terms of resilience is a multifaceted conundrum relating to the less tangible social disturbances such as poverty, drug abuse, and crime as well as the highly visible disturbances of natural disasters. The particular methods for how to apply resilience theory as a framework for spatial planning, design, and management is a burgeoning sector of resilience research.

One example of a large scale application of resilience theory is by Brian Walker and Nick Abel in their analysis of resilient rangelands. This is a significant piece of research because both Walker and Abel are central players in resilience theory, which lends credibility to an application to this planning and management research effort. In *Resilient Rangelands – Adaptation in Complex Systems*, Walker and Abel directly apply the tenets of resilience theory to understanding rangeland systems in different locations in terms of management practices and how the landscape dynamically changes over time. The research is conducted at different scales, looking at local, regional, and global implications. The authors develop a series of determinants for ecological resilience, and the social adaptations that also have an effect. These determinants mostly impact management decisions, and are at a generally large regional scale. Walker and Abel conclude by synthesizing human relation to variable processes:

“Variables to which humans must adapt operate at different rates. The success of adaptation is related to that rate. Humans adapt well to changes in fast variables such as grass growth, animal numbers, stock prices, and interest rates. We are less successful in adapting to variables of intermediate rate such as human population increase, the spread of an insidious disease such as HIV, slow soil loss, or progressive increases in woody cover. Humans are least successful in adapting to slow variables such as climate change, the depreciation of infrastructure, or the depletion of an aquifer” (Walker and Abel in *Panarchy*, 308).

For landscape architects and urban designers, this conclusion is significant because designers tend to have greater effect during relatively shorter time scales through the design and implementation process. The conclusion also alludes to an increasing effort in affecting change at larger spatiotemporal scales as we gain a better understanding through

resilience theory. The conclusion also alludes to an increasing effort in affecting change at larger spatiotemporal scales as we gain a better understanding through resilience theory.

Another example of the application of resilience theory also focuses on the floodplain scale in "Integrating Resilience into Floodplain Restoration." Here, Gregory Hulse and Stan Gregory seek to amend socio-ecological issues in the Willamette River Valley in Oregon. More detail into this literature source will be explored later, but what is important to note here is the scales that this research analyzes (smaller than a region, larger than an urban area and over 50+ years) and the methods used to plan for a resilient future. Extensive GIS analyses are central to this research and will assumedly become even more prominent in future endeavors. "...we argue that data visualization tools are a central ingredient in any successful approach to establishing and maintaining lines of communication, especially when the ultimate aim is to bring about constructive change on the ground in how land is used and managed" (Hulse and Gregory 2004, 310). These tools do, however, present some limitations. "As geospatial data and GIS have become accepted parts of land and water management, the cartographic challenges of representing processes as well as patterns have become apparent" (Hulse and Gregory 2004, 310). While this research is in response to a single critical threshold (flooding and socio-ecological adaptive capacity) there are also more comprehensive approaches to resilience.

The Albano Campus Masterplan redefines the approach to a university campus in Stockholm, Sweden. A partnership between urban designers and resilience scientists, the masterplan seeks a holistic approach to socio-ecological resilience. The primary limitation to this plan is the lack of economic methods, but there is a unique component that addresses the institutional management of the landscape in terms of resilience. "The discussion on urban design most often revolves around physical components such as urban shape and housing typologies and rarely includes the institutional framework" (Barthel et al. 2010, 5). The overall approach leverages the Albano Masterplan as a projective design of resilience theory. "The ambition has been to work at two levels simultaneously. One is to investigate the needs for such development with the intent of formulating a theoretical basis general enough to be valid for other projects in other places. The other is to test these principles on an actual case, Albano, where site specific conditions and local conflicts over objectives test their validity and show how they must be adapted to a specific case" (Barthel et al. 2010, 14).

Of particular interest in this application of theory to design is the approach towards urbanism. "Urban form is not something that exists in isolation and is not the only instrument affecting the self-organizing systems of the city. The urban form exists within a framework of rules and regulations dealing with how land may be used and where development is one use among many, or rather, a way to create conditions or strengthen the potential for certain uses" (Barthel et al. 2010, 25). This conceptual perspective of urban form suggests a new role of spatial organization that affects socio-ecological resilience, echoing the work of Cumming and Fleischhauer. "In the case of urban design, for example, it becomes evident that we need a better understanding of how urban form affects both social and ecological systems to reach different goals, e.g. resilient urban design" (Barthel et al. 2010, 25).

The final significant concept from this source is the nexus of social and ecological systems within the urban environment. “The important distinction is that the spatial system is a means for the social system, i.e. it provides a structure for social processes. This has great similarities with how we understand ecological systems and may thus be a first step towards an integration of the process oriented systems, the ecological and the social, and a potentially shared framework: space” (Barthel et al. 2010, 12). This spatial framework is the realm of landscape architecture and urban design, which further establishes the relevance of resilience as a method of understanding and justifying design methods.

### **Adaptation of Resilience Theory**

The integration of ecology and urbanism is not a new topic, and was in fact explored by Holling even before his quest of resilience theory. His work *Toward an Urban Ecology* provides a critical link between resilience theory and the body of literature concerned with the synthesis of urbanity and ecology. Holling identifies a relationship between the characteristics of ecology and those of urban systems. “By responding to events at more than one point in space [ecologies] show a spatial interlocking property. By encompassing many components with complex feedback interactions between them, they show a systems property. And through the common appearance of lags, thresholds, and limits they present structural properties. An urban system presents examples of all these characteristics” (Holling and Orians 1971, 1).

Perhaps the most influential work on integrating ecology and urbanism is *Integrating Humans into Ecology: Opportunities and Challenges for Studying Urban Ecosystems*. Alberti et al. describe cities as emergent phenomena, and draw upon the new world views of non-equilibrium systems. Cities are referred to as complex ecological entities that are human-dominated ecosystems. It is also argued here that the field of ecology faces extraordinary challenges in the future due to global connectedness and increasing human dominance. The greatest challenge is to fully integrate the complexity of global scale human activity into ecological research. Another significant point is the apparent lack of solid research into urban ecology in terms of addressing “how human and ecological patterns emerge from the interactions between socioeconomic and biophysical processes” (Alberti et al. 2003, 1173). Part of where these processes meet is the realm of urban design.

Alberti et al. also reference resilience theory as a point of departure for the direction of research in urban ecosystems. “Theories about complex adaptive systems provide tools with which to analyze how landscape-scale organization of structures and processes arises in urbanizing regions; how it is maintained; and how it evolves by local interactions of processes that occur at smaller scales among social, economic, ecological, and physical agents (self-organization)” (Alberti et al. 2003, 1176). The authors also hypothesize that resilience in urbanity depends on both human and ecological processes. “Over the long term, human services in urban areas (housing, water supply, transportation, waste disposal, recreation) all depend on ecosystem functions for their productivity (Costanza et al. 1997, Daily 1997). Integrating humans into ecology will help identify the thresholds to best balance human and ecosystem services in urban ecosystems” (Alberti et al. 2003, 1177).

Similarly, Frederick Steiner argues that cities are human ecosystems based upon the understanding of eight primary concepts: systems thinking; language, culture, and technology; structure, function and change; edges, boundaries, and ecotones; interaction, integration, and institution; diversity; adaptation; and holism. These concepts share roots with resilience theory, and Steiner makes a claim to what he sees as resilient urban design. "In our most resilient cities, all our senses work together in a positive way. There are important public spaces for residents and visitors. Resilient cities offer multiple possibilities of shared experiences. The built environment possesses a nexus with nature. Creativity is evident in resilient cities because they are an unfinished, collaborative project, constantly adapting to change. Resilient cities are created continuously by their inhabitants" (Steiner 2004, 194). This definition of a resilient urbanism is a good start, but is far more theoretical than practical.

The field of landscape ecology, and particularly the work of Nina-Marie Lister, presents a pragmatic approach to engaging socio-ecological systems in urban environments. In an interview on ecological urbanism with the ASLA blog *The Dirt*, Lister talks about the importance of brownfields and green infrastructure as projects that landscape architects can begin to influence this change towards working ecologies. Lister also speaks directly to resilience theory and the concept of adaptive design. "The work of Canadian ecologist, C.S. "Buzz" Holling, pioneered this concept in terms of resource management. He called ecosystems "shifting steady-state mosaics" which means that stability is patchy, and it's scalar; it's not something that defines a whole system at any one point in time or space" (*The Dirt* 2011, 1). This concept in terms of design, planning, and management are "all part of the same spectrum of activities in which we engage with our landscape and living ecology. The central notion of adaptive design is that if we understand that landscapes and their ecosystems are fundamentally dynamic, that they're constantly changing, this means that there is an inherent amount of uncertainty in terms of how they behave" (*The Dirt* 2011, 8). An adaptive approach to design through the lens of landscape ecology begins to work towards a more defined framework for engaging urban design.

A more conceptual approach to what this framework might be is demonstrated in Barthel et al.'s historical analysis of Constantinople in terms of resilience. The authors delve into how Constantinople has proved to be a resilient city for many centuries, withstanding countless shocks and disturbances. The main point that the authors make is that it is spatial organization, location, and maintenance of the city that has allowed it to be resilient. In particular, food and water systems are analyzed in terms of metabolic flows and how the city was able to adapt and discover alternative sources in times of need after disturbances and shocks. "The ability of a city to survive under stress has its fundamental origins in how the city was organized and maintained" (Barthel et al. 2011, 2). The claim is that Constantinople is in fact a resilient city due to many factors, but that its ability to persist for centuries defines it as being resilient.

On the other hand, there are arguments that it is impossible to achieve urban resilience. Sonja Deppisch and Mareike Schaerfler argue that because of the non-linearity, dynamic nature of material flows, and temporal scales in large cities it is incredibly difficult to

model and attain urban resilience. It is acknowledged that resilience theory inherently attempts to describe the way that systems interact which is applicable to the urban environment, but that current research has fallen short of meeting goals of resilient cities. "Applied in this way, the concept of urban resilience with its currently debated research approaches does justice to the complexity of large cities only rudimentarily" (Deppisch and Schaerfler 2011, 29). Specifically, the quantitative measure of diversity as an indicator of resilience fails to address many social and institutional aspects of urbanity, although extensive qualitative analysis is conceded to be an important facet of future research. In general, this argument does not debunk the notion of urban resilience, but simply claims that the research to date has not achieved what it set out to. "Hence it appears necessary to expand the number of disciplines involved in studying urban resilience... in a field that has to date been approached especially from the perspectives of environmental and hazard research" (Deppisch and Schaerfler 2011, 30). This cross-disciplinary approach is a common theme amongst all the literature and will be of great importance in creating a framework for engaging urban design.

Jack Ahern presents the most concrete form of a framework for applying resilience theory to urban design practice. He asserts that cities will be the battleground of the 21st century in terms of the quest for sustainability. He claims that resilience theory offers a new perspective and a possible solution to the currently inadequate theory of sustainability which is based upon the equilibrium paradigm. Five urban planning and design strategies are identified that work to build a resilient urban future: multifunctionality, redundancy and modularization, diversity, multi-scale networks and connectivity, and adaptive planning and design (Ahern 2011, 4). It is also acknowledged that greater social memory and a capacity to innovate are critical to building resilience in the urban environment, including safe-to-fail landscapes which is a topic covered by Lister.

Ahern reiterates that the implementation and experimentation of these five strategies will require a large collaborative effort between relevant disciplines. "Addressing the challenges of sustainability and resilience arguably will require a transdisciplinary, integrative sustainability science that differs from science as we know it in terms of the structure, methods and content of the questions we ask. In addition to adaptive design focused on physical urban systems, and urban biodiversity, research is needed on how to achieve a greater social learning and meaningful social engagement and participation in decision-making and policy setting" (Ahern 2011, 9). Many of the ideas presented in this literature group, including collaboration between disciplines, are central to the premises of landscape urbanism.

### **Theorization of Resilience**

Landscape urbanism represents a current theory of landscape architecture practice that shares a loose relationship with concepts of resilience, and demonstrates the potential to adopt resilience theory as an addendum as landscape urbanism moves forward. In the article *Not Unlike Life Itself*, James Corner speaks in general about the direction that the practice of landscape architecture is and should be headed. The main theme throughout this piece of literature is "design intelligence," which 'encourage(s) opportunism and risk-taking rather than problem solving.' Corner refers to terms like robustness, open-

endedness, adaptivity, dynamic systems, emergence, strategies, and frameworks. A series of topics are addressed in this essay: the direction of the profession, relation to ecology, a profession-specific vocabulary, design strategies, and life itself. Corner picks up on paradigms that are catching on to not only landscape architecture, but also business, politics, and ecology.

“Life scientists will tell you that a resilient system must be both robust and open. Such suppleness is essential for successful adaptation, which is in turn necessary for survival in an evolving open system. In order to grow and develop, life forms must both persist and adapt, their organizational structures sufficiently resilient to withstand challenges while also supple enough to morph and reorganize. These principles are as topical today in business and management as they are in biology and ecology, urbanism and the design of public space” (Corner 2004, 1). Here, Corner begins to describe what Holling and others have already been researching since the 1970’s: the dynamic, cross-scale interactions of systems. What is significant about this, however, is that designers in the landscape urbanism camp are moving towards the acceptance of resilience concepts in their design work.

One pitfall of the landscape urbanism movement is that the use of ecology tends to be as a metaphor or a model for design, rather than an inclusive component. The landscape theorist Richard Weller describes the role of landscape urbanism in bridging the historic rift between landscape planning and landscape design. He also expresses the importance of ecology as a scientific metaphor and as a creative relationship with imaginative design practices. “A new generation of landscape architects are prepared to negotiate the mechanics of the city, philosophically and practically treating both its culture and its nature as a singular dynamic ecology without edge. In this field condition the two disciplines of architecture and landscape architecture find each other entangled together *in the weave of the world*” (Weller 2006, 880). This suggests a movement away from ecology as metaphor and towards ecology as integral to urban design.

Other landscape urbanists, including Chris Reed, tend to use loose ecological metaphors as design tactics. Reed proposes four categories for understanding how ecology can engage design practice: structured, analog, hybrid, and curated. Most of the overlap with ecology that Reed suggests is in the form of vocabulary. “...the appropriation of the mechanisms and resiliency and even the language of ecology and ecological systems—in their multiple forms and manifestations, as mechanisms and/or models—forms the basis for a newly charged set of design practices: flexible, responsive, and adaptable as projects evolve and accumulate over time” (Reed 2010, 329). Reed uses the terms of resilience, flexibility, adaptability, etc. but it is not evident that there is a clear understanding of what these terms actually refer to from an ecological perspective. It is difficult to use ecology as a metaphor if the concepts are not fully understood, although the inherent complexity of the city lends itself to accept this terminology as a way to describe the nature of urbanity.

Another landscape theorist, Stan Allen, calls specifically for a new methodology of urban design that goes beyond the use of ecology as a metaphor to engage the complexity of

cities. He claims that landscape urbanism in particular is primed to spearhead this new movement. "New urban practices are emerging today at the intersection of geography, politics, ecology, architecture, and engineering. Among these practices, landscape urbanism in particular has acquired a privileged standing as the discipline capable of synthesizing expertise from a number of related fields" (Allen 2011, 40). Allen also instills hope that there is such a thing as a resilient urbanism in that "complex systems...such as cities or natural ecologies, are robust and adaptive: they produce complex effects through the interaction of simple variables, incorporate feedback, and are capable of adjusting as conditions change" (Allen 2011, 43). The question still arises then as to what the actual design methods are for promoting these "robust and adaptive" cities consisting of complex systems.

The design competition for Downsview Park in Toronto is one of the primary examples of early landscape urbanism in design practice, although none of the submissions are built. In *CASE Downsview*, Julia Czerniak introduces each of the competition entries and some of the key concepts that are common throughout. In particular, the submissions by OMA/Bruce Mau and James Corner/Stan Allen use ecological principles as a metaphor for the way that the site will react to change over time, and they also demonstrate an understanding of ecological reactions and processes. Czerniak acknowledges that the schemes at times lapse into "eco-speak" and perhaps do not truly function in the same manner that they claim to. This often times dubious relationship between ecology and landscape architecture is evident in this competition. "Long a part of landscape architecture's practical and pedagogical concern with natural science and environmental management and restoration, ecology's recent positioning as a 'material practice concerned with the behavior of large-scale assemblages over time' gives it greater visibility to and attention by designers" (Czerniak 2002, 16). Anita Berrizbeitia goes into greater detail about this relationship between ecology and design in her analysis of several of the entries.

Berrizbeitia identifies the prevalence of concepts of emergence, programmatic indeterminacy, adaptivity, and response to change among the three most talked about entries for Downsview Park: James Corner/Stan Allen, Bernard Tschumi, and OMA/Bruce Mau. She advocates systems thinking (which is the basis for resilience theory) and the acceptance of complexity in landscape theory, rather than a simplification of it. She calls for an application of systems theory as a framework for understanding the interactions between "complex environments" in order to move away from metaphor and towards precision. Ultimately, the discussion is about how these submissions represent a shift away from designs seeking ultimate stable states and towards those that self-organize around a set of processes and interactions that determine changing spaces and programs. "Furthermore, both Corner and Allen and OMA argue for this kind of openness and flexibility in the same terms as biologists do, that is, as necessary conditions for survival" (Berrizbeitia 2002, 120). The survival that Berrizbeitia is hinting at describes the end goal, which is adaptive change or resilience.

## Key Concepts

Throughout this literature there are several key themes that are important to establish for the purposes of this thesis. These themes are nonlinearity, resilience of cities vs. resilience in cities, and interdisciplinary collaboration. Nonlinearity is the polar opposite of linearity. "A linear relationship between two elements in a system can be drawn on a graph with a straight line... A nonlinear relationship is one in which the cause does not produce a proportional effect. The relationship between cause and effect can only be drawn with curves or wiggles, not with a straight line" (Meadows 2008, 91). Nonlinear relationships are at the heart of almost every source in this review from Corner to Holling, and Lister to Cumming. Nonlinearity also begins to delve into a complex philosophical approach led by Manuel de Landa and Gilles Deleuze, which is worth mentioning because it influenced a handful of authors including Weller and Mostafavi.

"Similarly, for the philosopher and historian Manuel de Landa the city is a coagulation of fluctuating systems, a slowing or acceleration of larger temporal processes. The city and its global landscapes are an admixture of cultural, technological, and natural systems, an admixture that encrusts in urban form and its institutions, accretions of mind and matter that can be viewed as crystallizations" (Weller 2006, 878). This perspective is highly complex and theoretical but is worth mentioning because it influenced my own perspective. In *Art of Instrumentality*, Weller also points to landscape architects as a body of professionals who are primed to manage these complex mechanics of the city and come to a better understanding of the nonlinear relationships that urbanity is comprised of.

Another critical concept is resilience of cities vs. resilience in cities. This is a distinction that is discussed by Ernstson et al. in *Urban Transitions: On Urban Resilience and Human-Dominated Ecosystems*. They assert that "in order to address urban resilience, we propose a distinction between at least two scales that can aid in aligning analysis, governance and urban politics. The first concerns "resilience in cities," which operates at the city scale and deals with sustaining local-to-regional ecosystem services. The second is "resilience of cities," which instead operates at the scale of a "system of cities," which is a concept from geography meaning a set of cities tied to each other through relations of exchange, trade, migration, or others that sustain the flow of energy, matter and information among the cities (Pumain et al. 1989; Batty 2008)" (Ernstson et al. 2010, 533). This is an important distinction, because it identifies the scale at which resilience is operating at. For instance, the argument can be made that the city of Detroit is currently exhibiting non-resilient characteristics (resilience in cities), but looking at the entire Midwest region the cities are behaving in an overall resilient manner (resilience of cities). This resilient manner is characterized by a functional economy, strong identity, positive population rates, and overall stability in the face of global changes.

The final key concept is one that is common amongst each group of literature, which is the need for greater interdisciplinary collaboration. This is especially relevant to urban design practice: "working inclusively and collaboratively across multiple scales and with broad scope, strategic design intelligence can surely move toward a more effective and powerful form of urban design" (Corner 2004, 3). Mostafavi echoes Corner in his description of ecological urbanism. "[Ecological urbanism] utilizes a multiplicity of old and new methods, tools, and techniques in a cross-disciplinary and collaborative approach toward urbanism

developed through the lens of ecology. These practices must address the retrofitting of existing urban conditions as well as our plans for the cities of the future" (Mostafavi 2010, 26). If this literature teaches anything about the future of urban design practice, it is that the issues related to cities are far too complex to be solved by an individual profession. This need is identified by Holling, Alberti, Weller, Corner, Mostafavi, and many more. Landscape architects are suited to serve a role as facilitator of a variety of disciplines, with resilience theory as another common set of ideas that can help bridge the gap between disciplines, especially ecological and urban systems.

### **Extracted Case Studies**

From this literature, five case studies were extracted to further explore for methods used to promote resilience. The case studies were selected based upon the four groups of literature identified previously. The only group that is not represented is the primary resilience theory body of literature. This is because the sources within that group are solely the development of the theory and do not contain projects where the theory is applied.

### **Application of Resilience**

1. Resilient Rangelands (Walker and Abel in *Panarchy*, 2001)
2. Willamette River Valley (Hulse and Gregory 2004)

Both case studies are important literature sources that serve as precedents for the direct application of resilience theory. Analyzing the design strategies and methods for promoting resilience will add a level of depth to the literature review and inform how a framework for engaging urban design might be developed.

### **Adaptation of Resilience**

1. Henna, Finland- A Resilient Socio-Ecological Urbanity (Bonometti et al. 2010)

This is a case study that represents the adaptation of resilience theory in an application to urban design from a purely design perspective. This is one of the only precedents of its kind, but is not a constructed project. Because it is one of the only precedents of its kind, it is a critical source to analyze for the types of methods and approach for adapting resilience theory for purposes beyond the more scientific frameworks the theory is known for.

2. Albano Resilient Campus (Barthel et al. 2010)

This case study is unique because it involves the collaboration of both designers and resilience experts from the Stockholm Resilience Centre. The Albano Campus is a masterplan that directly employs resilience theory as a framework and guiding force behind the overall vision. It is a comprehensive report that goes into great detail about the approach and goals of the framework, and is critical to this thesis because the campus is in an urban environment.

### **Theorization of Resilience**

1. Downsview Park / Emergent Ecologies (James Corner Field Operations 2002)

Emergent Ecologies is a widely referenced as an early example of landscape urbanism, and the submission embodies the type of language associated with ecology that closely relates to resilience theory. This relation of language and design concepts illustrates

the connections between landscape urbanism and resilience theory, establishing the relevance of using resilience as an addendum to current landscape theory.

### **ULI/Hines Competition**

1. Touch (Kansas State University 2009)
2. Panorama Station (MIT and University of Wisconsin 2009)
3. Bayou Commons (Harvard University and University of Colorado 2012)

These case studies were analyzed to determine the extent of how past ULI/Hines Competition entries have used methods for promoting resilience. None of these case studies explicitly used resilience theory as an approach or fit into a literature category, but understanding how some of the methods used may overlap will help inform the approach for the 2013 competition entry and projective design for this thesis. Out of all the submissions, these three were chosen for several reasons. Touch is a 2009 submission from Kansas State University. Panorama Station was the winning team from that year, which justifies a comparison to Touch. Bayou Commons was the winning team from 2012, and set a new standard for design quality in the competition which makes it a relevant case study.



# CASE STUDY ANALYSIS

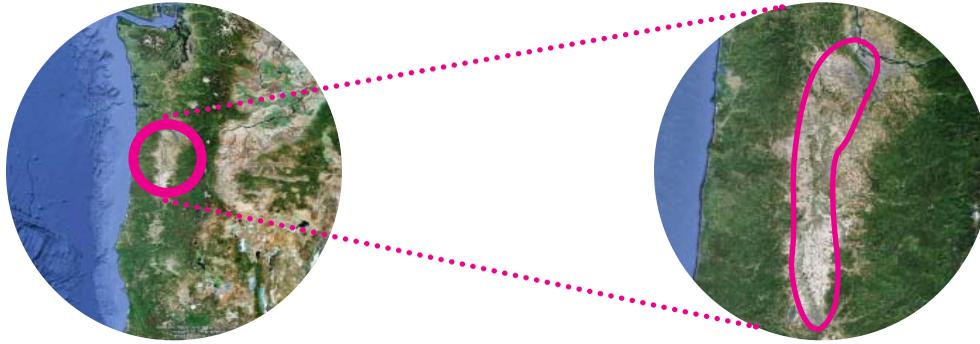
The following case study analyses are derived through the literature review and represent three of the four literature groups: application of resilience, adaptation of resilience, and theorizing resilience. The projects analyzed were chosen because they represent the various ways that resilience theory has thus been applied. There is also a group of projects that represent the 2009 and 2012 ULI/Hines Urban Design Competition. These were analyzed in order to provide a comparison to apply the extracted methods to the 2013 ULI/Hines competition which functions as a projective design for this thesis.

The case study analysis uses a universal matrix to provide a common ground to compare results. The matrix uses five categories of potential methods: identify and respond to thresholds, promote diversity, develop redundancies, create multi-scale networks and connectivity, and implement adaptive planning and management strategies. Each case study results in a different approach towards resilience, emphasizing different scales and systems through different methods in each one. These are arranged in a common analysis matrix and recorded in corresponding written form.

It is important to note that each case study had a varying amount of information available for analysis, which affected the outcome of the analysis matrix. The following is a summary of the sources that were analyzed:

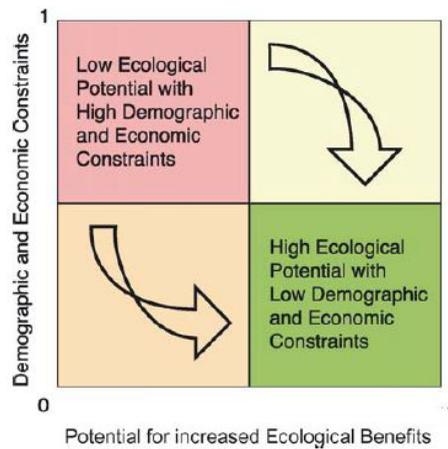
1. **Resilience in the Willamette River Floodplain:** journal article, 20 pages. (Hulse and Gregory 2004)
2. **Resilient Rangelands:** a chapter in *Panarchy*, 22 pages of text and charts. (Walker and Abel in *Panarchy* 2001)
3. **A Resilient Social-ecological Urbanity:** design presentation book, 18 pages. (Bonometti et al. 2010)
4. **Albano Resilient Campus:** masterplan document, 76 pages. (Barthel et al. 2010)
5. **Downsview Competition / Emergent Ecologies:** chapter in *CASE Downsview Park Toronto*, 6 pages. (Czerniak 2002)
6. **ULI/Hines Competition 2009 / Touch:** first and second round of presentation boards and the financial pro forma summary. (Perry 2009)
7. **ULI/Hines Competition 2009 / Panorama Station:** first and second round of presentation boards. (ULI Archives 2013)
8. **ULI/Hines Competition 2012 / Bayou Commons:** first and second round of presentation boards and the financial pro forma summary. (ULI Archives 2013)

# RESILIENCE IN THE WILLAMETTE RIVER FLOODPLAIN



## 4.1 Location

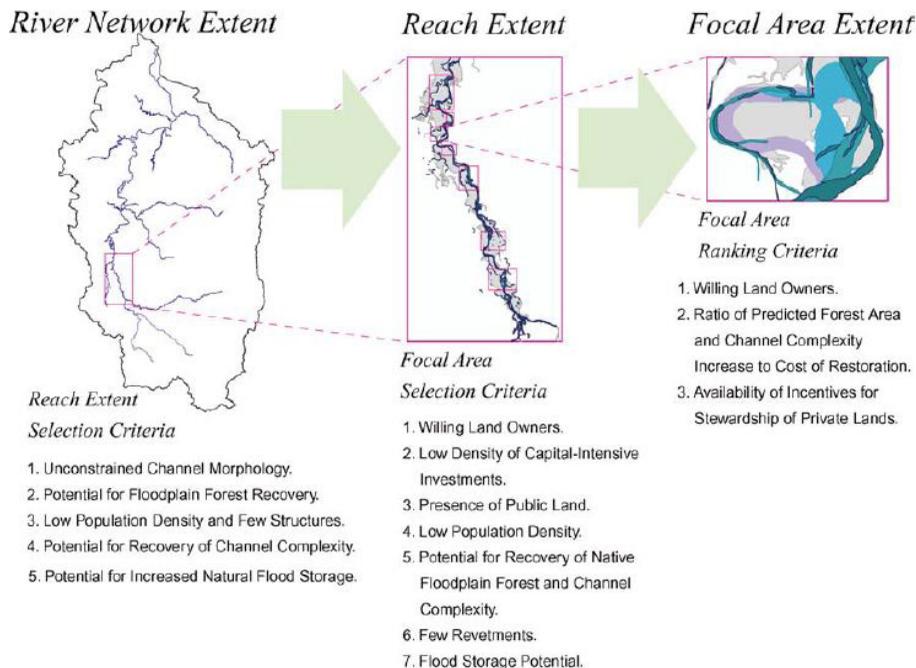
This research was conducted in the Willamette River Valley between Eugene and Portland, OR. It is an area that has undergone extensive changes and become a human-dominated ecosystem.



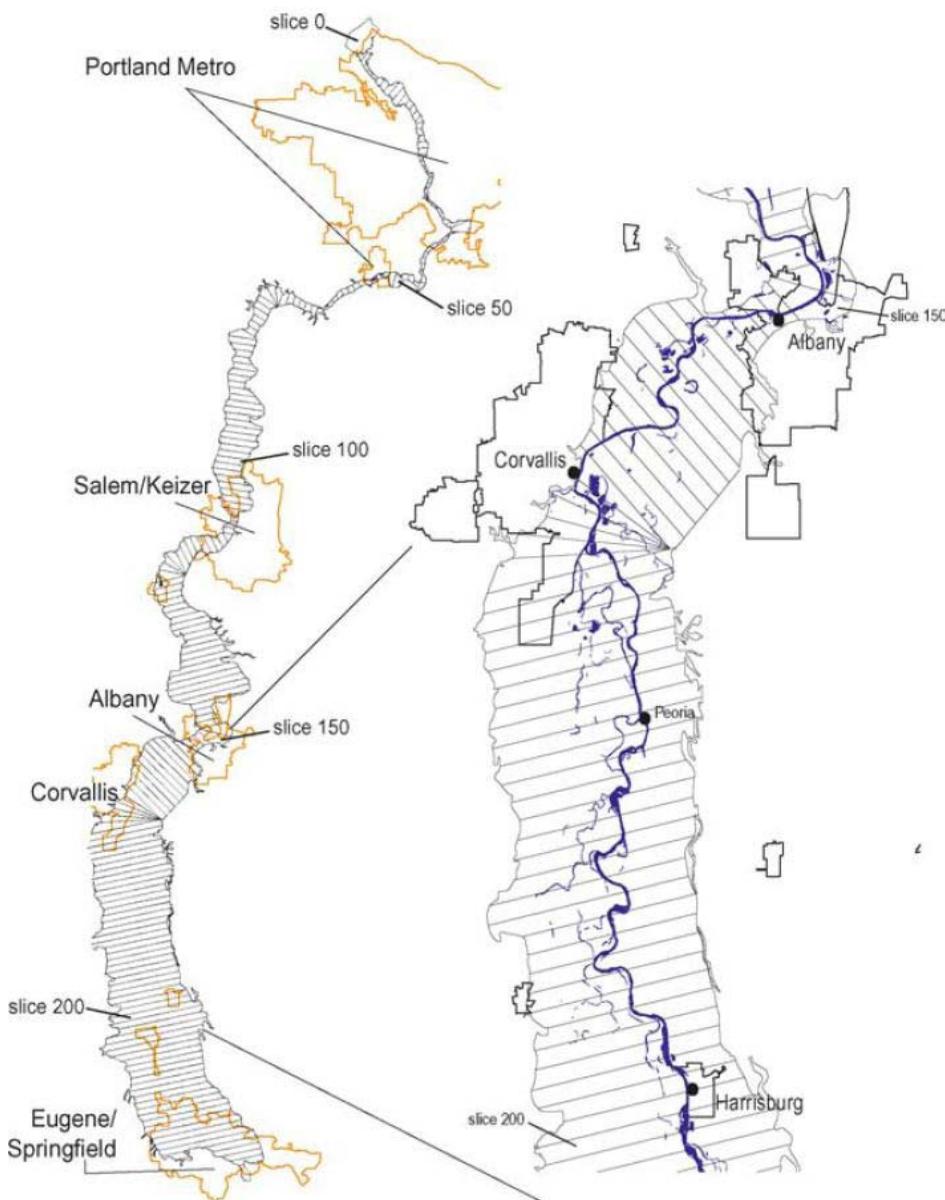
## 4.2 Resilience Framework

The framework prioritizes areas within the valley based upon social and ecological constraints. Areas with low ecological potential and high social constraints are the least priority, while areas with high ecological potential and low social constraints are the highest priority. The areas are defined by perpendicular slices across the stream channel, and a range of scales is analyzed. In relation to resilience, this effort is very specific and directed towards a single threshold: flooding along the Willamette River.

Figure 1. Conceptual framework for prioritizing restoration locations.



Gregory Hulse and Stan Gregory explore resilience in the Willamette River Valley in Oregon. This research is in response to one threshold, flooding, which in turn has secondary effects. One method for increasing resilience to the disturbance or shock of flooding is explored, which is increasing the flood storage capacity through natural means. Extensive geospatial analysis is conducted to determine areas of priority for restoration efforts within the historical floodplain. This analysis is based upon areas with low ecological potential and high social constraints being the least priority, and areas with high ecological potential and low social constraints being the highest priority and the most suitable. The results indicate a fairly even set of varying priorities, with areas of high urbanization generally having the least suitability. This prioritization coupled with suggested institutional management strategies that increase adaptivity and strengthen



### 4.3 Methodology

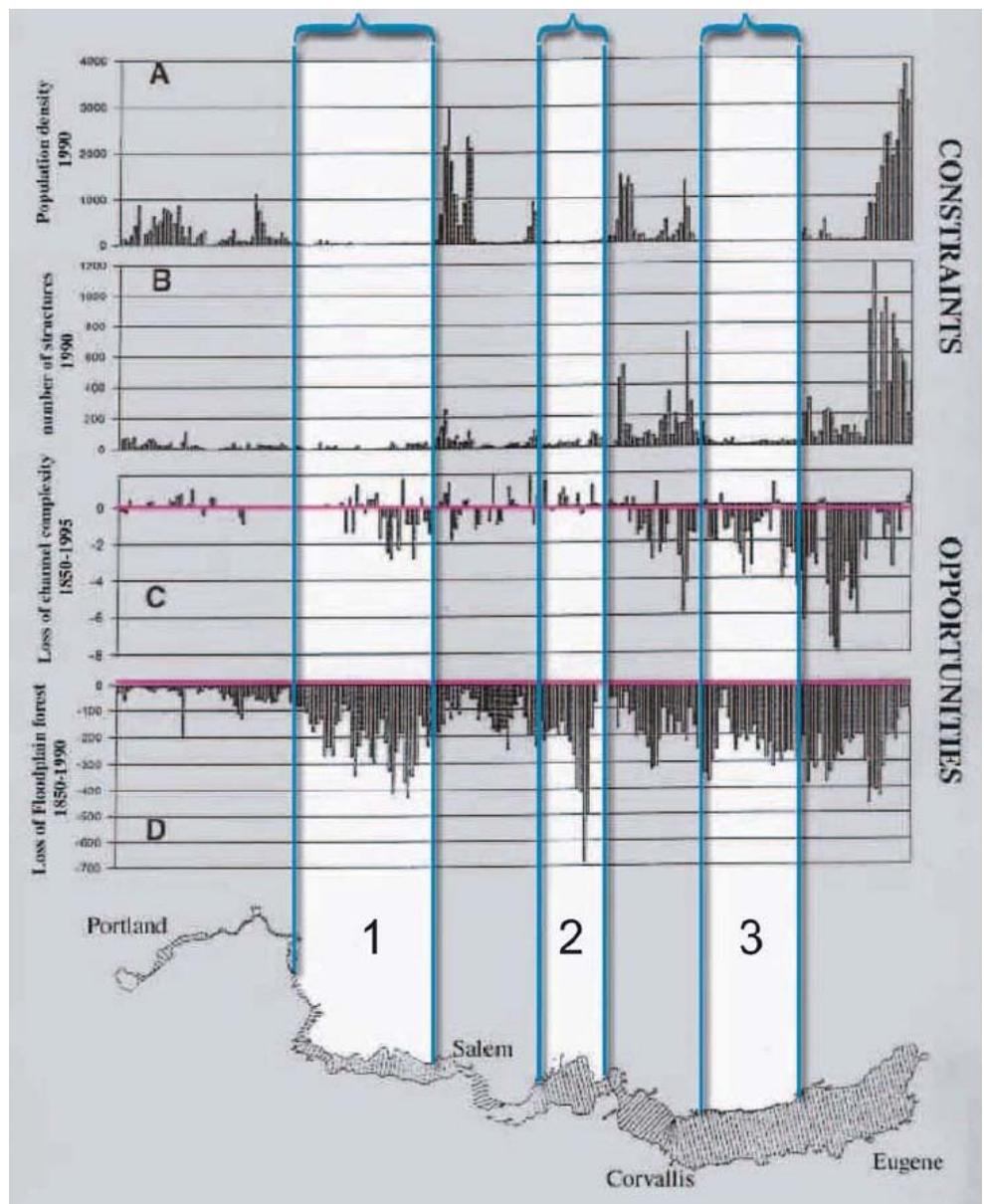
The diagrams at left describe the slices across the stream channel that were measured for social and ecological constraints. Benefits of increased channel complexity, habitat connections, biodiversity, and increased flood capacity were some of the ecological goals of the research.

communication between planners and policy-makers will promote resilience in the valley.

This research is unique because although it applies a holistic approach and addresses a range of scales, the methods and results are limited. Here, resilience is simplified to looking at a response to one critical threshold. Even with this simplification, there are implications that extend to other systems although these side effects are not discussed in the research. These are the increase in social memory and adaptivity because of recreational opportunities created through the extension of floodplain forests, increased carbon sequestration, the promotion of centralized economic activity, and a reduction in energy use via less stress on water treatment facilities. The majority of the positive

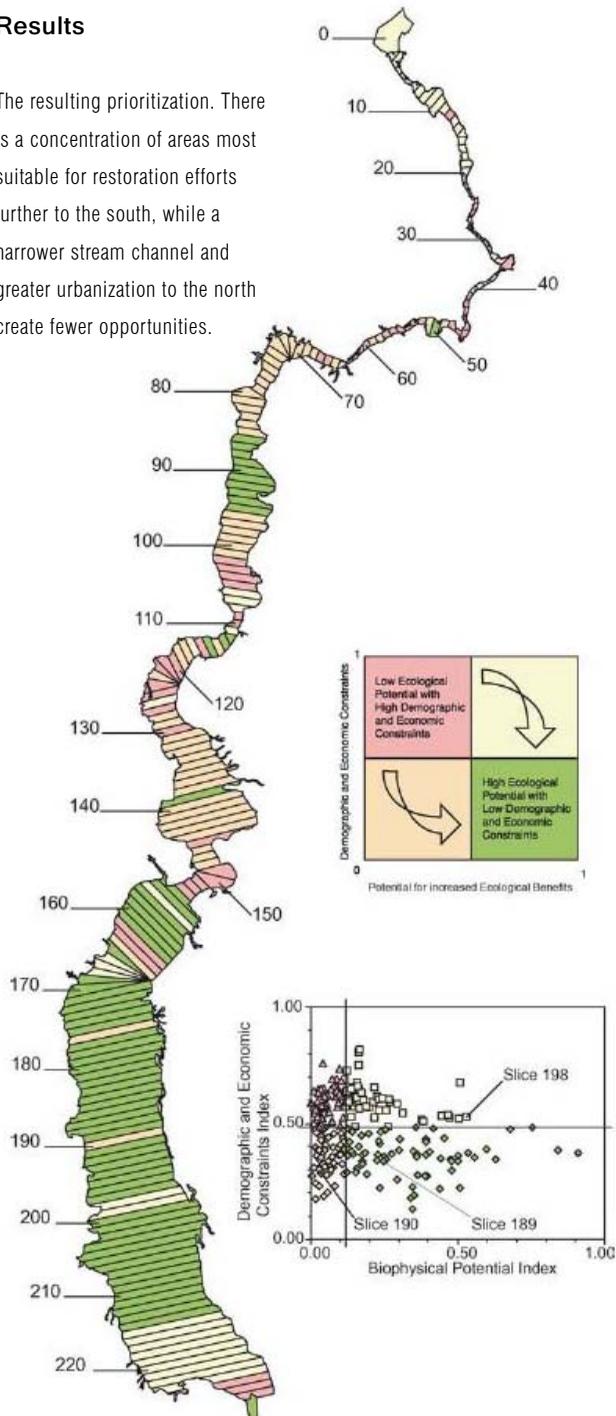
#### 4.4 Opportunities + Constraints

This diagram demonstrates that generally, dense urban areas have too many social constraints which allows for restoration efforts to be prioritized in areas between cities. Concurrently, there is higher ecological opportunity to increase habitat diversity and restore floodplain forests to absorb flood disturbances.

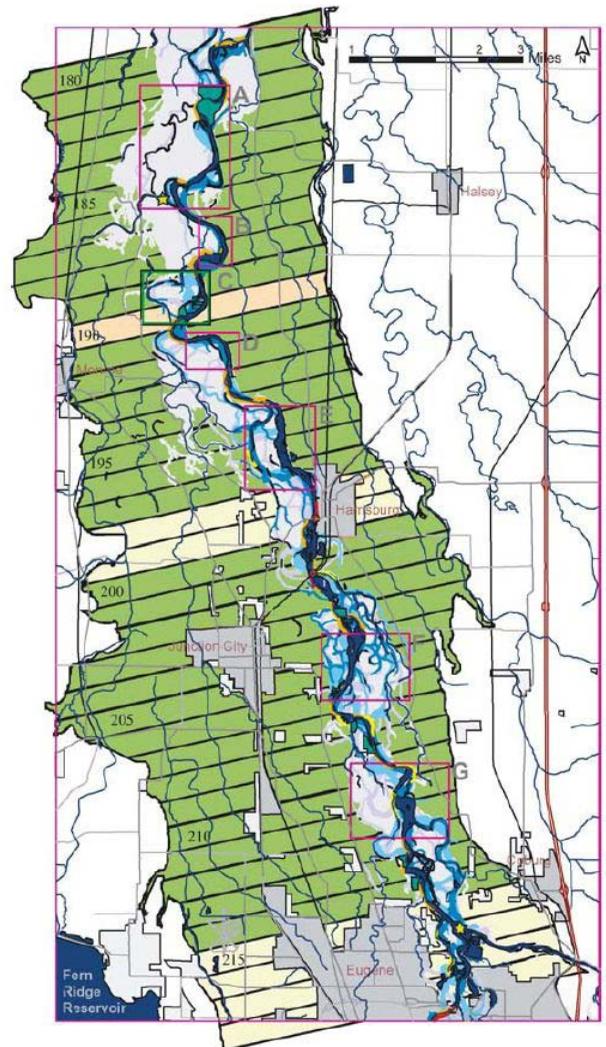


## 4.5 Results

The resulting prioritization. There is a concentration of areas most suitable for restoration efforts further to the south, while a narrower stream channel and greater urbanization to the north create fewer opportunities.



effects of increased resilience that are discussed relate to ecological benefits. This approach is a testament to the component of resilience theory that acknowledges the inability to attain holistic resilience, that achieving resilience at one scale or for one system can sacrifice resilience at scales and systems above and below within the panarchy. It is possible, for instance, that by promoting resilience at a regional and metropolitan scale within the Willamette River Valley may decrease site-scale resilience. The case study analysis demonstrates that the site scale was not considered as an integral part of this research. Inherently, many of the proposed methods overlap at the regional and metropolitan scales.



SPATIAL  
SCALE

REGIONAL



METRO



SITE



|                |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |
|----------------|------------|-----|------|------|-------|--------|
| THRESHOLDS     | SOCIAL     | 1   |      | 2    |       |        |
|                | ECOLOGICAL | 3   |      | 4    |       |        |
|                | ECONOMIC   |     |      |      |       |        |
| DIVERSITY      | SOCIAL     |     |      |      |       |        |
|                | ECOLOGICAL | 5   |      | 6    |       |        |
|                | ECONOMIC   |     |      |      |       |        |
|                | SPATIAL    |     |      |      |       |        |
| REDUNDANCY     | SOCIAL     |     |      |      |       |        |
|                | ECOLOGICAL | 7   |      | 8    |       |        |
|                | ECONOMIC   |     |      |      |       |        |
|                | SPATIAL    |     |      |      |       |        |
| CONNECTIVITY   | SOCIAL     |     |      |      |       |        |
|                | ECOLOGICAL | 9   |      | 10   |       |        |
|                | ECONOMIC   | 11  |      | 12   |       |        |
| PLANNING       | ECOLOGICAL | 13  |      | 14   |       |        |
|                | ECONOMIC   |     |      |      |       |        |
| TEMPORAL SCALE |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |

## EXTRACTED METHODS

- 1
  - Restoration of riparian forests and floodplains increases social memory through recreational opportunities
  - Promote understanding and mental models of biophysical resilience in human-dominated ecosystems to establish greater adaptivity and prevent repetitious mistakes
- 2
  - Restoration of riparian forests and floodplains increases social memory through recreational opportunities
  - Promote understanding and mental models of biophysical resilience in human-dominated ecosystems to establish greater adaptivity and prevent repetitious mistakes
- 3
  - Increase floodplain forest area increases adaptability to flood events through natural water storage
  - Areas with greater risk to ecological disturbance (flooding) have a higher prioritization for restoration
- 4
  - Increase floodplain forest area increases adaptability to flood events through natural water storage
  - Areas with greater risk to ecological disturbance (flooding) have a higher prioritization for restoration
- 5
  - Increase channel complexity, increases habitat and biodiversity of fish and riparian communities
- 6
  - Increase channel complexity, increases habitat and biodiversity of fish and riparian communities
- 7
  - Increase floodplain forest area increases adaptability to flood events through natural water storage
- 8
  - Increase floodplain forest area increases adaptability to flood events through natural water storage
- 9
  - Create and enhance corridor linkages between restored floodplain forests
- 10
  - Create and enhance corridor linkages between restored floodplain forests
- 11
  - Emphasize existing areas of density and economic activity to promote connectivity between nodes, and not prioritize these areas for restoration efforts
- 12
  - Emphasize existing areas of density and economic activity to promote connectivity between nodes, and not prioritize these areas for restoration efforts
- 13
  - Implement adaptive management strategies for resource planners and city planners that influence official decision making
  - Model scenarios to understand possibilities for different prioritization strategies
- 14
  - Utilize data visualization tools to successfully communicate between the designers and policy-makers

# RESILIENT RANGELANDS



## 4.7

### Location

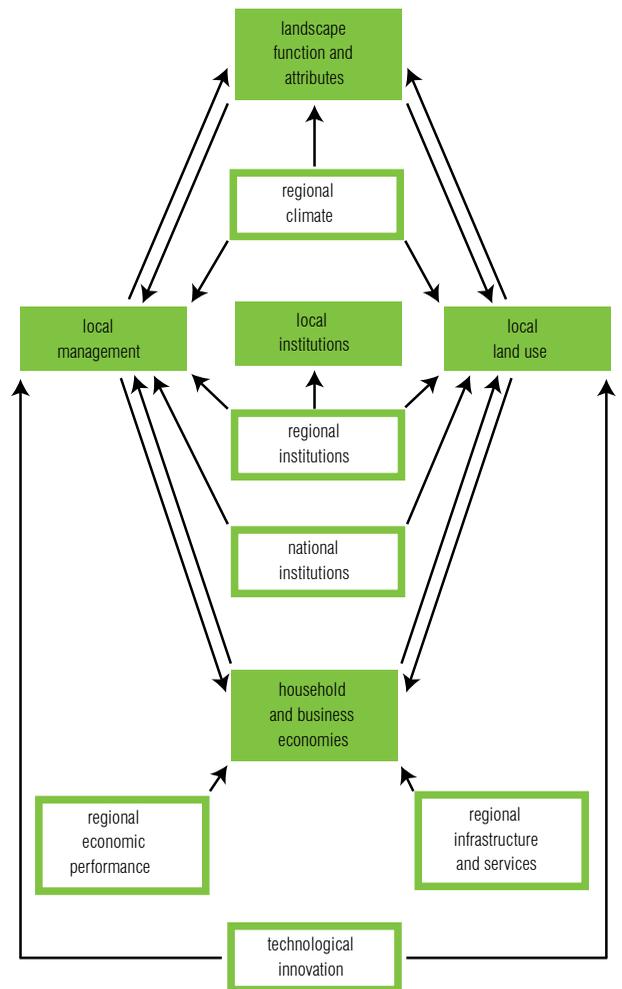
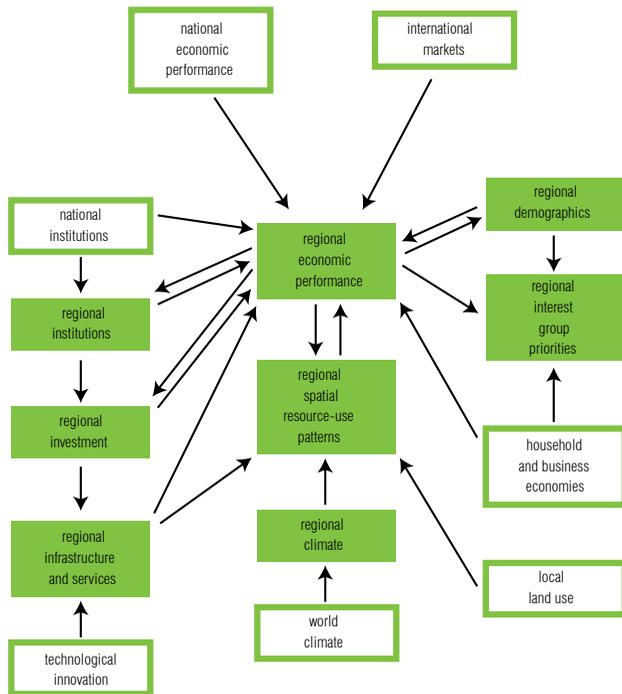
Rangeland landscapes cover a large portion of Australia. This research addresses the rangeland typology in a general approach, but the image at left was taken in Western Australia after a series of floods in 2009. This research addresses how landscapes respond resiliently to such disturbances as floods and droughts at multiple scales. The methods discussed heavily involve institutional management practices.

Brian Walker and Nick Abel pioneer an effort into applying resilience theory as a framework for the management of rangeland landscapes in Australia. This research holistically addresses the function of these landscapes at the local, regional, and national scale. As the analysis describes, not every scale and system has a proposed method for increasing resilience; they are selective in how they work to distribute resilience because, again, holistic resilience is not achievable. Multiple thresholds are addressed, including erosion, drought, flooding, and climate change. In general, the proposed framework provides more methods at the local scale, with regional and national methods being more focused on adaptive planning and management practices. This is an interesting result, because it indicates that methods are not necessary to suggest at every system and scale. Redundancies are also not explicit in the proposed methods, but the redundancies identified in the research are implied from the diversity methods. It is also of great interest that at the regional scale the majority of the methods are related to economic strategies.

All of the methods suggested in the framework relate to adaptive capacity and how various factors inhibit or promote the ability for systems to adapt and respond to shocks and disturbances. Despite that many methods are suggested, each one is clearly a critical component to resilience within the panarchy. The methods are, however, fairly general which has more implications for planning and management practices. The resulting goals serve as a series of benchmarks that subsequent design projects can work to promote. Site scale methods in particular would be of most use in these cases, with larger-scale planning and management efforts also influencing the site scale.

Some of the topics also addressed in this research include flows of protein and energy, mental models in relation to social memory and adaptivity, demographic structure,

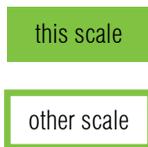
connections between economic nodes, the development of technology, and institutions/policies. These topics suggest design solutions, but they are not explicit as to what these solutions might be. In this case, the framework is a series of suggestions rather than for methods directly applicable to landscape architecture or design practice.



#### 4.8 Resilience Framework

These two frameworks address the regional (above) and site (right) scales and the complex interactions between systems. What is of most interest is how factors from smaller and larger scales influence factors at the scale being analyzed.

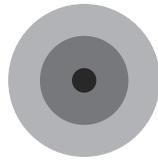
influence originates at:



REGIONAL

METRO

SITE



SPATIAL  
SCALE

|                |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |
|----------------|------------|-----|------|------|-------|--------|
| THRESHOLDS     | SOCIAL     |     |      | 1    | 2     |        |
|                | ECOLOGICAL |     |      |      | 3     |        |
|                | ECONOMIC   | 4   |      |      | 5     |        |
| DIVERSITY      | SOCIAL     |     |      | 6    | 7     |        |
|                | ECOLOGICAL |     |      |      | 8     |        |
|                | ECONOMIC   |     |      |      | 9     |        |
|                | SPATIAL    |     |      | 10   | 11    |        |
| REDUNDANCY     | SOCIAL     |     |      | 12   |       |        |
|                | ECOLOGICAL |     |      |      | 13    |        |
|                | ECONOMIC   | 14  |      | 15   | 16    |        |
|                | SPATIAL    |     |      |      | 17    |        |
| CONNECTIVITY   | SOCIAL     | 18  |      | 19   |       |        |
|                | ECOLOGICAL |     |      | 20   |       |        |
|                | ECONOMIC   | 21  |      | 22   | 23    |        |
| PLANNING       | ECOLOGICAL |     |      | 24   | 25    |        |
|                | ECONOMIC   | 26  |      |      |       |        |
| TEMPORAL SCALE |            |     |      |      |       |        |

## EXTRACTED METHODS

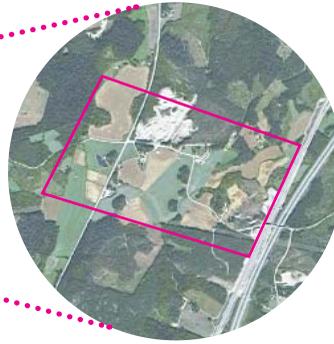
- 1
  - Increase socio-cultural memory develops an accumulation of understanding
  - Create a response to an aging rangeland population
- 2
  - Communication network assists the spread of ideas
  - Rate of learning is faster than the rate of degradation
  - A social acceptance to use fire as a land management strategy
- 3
  - Increase memory of past disturbances to avoid repetitious mistakes
  - Drought-adapted forage species and herbivores
  - Disestablishment of permanent water sources on land systems promotes landscape function and continuous grazing habits
- 4
  - Public savings enable recovery from disturbances but can foster dependency
- 5
  - Access to off-farm jobs and investments
  - Smart buying and selling strategies based on accurate perceptions of landscape function and economic system
  - Savings increase economic options
  - A larger land holding yields economies of scale, lower debt and more savings, better credit rating, and more options in responding to disturbances
  - Paddock layout relates to land system boundaries which increases production levels and adaptation
- 6
  - Balanced age structure enhances capacity to respond to disturbances and create opportunities
- 7
  - Diversity of age amongst rangeland households
  - A relatively large workforce with a mix of sexes and ages expands adaptive opportunities
- 8
  - Mixed grazer and browser animal populations increase forage and marketing options, reduce drought risk, and slow shrub encroachment
- 9
  - Diverse enterprises linked to different markets and requiring different weather conditions reduce risk
  - A range of energy sources (human labor, horses, oxen, fossil fuels) widens resource-use opportunities
- 10
  - Access to a region with spatially variable climate enables survival through mobility
  - Access to a diverse land systems at this scale offers a range of opportunities in time and space
- 11
  - Road network permits the pursuit of protein and energy
  - Access to a mix of complementary land systems at a fine scale e.g. river channels with heavy soils amid uplands with lighter soils, provides reliable fodder supply at a local scale
  - Access to grazing in different climatic zone provides reliable fodder supply at a regional scale, e.g. ownership of land in other places
- 12
  - Reciprocal obligations called upon in crises

## EXTRACTED METHODS (CONT'D)

- 13 • A range of energy sources (human labor, horses, oxen, fossil fuels) widens resource-use opportunities
- 14 • Loans and grants assist recovery after economic disturbance that can foster adaptation
- 15 • High level of services encourages capable people to stay and innovate
- 16 • Access to off-farm jobs and investments
- 17 • Access to a mix of complementary land systems at a fine scale e.g. river channels with heavy soils amid uplands with lighter soils, provides reliable fodder supply at a local scale
- 18 • Communication network assists the spread of ideas
- 19 • Communication network assists the spread of ideas
- 20 • Access to a region with spatially variable climate enables survival through mobility
- 21 • Road network permits the pursuit of protein and energy
- 22 • Road network permits the pursuit of protein and energy
- 23 • Diverse enterprises linked to different markets and requiring different weather conditions
- 24 • Use of fire as a land management strategy (safe-to fail landscape)
- 25 • Use of fire as a land management strategy (safe-to fail landscape)
- 26 • Increase flexibility in institutions and policies to create sensitivity to feedback from smaller scales
- Weather and price sensitive tax policy spreads benefits and costs across years
- Community structures and projects that bring innovative approaches and outside resources
- Increase complexity of mental models held by agencies to stress adaptation and uncertainty rather than command and control



# A RESILIENT SOCIAL-ECOLOGICAL URBANITY



## 4.10 Location

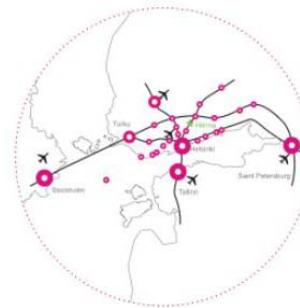
The site is located in a semi-rural area with existing highway and rail infrastructure adjacent in Henna, Finland. The proposal was done by N2M Architects out of Germany.



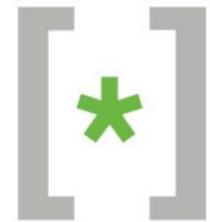
**Global network**  
Eurasia



**Region cluster**  
Polycentric system



**Local region**



**GLocal**

A Resilient Social-Ecological Urbanity: A Case Study of Henna, Finland seeks to reinterpret urban development with a multi-level framework for creating urban resilience. Resilience theory is an explicit source for this project, as well as the four categories that facilitate urban resilience according to the research prospectus of the Resilience Alliance: metabolic flows, social dynamics, built environment, and governance networks. The project was completed by N2M Architecture of Hanover, Germany.

In terms of the application of resilience theory, the project focuses primarily on the metropolitan scale. Methods for the regional and site specific scales are suggested, although in more implied and vague ways. Social adaptivity is a major component of their proposal through the coupling of ecological and social systems. Adaptivity in relation to specific critical thresholds are not mentioned, except for the slow process of climate change and the depletion of non-renewable energy sources. The adaptivity lies in flexible program of open space and buildings, and local governance networks that increase social memory and adaptivity. The categories of diversity, redundancy, and connectivity have overlapping methods and themes at the metro scale. The majority of these methods are in relation to the spatial qualities of urban development and how they relate to energy reduction.

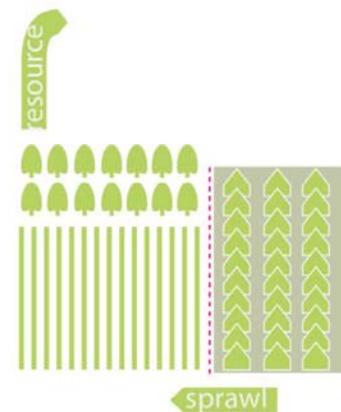
Ecological methods are implied, but not explicit in this case study. Topics of biodiversity, stormwater, patches and connectivity, and management strategies are not discussed.

## 4.11 Spatial Scales

The case study situates the relevance of the site globally, regionally, and locally. While connectivity to the greater context is addressed generally, there are no specific methods suggested for promoting resilience at these larger scales.

As mentioned, the majority of the ecological concern is in response to energy use. Stormwater is not mentioned, but grey and black water treatment in relation to energy reduction is a key strategy. Recycling and adaptive solid waste management practices tighten feedback loops and increase interaction with social systems. These strategies ultimately have an influence at the regional scale, but there are not specific methods suggested for creating resilience at the regional scale.

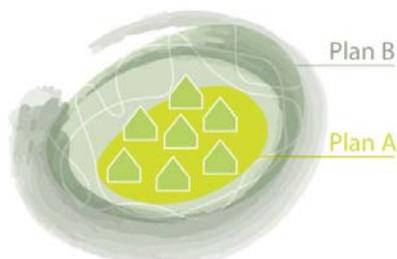
What is of special interest is the abstract urban form that is proposed as a direct result of this resilient urban framework. Less tangible methods described above are important strategies, but a focus for this project is to carry these methods into the built environment. Redundancy, diversity, replicability, and flexibility are all evident in the design. Common grid structures and open space dimensions facilitate a diversity of use and program, while allowing for flexible adaptation should a disturbance create a need to shift these uses and programs. It is mentioned that the design should create a unique identity that promotes social diversity within the regional context, but it is not evident in this modular system how things like cultural character and social expression will emerge. Perhaps the form is only suggestive, and is an abstract representation of what the built environment will really look like. Regardless, there is a more rigid primary development located adjacent to existing transportation infrastructure, with secondary and more flexible residential development around these “spines.” This hierarchy creates a diversity of spaces while maintaining a more stable set of structures around key transportation nodes.



General Sprawl Situation



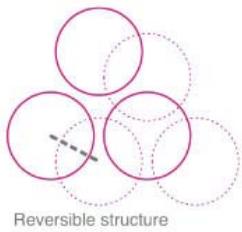
Social Ecological System



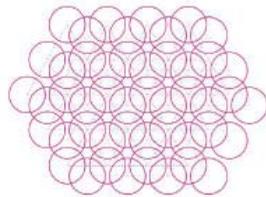
Plan A - General Parametric Urban Planning  
Plan B - Extra Zone Supporting Resilient Urban Development

#### 4.12 General Concepts

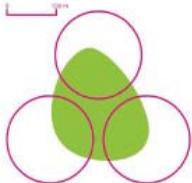
The proposed design seeks to avoid the typical semi-rural development pattern of resource input centered around agricultural production and sprawl. The focus is on coupled social-ecological systems that activate agricultural land, diversify land use patterns, promote connectivity, and incorporate a flexible buffer zone that supports resilient urban development.



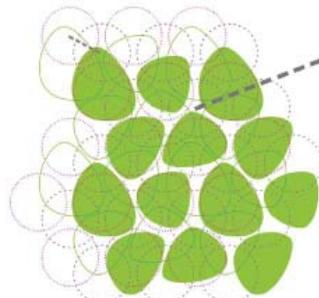
Reversible structure



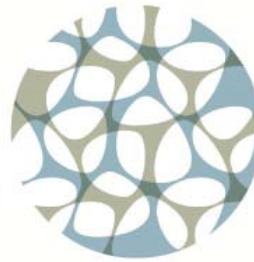
Undefined carpet



Settlement island



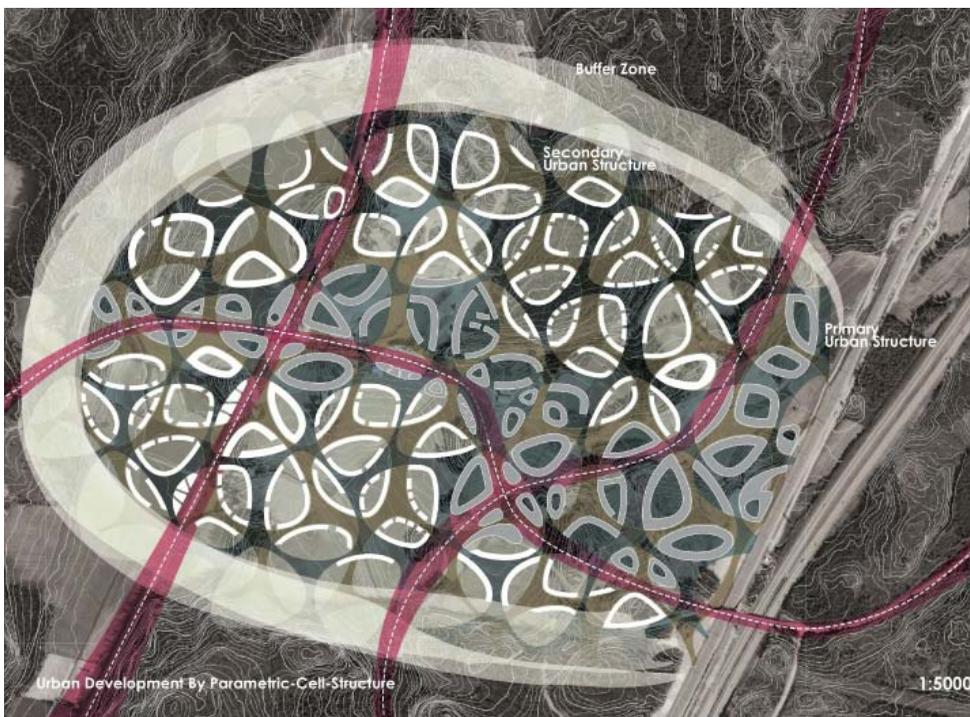
Undefined carpet islands



Urban structure  
Primary structure  
Secondary structure

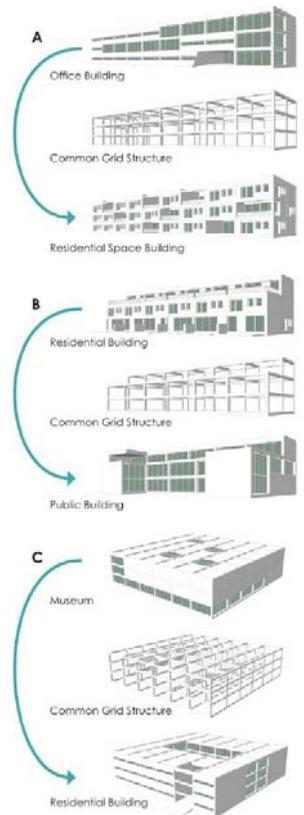
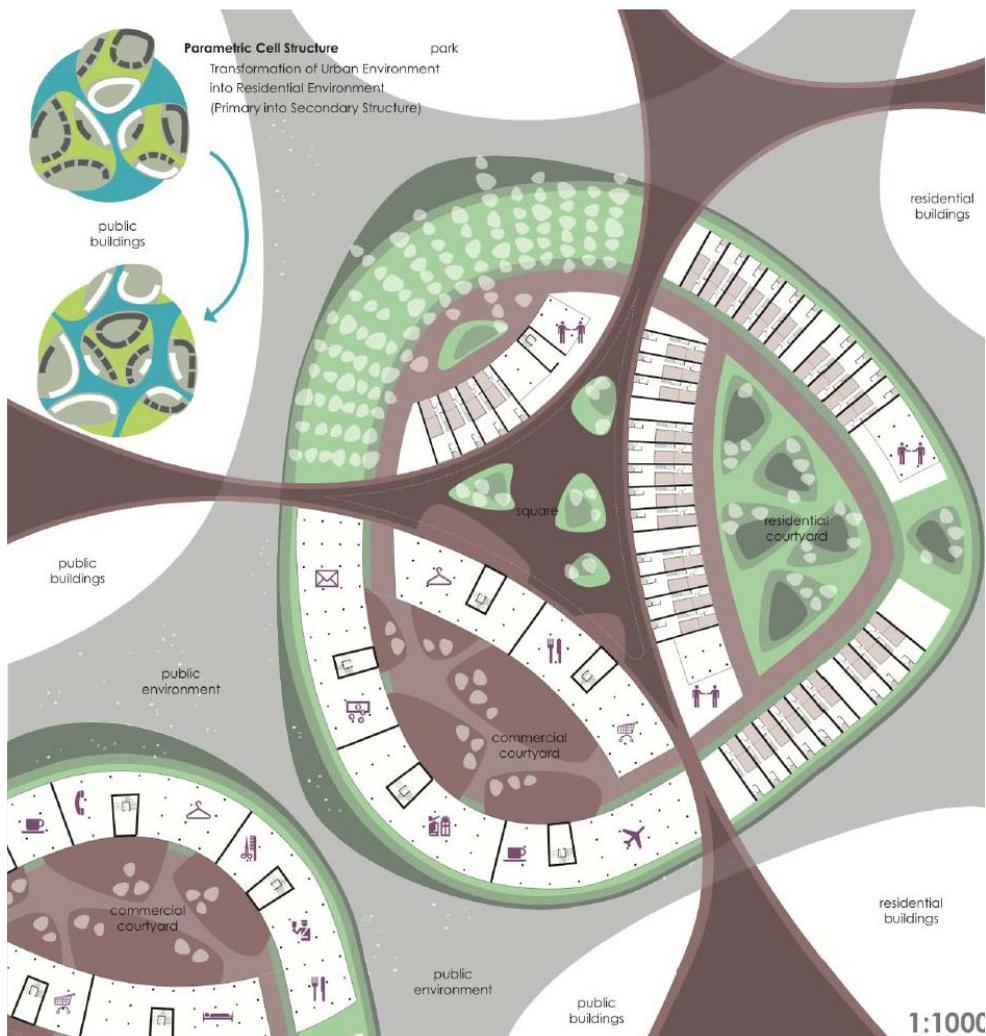
#### 4.13 Design Process

The design process for arriving at the final urban development pattern results in an abstract form. The connections between “carpet islands” suggest some level of connecting ecological and social flows, but it is not clear how the form will facilitate these flows. The form does promote flexibility in terms of space and program, as well as a replicable method for any site.



#### 4.14 Masterplan

The resultant urban form consists of primary structures located adjacent to existing transportation infrastructure, with secondary structures providing more flexibility and adaptivity. The secondary structures consist of most of the residential land use. It is clear that in relation to the context, the plan does not take into account topography, drainage ways, ecological corridors and patches, and other existing conditions. There is no evident character but it represents the components of resilience.



In conclusion, this case study is a tremendous example for the application of resilience theory to an urban design typology. It is limited in expressing what the quality and character of the created environment, but goes into depth on how the design will work in terms of social and economic systems. The ecological component is somewhat weak, with the majority of the methods concentrating on energy use, CO<sub>2</sub> emissions, and resource management. The local and regional flora and fauna are not considered, and their connections to the surrounding context are non-existent. Ultimately, the proposed design is not site specific and could be located anywhere. This is a necessary part of a framework, replicability, but when we look at true social memory and adaptivity it is necessary to consider the quality of the spaces created and the cultural history that make the development unique. It is also unclear at what time scales this project operates at; something that is crucial to any research in resilience.

#### 4.15 Site Plan

The spatial dimensions of the open space network and the structural grids of the buildings facilitate a modular approach that allows for adaptation in program and use. The plan accommodates a diversity of land use and encourages social diversity through a variety of housing prices and options. There is also implied program indeterminacy and open-endedness that parallels concepts of emergence and self-organizing processes. Again, there is also a lack of cultural influence.

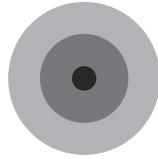
4.16  
Analysis Matrix

REGIONAL

METRO

SITE

SPATIAL  
SCALE



|              |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |
|--------------|------------|-----|------|------|-------|--------|
| THRESHOLDS   | SOCIAL     |     |      | 1    |       | 2      |
|              | ECOLOGICAL | 3   |      | 4    |       | 5      |
|              | ECONOMIC   | 6   |      | 7    |       |        |
| DIVERSITY    | SOCIAL     |     |      | 8    |       | 9      |
|              | ECOLOGICAL |     |      | 10   |       |        |
|              | ECONOMIC   |     |      | 11   |       |        |
|              | SPATIAL    |     |      | 12   |       | 13     |
| REDUNDANCY   | SOCIAL     |     |      | 14   |       | 15     |
|              | ECOLOGICAL |     |      |      |       |        |
|              | ECONOMIC   |     |      | 16   |       |        |
|              | SPATIAL    |     |      | 17   |       | 18     |
| CONNECTIVITY | SOCIAL     | 19  |      | 20   |       |        |
|              | ECOLOGICAL | 21  |      | 22   |       | 23     |
|              | ECONOMIC   | 24  |      | 25   |       |        |
| PLANNING     | ECOLOGICAL |     |      | 26   |       |        |
|              | ECONOMIC   |     |      | 27   |       |        |

TEMPORAL  
SCALE

\* note that time scales were not present in this case study

## EXTRACTED METHODS

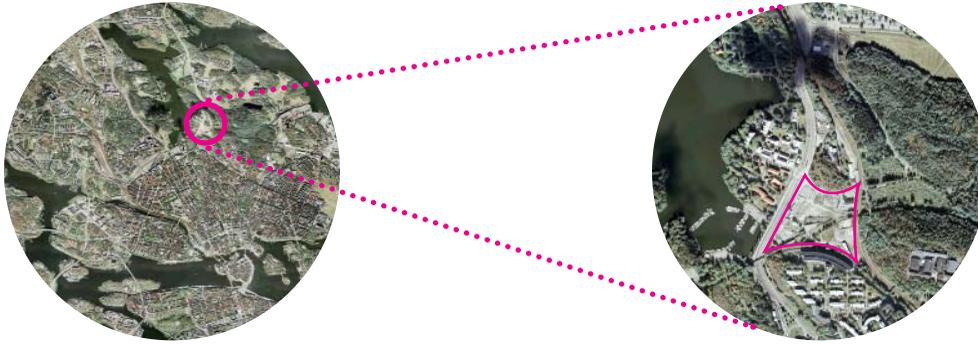
- 1
  - Provide a variety of community-managed food production networks, which promotes social adaptivity
  - Tighten feedback loops associated with solid waste management- recycling builds social adaptivity and memory
- 2
  - Site programs adaptable to change
  - Build social memory by creating "social ecological melting areas" where the community works and recreates in an ecological environment
  - Open space network is of dimensions appropriate for semi-private residential or public commercial use in the event of a regime shift
  - Promote a unique social community identity
- 3
  - Reduce CO2 emissions to prevent a critical threshold being passed in non-renewable energy use
  - Reduce CO2 emissions of regional municipal solid waste transportation networks
- 4
  - Facilitate the production of fertilizers and biogas through black water treatment strategies- reduces energy demand and ecological stress
  - Utilize wetland filtration systems to cleanse grey water and reduce energy use in water filtration processes
  - Tighten feedback loops associated with the water cycle especially in terms of treatment processes
  - Reduce the carbon footprint
- 5
  - Utilize rainwater harvesting strategies for local freshwater consumption
- 6
  - Reduce susceptibility to regional economic shocks by localizing resources
- 7
  - Provide a variety of community-managed food production networks, which promotes economic adaptivity
- 8
  - Address outer edge conditions to promote resilient social structures
  - Heterogeneity of household prices and types attracts a variety of social groups
- 9
  - Create a social ecological urbanity with a unique identity in relation to the regional context
- 10
  - Multiple energy sources- geothermal, biogas, and wood fuel
- 11
  - Heterogeneity of household prices
- 12
  - Create a heterogeneous pattern of development including natural ecosystems, agriculture, and urban development
  - Hierarchy of development with primary urban structures along existing transportation infrastructure and secondary urban structures adjacent that have more adaptive properties
- 13
  - Buildings have a variety of spaces that can facilitate a diversity of use
- 14
  - Multiple public and private greenhouse spaces for food production
- 15
  - Overlapping programs within public spaces- food production, community development, reducing energy use, etc.
- 16
  - Incorporate local food sources as a supplement and an alternative to regional and global food sources
- 17
  - "Social ecological melting areas" throughout the development
- 18

## EXTRACTED METHODS (CONT'D)

- Building structures have a common grid system that accommodates a diversity of programs and building types
- 19 • Connect to regional destinations through innovative and energy efficient public transportation
- Reduce solid waste transportation connectivity
- 20 • Maintain regional connectivity, but promote a unique community identity
- Promote pedestrian and bicycle use over energy-intensive modes of transportation
- 21 • Reduce the regional ecological footprint in terms of energy and resource management
- 22 • Buffer zone between agriculture and urbanity determines an urban development boundary, protecting natural systems
- 23 • Development remains permeable to ecological flows of species
- 24 • Reduce regional connectivity in terms of food and energy production
- 25 • Promote an economic network that focuses on local resources, reducing regional connectivity
- 26 • Local governance networks manage socio-ecological demands
- 27 • Local governance networks manage socio-ecological demands
- Provide a variety of community-managed food production networks, which promotes social adaptivity



# ALBANO RESILIENT CAMPUS

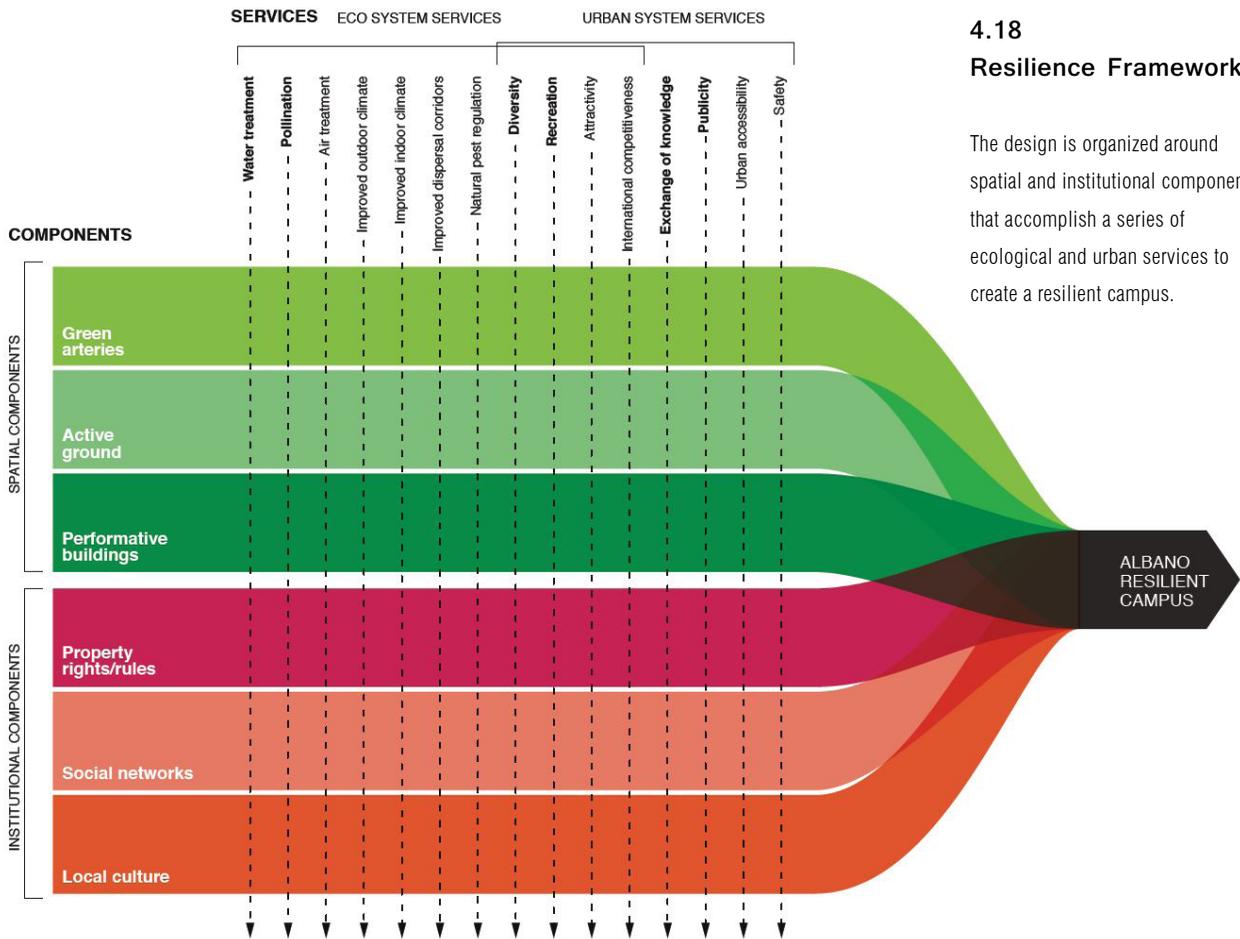


## 4.17 Location

The Albano campus is located on the periphery of Stockholm, Sweden and is adjacent to the large National Urban Park- a key connection both socially and ecologically.

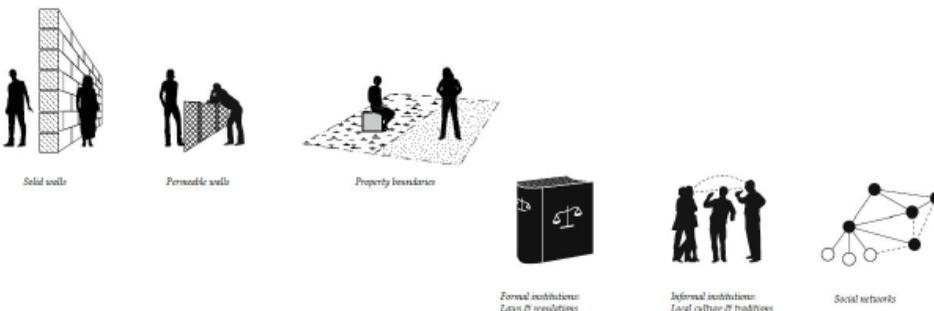
## 4.18 Resilience Framework

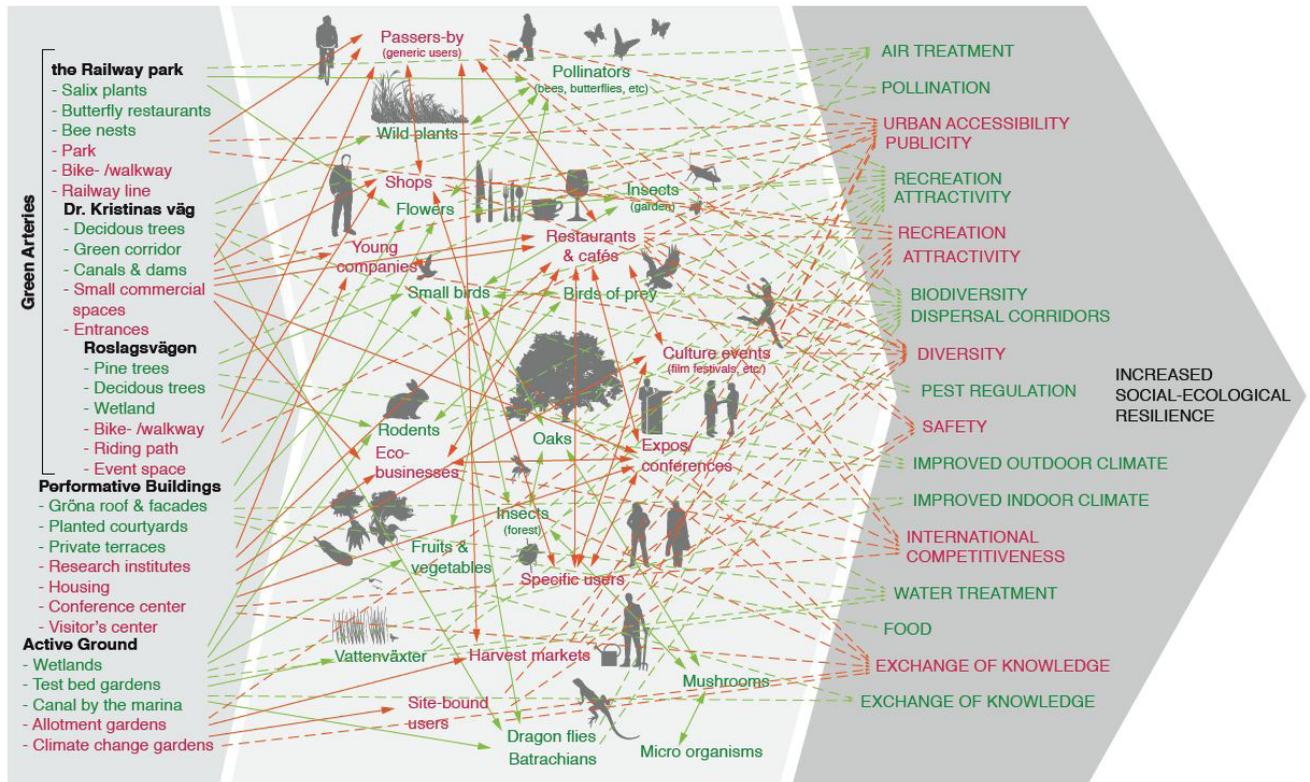
The design is organized around spatial and institutional components that accomplish a series of ecological and urban services to create a resilient campus.



## 4.19 Boundaries + Networks

The design acknowledges boundaries, both physical and institutional. Institutions and networks also influence resilience from a management perspective.



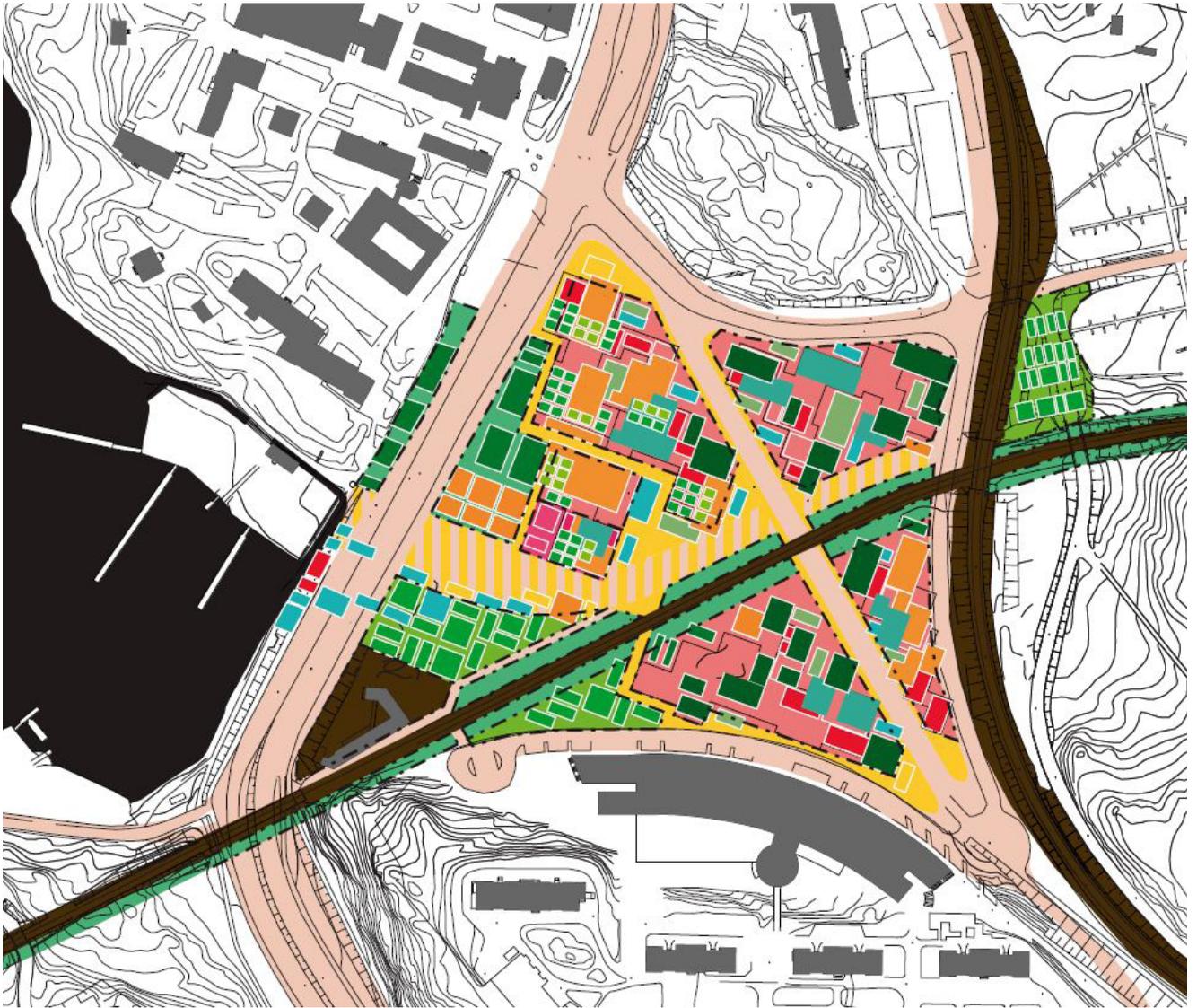


The Albano Resilient Campus Masterplan is a comprehensive application of resilience theory to the redevelopment of a major academic institution located in Stockholm, Sweden. At the heart of the design is establishing strong connections between social and ecological systems, with a lesser focus on economic strategies for promoting resilience. Three main design strategies are used to achieve the overall goals for a resilient campus: green arteries, active ground, and performative buildings. The green arteries provide social and ecological connectivity to the context and the region. Active ground establishes diversity through division of management and habitat type, and performative buildings create economic, social, and institutional hot spots. These three physical design strategies coupled with property rights/adaptive management, social networks, and local culture provide four ecosystem and urban services: exchange of knowledge, publicity, recreation, and biodiversity.

There are several methods used in this plan that are of significance. The first is the approach towards institutional management, which focuses on a diversity of groups both in size and power. Management is divided by active ground area and local interest groups meet regularly to make economic and ecological decisions. The proposed largest or most influential institution is the university itself, Akademiska Hus. Overall, the management strategy uses diversity and redundancy to promote adaptivity in decision making. The second significant approach deals with connectivity. The Albano campus was identified as a key connection for the National Urban Park because of its adjacency and scale- this drives the entire ecological plan and establishes the campus as a unique

#### 4.20 Design Process

Through the three spatial design strategies- green arteries, performative buildings, and active ground- a series of processes develops and socio-ecological resilience is promoted. Social and ecological systems are weighted equally important, and many of the methods used overlap between systems.

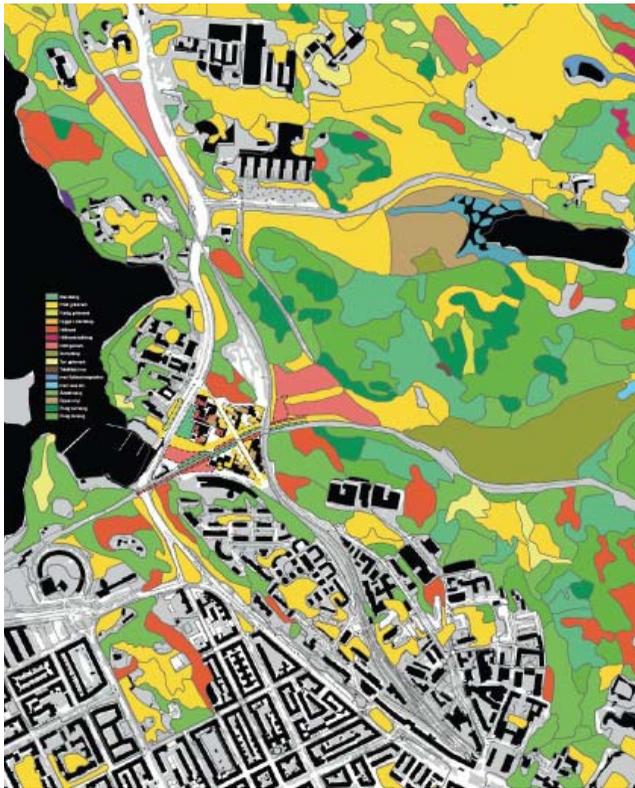


socio-ecological node. What is significant in this is identifying what socio-ecological role the site plays in the greater context. What lacks in this regional connectivity are specific economic methods, but these may have been deemed unnecessary to the masterplan.

There are common themes amongst the proposed methods for Albano. One which reoccurs the most is small scale resilience influencing large scale resilience- there is a strong focus on diversity at the site scale influencing the entire campus at the metro scale. This is found in management strategies, multiple habitat types, social groups, social and ecological connectivity, and spatial type and scale. Another is the equal influence between social and ecological systems when applying methods for resilience. The symbiotic relationship between these two

#### 4.21 Masterplan

The resultant masterplan represents an entity with a diversity of spaces and services within. Generous green arteries accommodate flows of ecological species and connect the site regionally. The campus is a critical link to the adjacent National Urban Park and serves as a unique social and academic destination both locally and regionally.

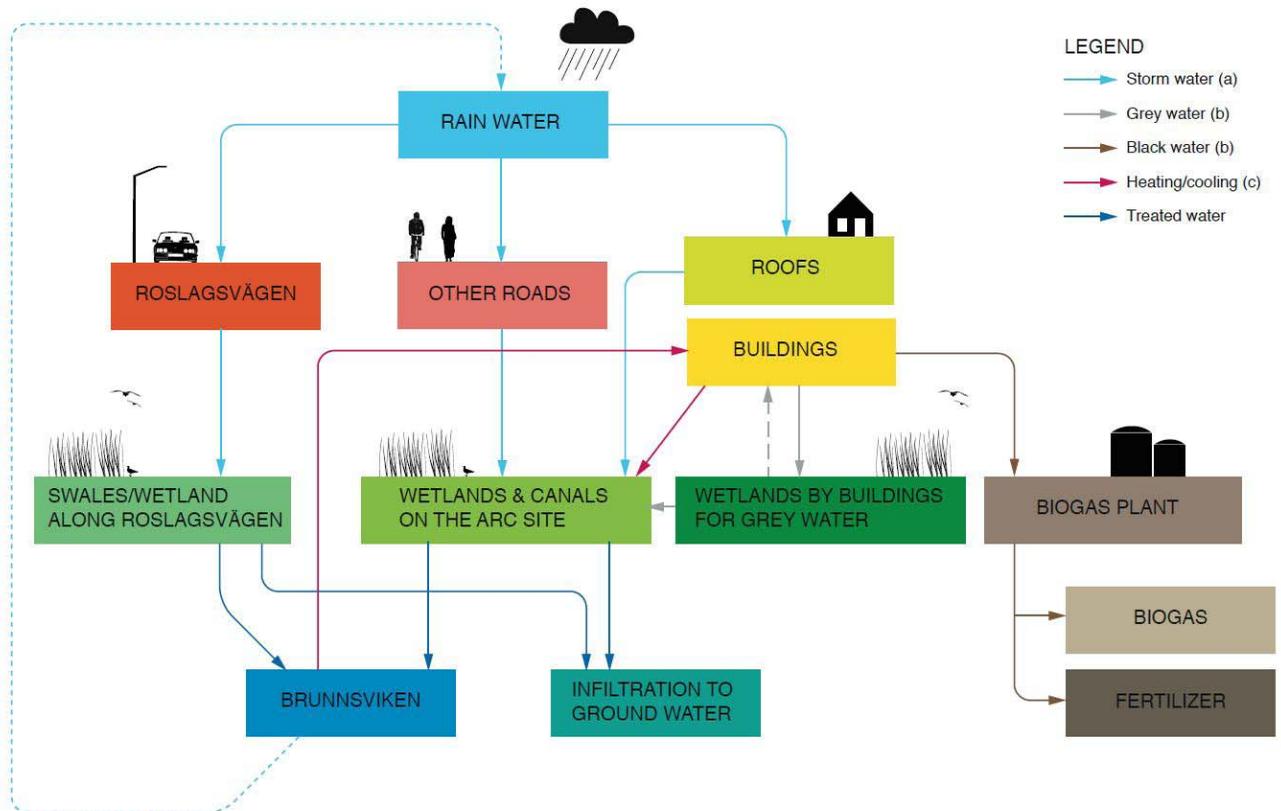


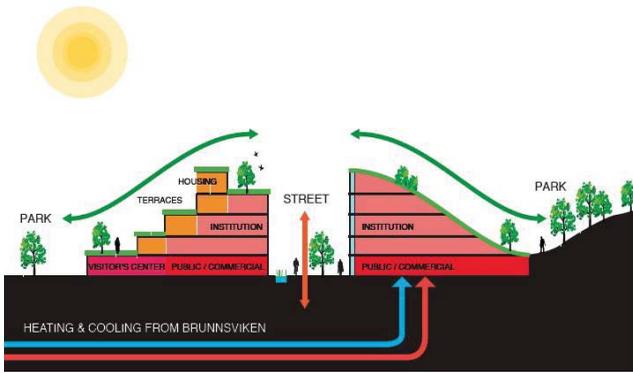
#### 4.22 Ecological Connectivity

The campus provides a diversity of habitat type and scale, which compliments and extends contextual ecological systems. This critical map also demonstrates the importance of the site as a nexus of ecological patches, bridging transportation infrastructure and transitioning from a dense urban environment to the peri-urban context.

#### 4.23 Feedback Loops

One goal of the masterplan is to tighten feedback loops in relation to water and solid waste. By localizing these resources, Albano becomes more independent from local sources and resilient to shocks at that scale.





#### 4.24 Performative Building Section

The building sections promote ecological connectivity along the sides of the structures, concentrating social and human use at the central core. Geothermal heating and cooling moderate temperature and adapt to small-scale climate changes.

systems is what creates a unique and single entity. Two important components that are left out of this masterplan are critical thresholds and time. There are suggested strategies for promoting resilience to unspecified thresholds at the metro and site scale, but it is important to identify what the masterplan is designed to be resilient to and at what scale. The second missing component is time. There is no mention of how long this plan is aimed to be resilient for, or how it may change over time. Despite a comprehensive and thorough documentation of a plan for a resilient socio-ecological community, the absence of these thresholds and scales is critical.

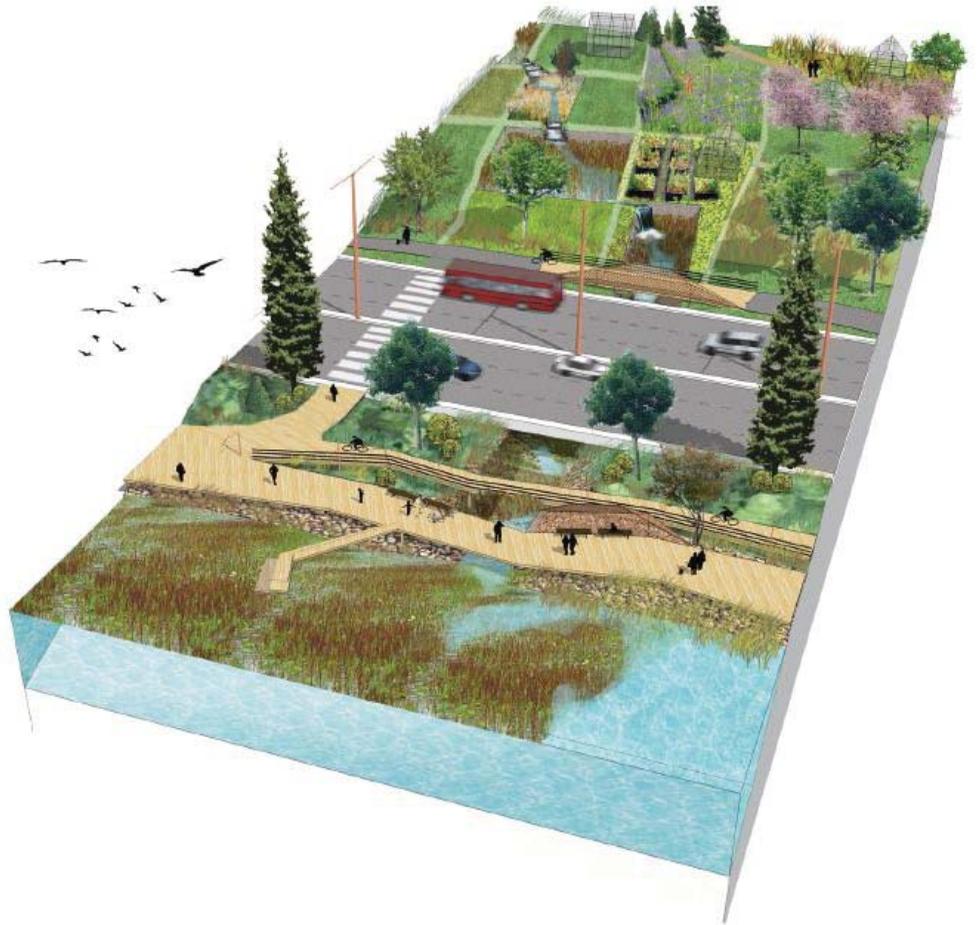


#### 4.25 Active Ground

The active grounds combine social and ecological performance. They are governed by local institutions, both formal and informal, that influence resilience through adaptive decision making.

## 4.26 Infrastructure Crossing

Infrastructure is seen as an opportunity to increase diversity. Wetland habitat at strategic crossing points allows a variety of species to safely cross the busy highway. A boardwalk connects human interaction with ecological processes, increasing social adaptivity and memory.

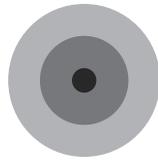


## 4.27 Corridor

The campus facilitates a strong academic environment but also attracts a diversity of visitors. The campus adjacent to this highway corridor blends in with the ecological habitats.



REGIONAL



METRO



SITE



SPATIAL  
SCALE

|                   |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |
|-------------------|------------|-----|------|------|-------|--------|
| THRESHOLDS        | SOCIAL     |     |      | 1    |       | 2      |
|                   | ECOLOGICAL |     |      | 3    |       | 4      |
|                   | ECONOMIC   |     |      | 5    |       |        |
| DIVERSITY         | SOCIAL     | 6   |      | 7    |       | 8      |
|                   | ECOLOGICAL | 9   |      | 10   |       | 11     |
|                   | ECONOMIC   |     |      | 12   |       | 13     |
|                   | SPATIAL    | 14  |      | 15   |       | 16     |
| REDUNDANCY        | SOCIAL     | 17  |      |      |       | 18     |
|                   | ECOLOGICAL | 19  |      | 20   |       | 21     |
|                   | ECONOMIC   |     |      | 22   |       |        |
|                   | SPATIAL    |     |      | 23   |       | 24     |
| CONNECTIVITY      | SOCIAL     | 25  |      | 26   |       | 27     |
|                   | ECOLOGICAL | 28  |      | 29   |       | 30     |
|                   | ECONOMIC   |     |      | 31   |       |        |
| PLANNING          | ECOLOGICAL |     |      | 32   |       | 33     |
|                   | ECONOMIC   |     |      |      |       | 34     |
| TEMPORAL<br>SCALE |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |

\* note that time scales were not present in this case study

## EXTRACTED METHODS

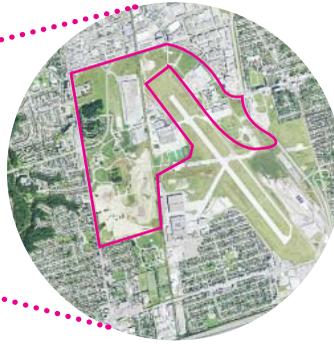
- 1 • Presence of academic institution provides stability and a constant flux of knowledge
- 2 • Performative buildings integrate socio-ecological memory and adaptivity into everyday life
- 3 • Local food sources provide adaptivity to shocks in the food system
- 4 • Biogas and fertilizer production minimizes local energy use in relation to dependence on fossil fuels
- 4 • Performative buildings provide adaptivity to changes in temperature and climate
- 5 • Stormwater is collected and treated on site in response to water thresholds
- 6 • Biogas and fertilizer production enhances local economy
- 6 • Create a unique regional and international identity
- 6 • Establish the campus as a contributing and diverse component to the regional academic network
- 7 • Create a campus that is both academically focused and a metropolitan destination for Stockholm- diversifying use to recreation, the exchange of knowledge, and natural and cultural experiences
- 8 • Cultural experiences in close proximity
- 8 • Activities- focused around a diverse user group that extends beyond academia
- 8 • Diversity of users
- 8 • Performative borders diversify the human experience
- 8 • Performative buildings create a diversity of use and social program
- 9 • Connectivity to adjacent urban park creates opportunities for greater biodiversity
- 10 • Facilitates the flow of species between two major ecosystem patches
- 11 • Performative buildings promote species diversity
- 11 • Creating small scale habitat for mushrooms, micro-organisms, butterflies, and insects
- 11 • A network of performative buildings creates diverse habitat patches
- 11 • Diversity of habitats in the active ground
- 12 • Small commercial spaces compliment adjacent land uses
- 13 • Harvest markets provide small scale income
- 14 • Regional nexus of multiple systems- hydrologic, ecological, social
- 15 • Multiple transportation corridors facilitate a variety of modes
- 16 • Diversity in scale of active ground and green arteries
- 16 • Performative borders diversify and facilitate ecological processes and connectivity
- 16 • Diversity in scale of performative buildings
- 17 • A contributing and unique component of the regional educational institution network
- 18 • Buildings create opportunities across campus for a diversity of users
- 18 • Multiple active ground areas reduces stratification in management

## EXTRACTED METHODS (CONT'D)

- 19 • Creates a large public open space within an urban environment that has other similar areas
- 20 • A network of performative buildings creates diverse habitat patches
- 21 • Canal opens connectivity to adjacent waterfront
- Multiple connectivity points under major transportation infrastructure
- 22 • Multiple local food sources
- 23 • Multiple transportation corridors facilitating a variety of modes
- Multiple entry points into the campus
- 24 • Multi-functional landscapes, i.e. active ground acts as food production as well as institutional meeting and even areas
- 25 • Create a regional destination both academically and for a diversity of users
- 26 • Green arteries provide multi-modal transportation
- Create key connections to other academic institutions
- Connect to existing street system, but not become overly connected
- 27 • Green artery intersections act as catalysts for complex interactions between systems
- 28 • Key connection to the National Urban Park, bridging two halves across a highway
- Wetland network provides critical habitat connections for endangered amphibian species
- 29 • Green arteries species movement with a diversity of habitat types
- 30 • Green artery intersections act as catalysts for complex interactions between systems
- Biogas and fertilizer production minimizes local energy use
- Multiple connectivity points under major transportation infrastructure
- Linear connectivity along existing rail lines facilitates species flow
- "Ecoducts" allow for smaller species, i.e. butterflies and insects to connect between meadow ecosystems
- 31 • Connecting to and complimenting adjacent land uses
- 32 • Exchange of knowledge through pedagogical activities, field studies, and experiments promotes socio-ecological adaptivity
- Wetland network absorbs stormwater events
- 33 • Property rights are defined by habitat type within the Albano campus, making ecological management an embedded part of institutional entities
- Strong social networks arranged around institutional meeting facilitates the transfer of knowledge and information, creating well-informed decision processes that effectively manage the ecological systems at Albano
- Test bed gardens with public access increase knowledge base and social connectivity with ecological systems
- 34 • Active ground is managed by a diverse user group in order to increase resilience
- Strong social networks arranged around institutional meeting facilitates the transfer of knowledge and information, creating well-informed decision processes that effectively manage the economic systems at Albano



# DOWNSVIEW COMPETITION / EMERGENT ECOLOGIES

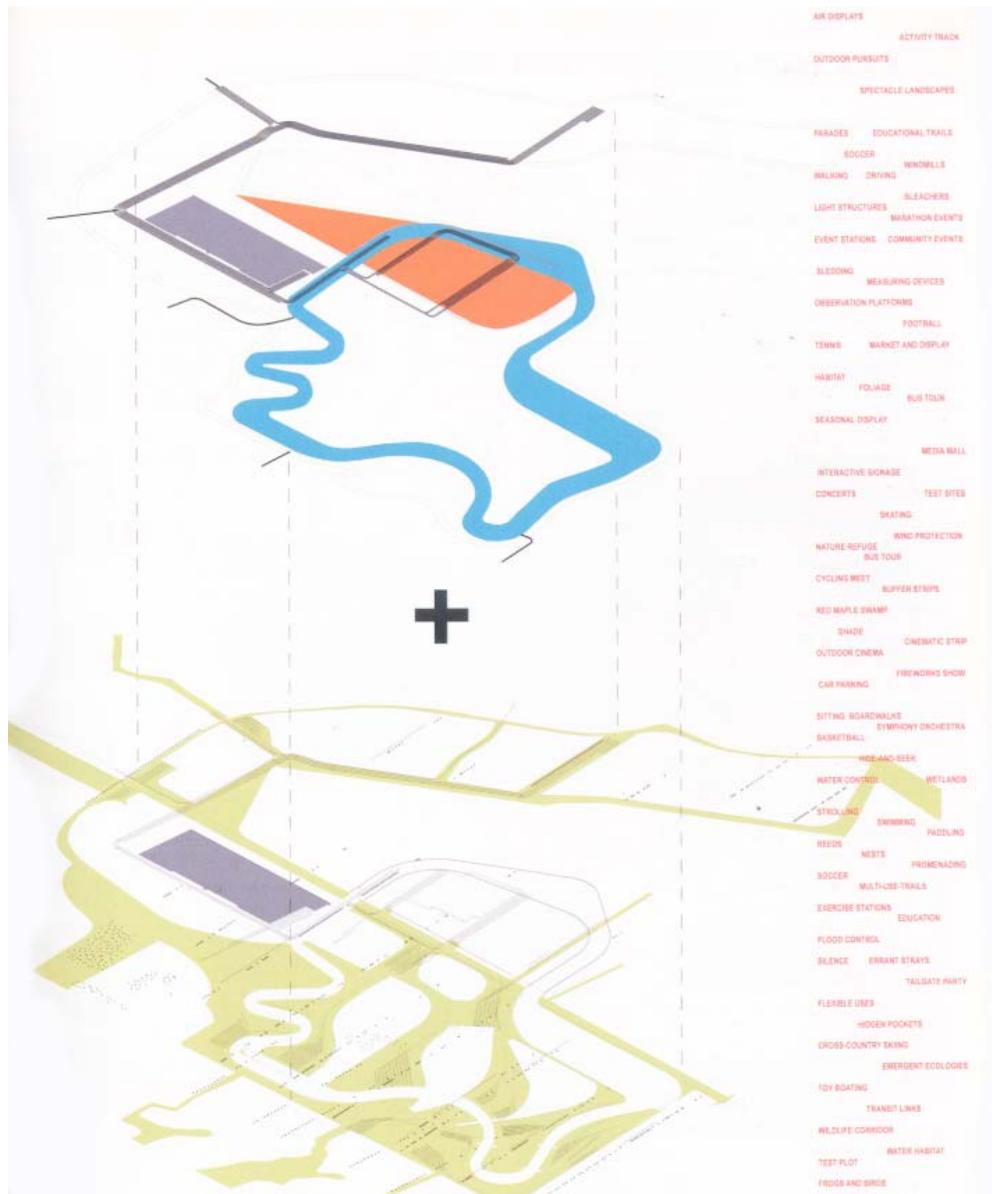


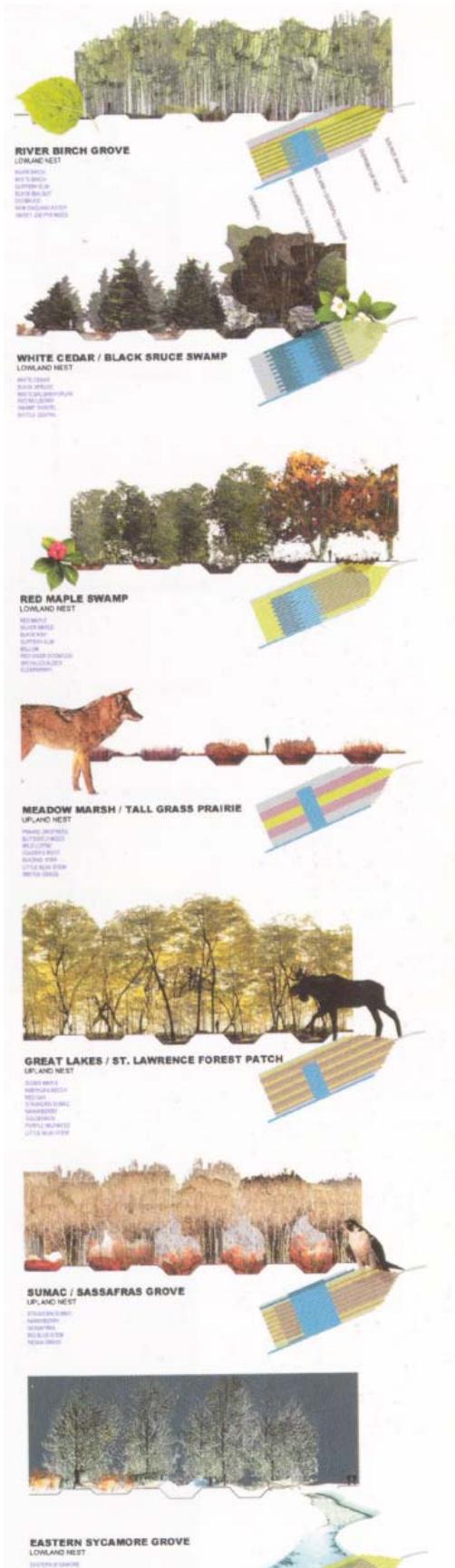
## 4.29 Location

The competition, taking place in 1999, is a 320 acre park located in Downsview, Canada near Toronto. The site is adjacent to an airfield and is in a dense urban environment.

## 4.30 Circuits + Flows

Corner and Allan develop two spatial frameworks or "lifelines" that guide the park over time: circuits (socio-programmatic) and flows (ecological matrix). These frameworks facilitate an adaptive response to change over time and promote emergent properties from self-organizing social and ecological processes. One component that is missing is how these frameworks connect to the context both locally and regionally. It is clear that the proposed series of ridges and furrows that guide and accommodate stormwater are based upon existing conditions and connectivity, but how they do is not explicit. Flash-flooding is the only critical threshold that is mentioned as one that the park responds to- why the park adapts socially and ecologically over time is not clear. In terms of this adaptivity, economic disturbance is not considered but it is one that has the potential to dramatically change the park into an undesirable stable state.



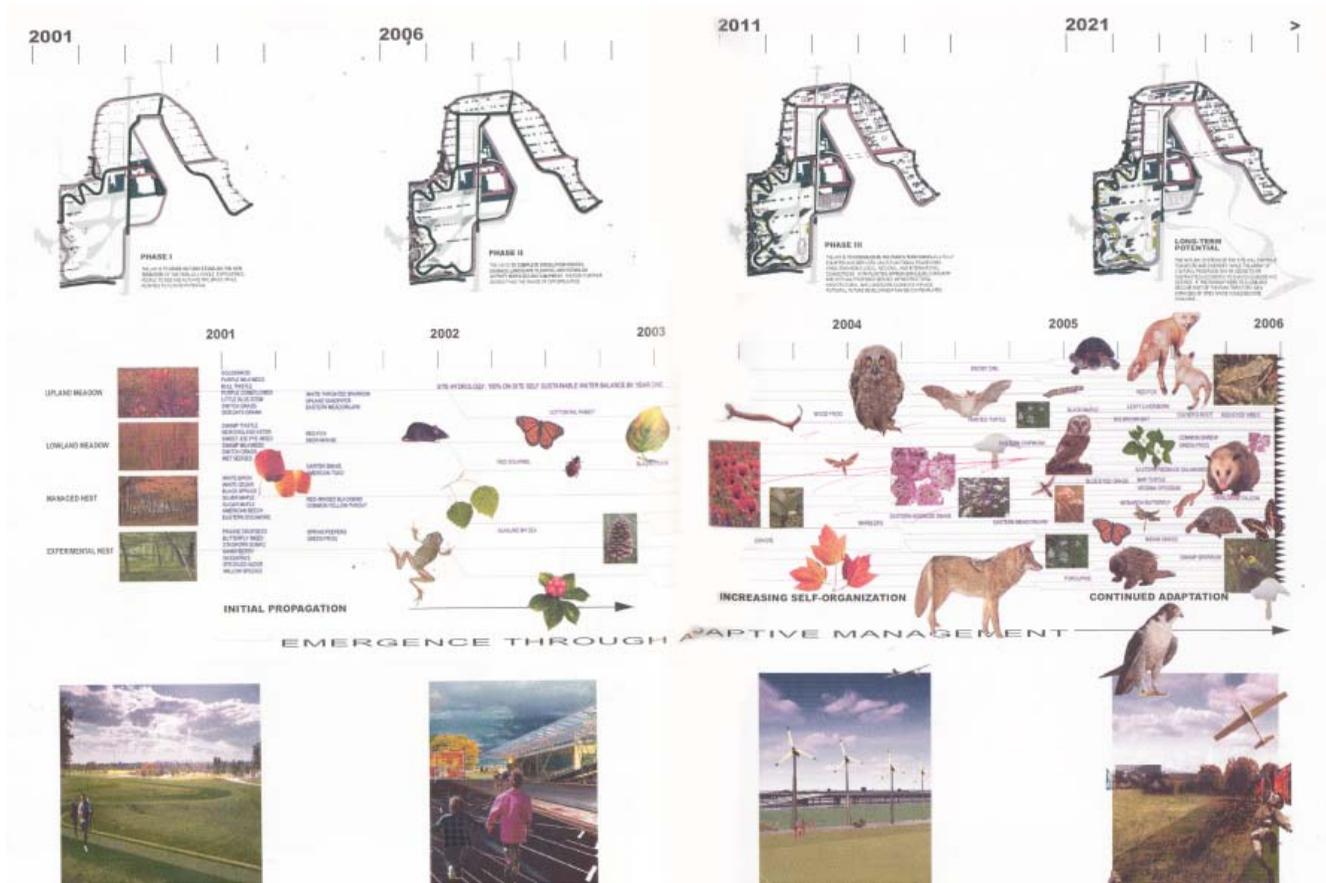


“Emergent Ecologies” is primarily a site-focused proposal with an approach that embraces concepts of open-endedness, adaptivity, emergence, and an integrated socio-ecological relationship. James Corner and Stan Allen present two spatial frameworks, one that is social and the other ecological. The social component is mostly related to the programmatic evolution of this urban park in response to actors of change, but what these components may be adaptable to in terms of thresholds is not specified. Ecological connectivity is described as “flows” and the Downsview Park proposal links two major ecosystem patches on the east and west side of the site. These flows are set up to adapt to flash flooding through a series of furrows and ridges that are made up of several different habitat types. Diversity and redundancy of this ecological matrix are critical in promoting resilience at the site scale. This is mirrored in terms of social program within the park, and in both cases the intent is to set up a framework that will allow for self-organizing processes to exhibit emergent behavior and dictate the development of programs and habitats.

Change through time is addressed, with an emphasis on an increase in biodiversity in a twenty year timeframe. Adaptive management strategies facilitate this change,

### 4.31 Habitat Nests

The proposed habitat nests are arranged around ridges and furrows that collect and guide stormwater. The habitat types are diverse and accommodate ecological adaptivity, emergence, and greater species diversity over time. They establish a connection with the social programs within the park and present opportunities for further social memory development.



#### 4.32 Adaptive Management

By using strategic phasing and adaptive management practices, the design allows for self-organization and emergence, both socially and ecologically. Multiple time scales are addressed, with biodiversity increasing within five years and a twenty year phasing strategy.

with the role of the designer to be merely a guide for the flows of energy, matter, life, information, and activity within the park. Other more vague strategies are suggested including ecological test sites, performance measurement devices, interactive landscapes, and educational trails that would work towards increasing social memory and adaptivity in relation to ecological processes. These strategies are not explicit in how they will manifest themselves in the design, and are one of the limitations of this proposal because of their non-specificity.

Some of the shortcomings in this proposal include a lack of regional and metropolitan scale methods, limited reference to social strategies beyond the park program, and no economic methods. The latter is critical when addressing socio-ecological systems because economy is a major part of society, but it is a product of the competition brief—as an open ideas competition it was not necessary to address economic feasibility or strategies. Corner and Allen do present a unique proposal that adopts an ecologically based vocabulary with many overlapping concepts of resilience theory. It demonstrates how landscape urbanists are primed to use resilience theory as an addendum to their current approach at a range of scales and project types.

### 4.33 Social Program

The program within the open space is indeterminate and will be the product of emergent properties. The images shown suggest a diversity of social use, scale, and habitat.

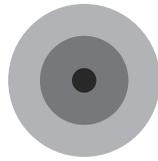


REGIONAL

METRO

SITE

SPATIAL  
SCALE

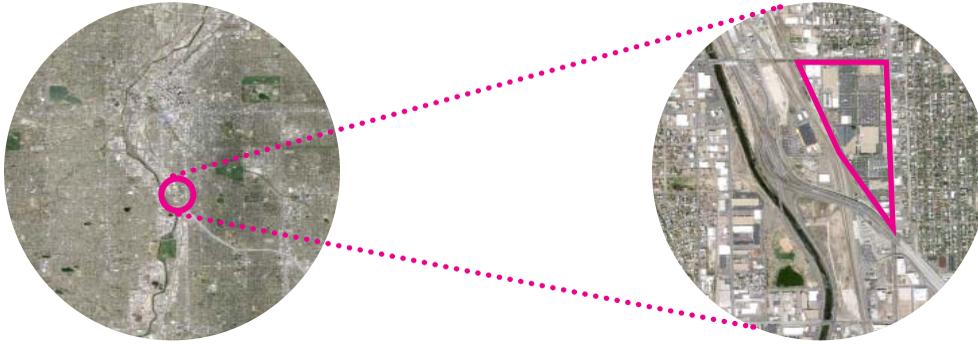


|                |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |
|----------------|------------|-----|------|------|-------|--------|
| THRESHOLDS     | SOCIAL     |     |      |      | 1     |        |
|                | ECOLOGICAL |     |      |      | 2     |        |
|                | ECONOMIC   |     |      |      |       |        |
| DIVERSITY      | SOCIAL     |     |      |      | 3     |        |
|                | ECOLOGICAL |     |      |      | 4     |        |
|                | ECONOMIC   |     |      |      |       |        |
|                | SPATIAL    |     |      | 5    |       | 6      |
| REDUNDANCY     | SOCIAL     |     |      |      | 7     |        |
|                | ECOLOGICAL |     |      | 8    |       | 9      |
|                | ECONOMIC   |     |      |      |       |        |
|                | SPATIAL    | 10  |      |      |       | 11     |
| CONNECTIVITY   | SOCIAL     |     |      | 12   |       | 13     |
|                | ECOLOGICAL | 14  |      | 15   |       | 16     |
|                | ECONOMIC   |     |      |      |       |        |
| PLANNING       | ECOLOGICAL |     |      | 17   |       | 18     |
|                | ECONOMIC   |     |      |      |       |        |
| TEMPORAL SCALE |            |     |      |      |       |        |

## EXTRACTED METHODS

- 1 • Increase social adaptivity thru use of ecological measurement devices
- 2 • Alleviate flash-flooding by replenishing groundwater
- 3 • Diversity of social programs and amenities on site
- 4 • Guiding emergence of diverse habitats including wetlands, forest, meadow, prairie, and riparian
  - Diverse habitats promote species diversity over time
- 5 • Diversifies the metro-context as a new large open space
- 6 • Variety of spaces created in terms of size and character, based on habitat
- 7 type
  - Multiple social programs within different locations on site
- 8 • “Drift fields” of lighting, equipment, and information
- 9 • Connectivity to adjacent local patches creates a redundant regional patch type
- 10 • Replication of habitats across the site
- 11 • Multiple flood-absorbing furrows
  - Large open space typology is redundant at the regional scale
- 12 • Multi-use trail system
- 13 • Multiple event type spaces accommodate a range of uses
  - Loose connections made via local, site-scale connections
- 14 • Multi-use trail system
  - Local residential access established
- 15 • Connectivity to regional natural systems established by phase III (year 10) through use of corridors
- 16 • Connectivity to local ravine and woodland systems established by phase III
- 17 (year 10) through use of corridors
  - Corridors enhance wildlife species to move through the landscape on site
- 18 • Allows for ecological adaptivity by establishing connections to two adjacent corridors
  - Ecological performance measurement devices, test sites
  - Develop a series of ridges and furrows to accommodate flash flooding, let the landscape respond to disturbance

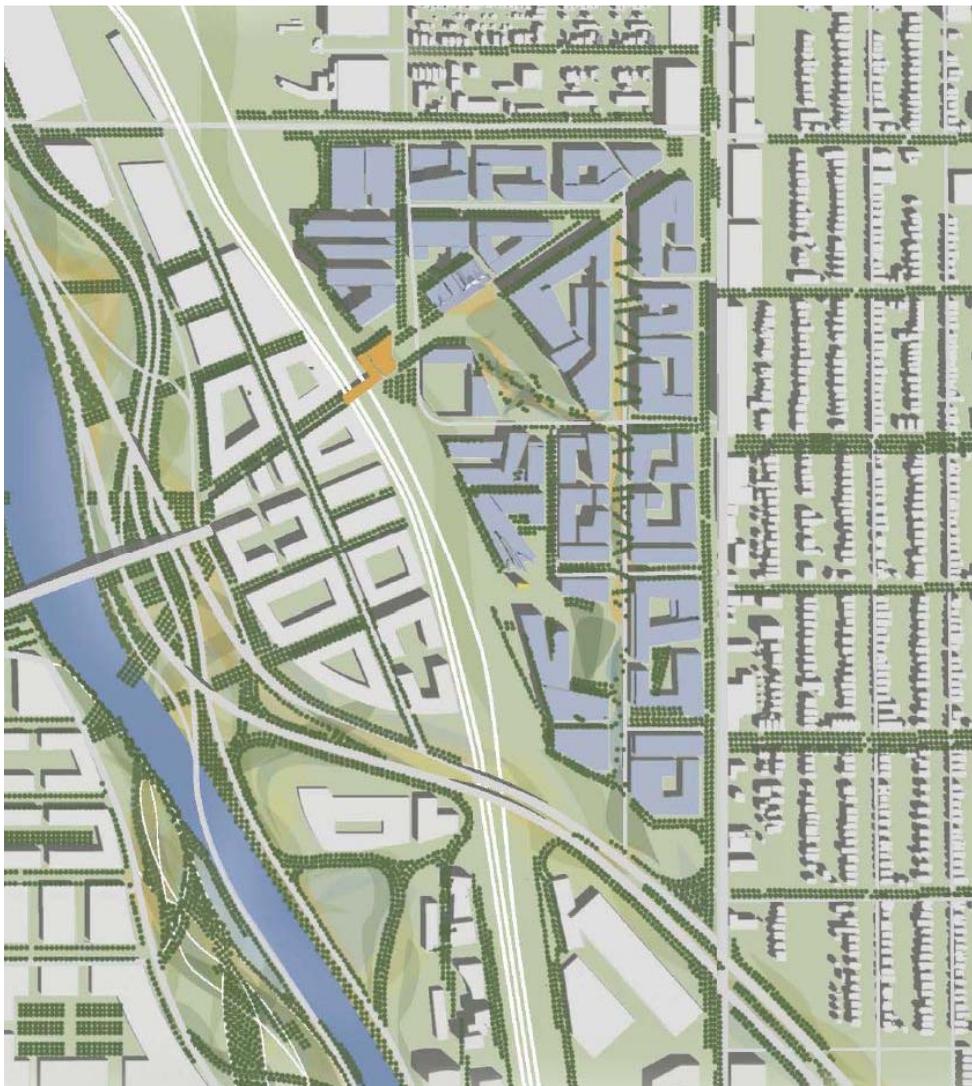
# ULI/HINES COMPETITION 2009 / TOUCH



## 4.35

### Location

The competition site is located in Denver, CO south of the central business district. It is the location of the Denver Design District and several big box stores.



## 4.36

### Masterplan

The masterplan builds off of the existing Broadway Blvd. economic spine to the east and engages the public transit station on the west edge. A diversity of building and open space types create a unique sense of place and promote social adaptivity by bridging adjacent neighborhoods.

Touch is a project that is rooted in creating a development that is adaptable to the future. There is an emphasis on regional and local connectivity, establishing a diverse sense of place, and creating a unique identity within the Denver metro context. The strategies that overlap with what resilience theory suggests are evenly distributed, with the exception of adaptive planning/management which is not present. Institutional management is not a goal of the competition, which explains why this component is missing from the submission. This is a site-focused competition, but the submission still relates how the site fits within the regional and metro context which is essential when thinking of resilience.

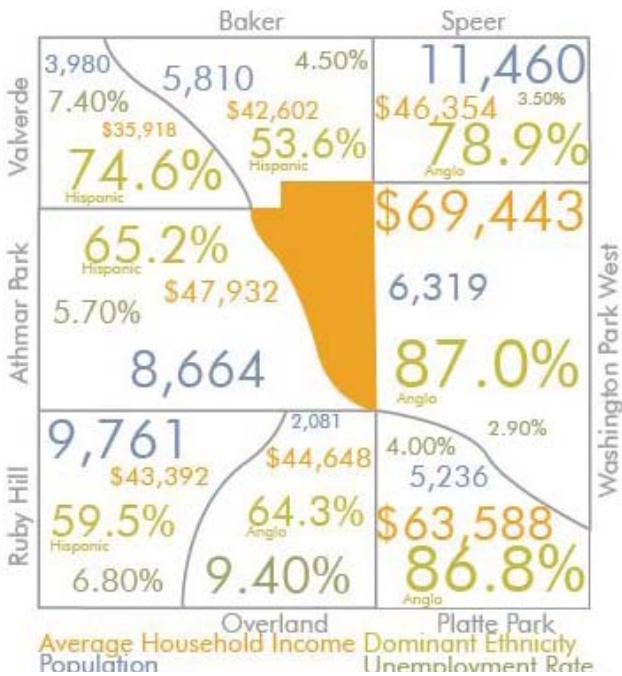
Connectivity is a central theme to the design of Touch. A regional transit system provides large scale connectivity, while the street network establishes pedestrian and vehicular modes in a hierarchical fashion. These systems connect to a series of diverse open spaces in terms of size, type, and character. Regionally, a biotech medical facility on site provides a stable economic entity along with the existing Denver Design District. This allows for uses in adjacent buildings to remain flexible, especially in terms of how big box retail will fluctuate over time. Adaptable architecture typologies allow for new building skins and technology to be implemented in the future, increasing economic and spatial resilience. The use of alternative energy sources, mainly passive solar, also decrease reliance of the buildings on dwindling non-renewable energy.

Touch also promotes diversity through the proposal at a range of scales. This in turn creates redundancies, and inherently the resilience of the development. It is not explicit as to how the economic feasibility component of the proposal relates to the other strategies of adaptivity, other than getting them built. There is a diversity of funding sources identified in order to generate the necessary funds to offset development costs. Construction distribution is evenly divided which also suggests diversity. Most of the economic strategies identified here are based on connectivity to adjacent economic nodes and cost savings from bundling infrastructure and creating adaptive structures.

#### 4.37 Metro Connections

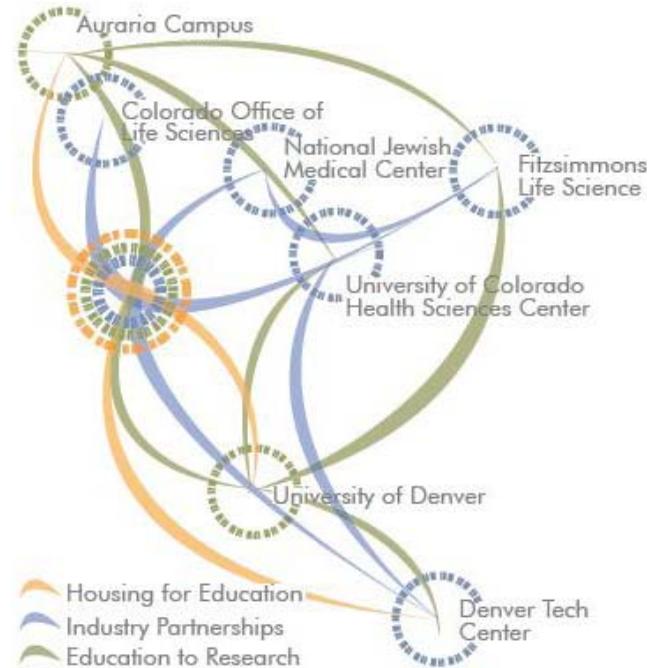
A hierarchy of connections is created to situate the site into the context. Multiple modes are considered including pedestrian, ecological, and vehicular.





### 4.38 Socio-Economic Bridge

The site is viewed as an opportunity to be a socio-economic bridge between adjacent neighborhoods that exhibit a diversity of demographics and income.



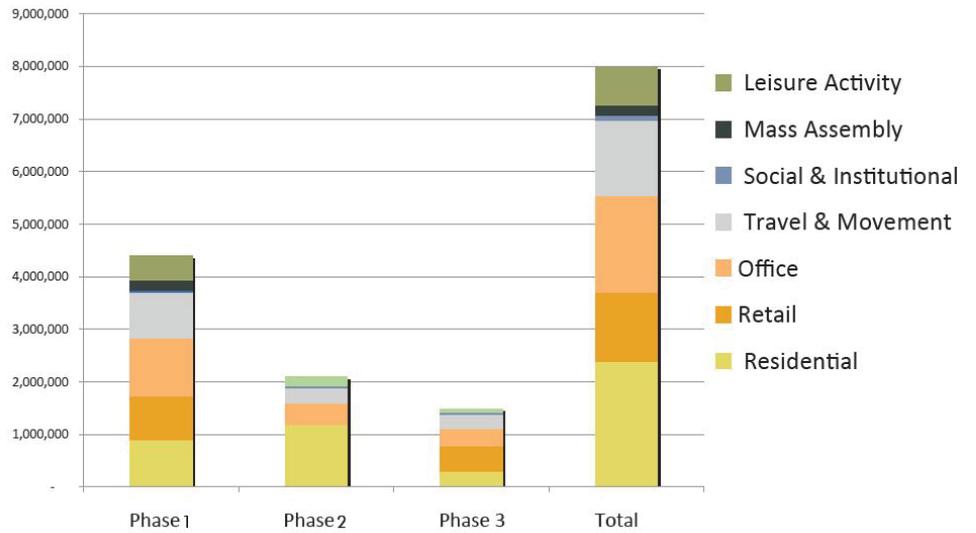
### 4.39 Regional Connections

The medical technology industry is proposed as a stable economic anchor for the development that connects to other entities in the region. This establishes the socio-economic importance of the development.

Ultimately Touch proposes strategies at the regional, metro, and site scales. In response to future economic shocks, the design focuses on the medical technology field to create a stable entity on site. Social adaptivity and memory is promoted by engaging the diverse adjacent neighborhoods and allowing the site to function as a catalyst for social interaction. Ecologically, Touch proposes multiple energy sources and promotes connectivity to metro and regional systems that increase habitat diversity. What is lacking in this connectivity is how ecological flows traverse across the adjacent rail line to the Platte River. Despite this absence of this strategy, the proposal uses a holistic approach to design that compliments many of the tenets of resilience theory.

#### 4.40 Development Program

Overall, the plan promotes a diversity of programs with an emphasis on residential and office space. An aggressive open space plan promotes social and ecological connectivity.



#### 4.41 Social Memory

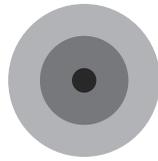
A strong sense of place that engages diverse social demographics creates a socially resilient community. The combination of arts and sciences in the development brings together people from different backgrounds and ways of living.



REGIONAL

METRO

SITE



SPATIAL  
SCALE

|              |            |    |    |    |
|--------------|------------|----|----|----|
| THRESHOLDS   | SOCIAL     |    |    | 1  |
|              | ECOLOGICAL |    |    | 2  |
|              | ECONOMIC   | 3  |    | 4  |
| DIVERSITY    | SOCIAL     | 5  | 6  | 7  |
|              | ECOLOGICAL |    | 8  | 9  |
|              | ECONOMIC   | 10 |    | 11 |
|              | SPATIAL    |    | 12 | 13 |
| REDUNDANCY   | SOCIAL     |    |    | 14 |
|              | ECOLOGICAL |    |    | 15 |
|              | ECONOMIC   | 16 |    | 17 |
|              | SPATIAL    |    | 18 | 19 |
| CONNECTIVITY | SOCIAL     |    | 20 | 21 |
|              | ECOLOGICAL |    | 22 | 23 |
|              | ECONOMIC   |    | 24 |    |
| PLANNING     | ECOLOGICAL |    |    |    |
|              | ECONOMIC   |    |    |    |

TEMPORAL  
SCALE

5 Y

10 Y

50 Y

100 Y

150+ Y

## EXTRACTED METHODS

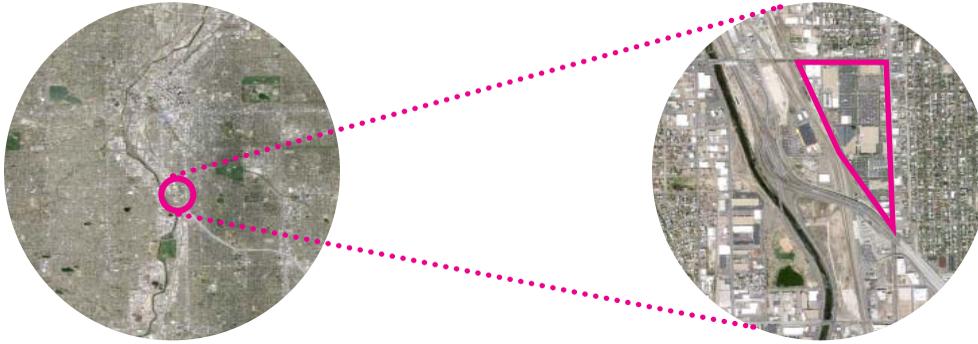
- 1 • Emphasis on a combination of art and technology increases social memory and adaptivity
- 2 • Brown roofs reduce the heat island effect and increase resilience to long-term climate change
- Geothermal heating/cooling increases resilience to long-term climate change- creates stability by linking to larger scale processes of the earth's temperature
- 3 • Establish multiple economic connections and partnerships with an emphasis on Denver's medical technology industry- stabilizes the development in a slow, large-scale economic process
- 4 • Flexible building typologies allow for seamless retrofit for new technologies- increases economic adaptivity and feasibility in the future
- 5 • The development serves as a node of intensification within the Denver Region, attracting greater social diversity
- 6 • Partnerships with medical technology increases social groups in the development
- 7 • Diverse open space creates a variety of human experience
- Diverse housing options promote a diverse collection of social groups in the development
- 8 • Expand habitat corridors to accommodate the flow of key species (unspecified)
- 9 • Expand habitat corridors to accommodate the flow of key species (unspecified)
- Brown roofs increase biodiversity through the use of recycled substrate materials that self-organize into habitats
- Bioswale network promotes biodiversity through habitat connections
- 10 • Continued artistic culture growth in the Design District is a unique component to the greater Denver Region
- 11 • Diverse land use including mixed-use residential, big box, small retail/ office, and institutional increases the resilience of the development to economic shocks and disturbances
- Multiple big box companies
- 12 • Multi-modal transportation corridors into the development- rail, car, bike, pedestrian
- 13 • Diversity of use within buildings
- 14 • Multiple housing options, shopping destinations, open-space program
- 15 • Multiple energy sources- geothermal, solar, passive solar, electric grid
- 16 • Establish multiple economic connections and partnerships with an emphasis on Denver's medical technology industry
- 17 • Bundled street infrastructure decreases economic maintenance cost by creating redundancies in access points
- Multiple institutional influences- Denver Design District and Medical Tech Center
- Multiple funding sources- TIF, LIHTC, Denver Design District, and construction loans

## EXTRACTED METHODS (CONT'D)

- 18 • Multiple access points through multi-modal transportation corridors into the development- rail, car, bike, pedestrian
- 19 • Bundled street infrastructure increases ease of access for maintenance and creates redundancy in spatial use
- 20 • Situate the development in the open space network of Metro Denver to create critical social connections onto the site
- Development acts as a social bridge between diverse neighborhoods representing a diversity of demographics
- 21 • Open space acts as a social network across the development, connecting people to businesses, institutions, and residences
- 22 • Establish multiple ecological connections in terms of hydrologic systems filtering before they enter the Platte River and creating habitat corridors for key species
- 23 • Bioswales and open space link habitat across the site
- 24 • Establish multiple economic connections and partnerships with an emphasis on Denver's medical technology industry
- Create an economic connection between adjacent neighborhoods with varying income levels and commercial uses



# ULI/HINES COMPETITION 2009 / PANORAMA STATION



## 4.43 Location

The competition site is located in Denver, CO south of the central business district. It is the location of the Denver Design District and several big box stores.



## 4.44 Masterplan

The masterplan emphasizes the Broadway Blvd corridor and builds off the density in the context. The urban form was organized around creating viewsheds to various mountain vistas.

Panorama Station revolves around five main goals: view-oriented public space, creating a car-free lifestyle, integrating water conserving landscapes and infrastructure, adaptive reuse of big box retail, and creating a sense of place. What is unique in this proposal is the acknowledgement of a critical threshold in a shift away from big box retail. In response to this threshold, the project proposes a flexible building structure typology that transitions into multiple scenarios for these retail stores. Another critical threshold is water use and Panorama Station proposes water conserving landscape practices and alternative infrastructure. What is unclear about this strategy is how they intend to collect and reuse rainwater when that is currently a prohibited practice in the state of Colorado.

#### 4.45 Goals

The goals seen below are what drove the proposal. Economics is not considered as one of these five guidelines, but is imbedded in the submission.



##### Provide View-Oriented Public Space

Maximize visibility of the mountain landscape to the West of the site.



##### Support a 15 Minute Car-Free Lifestyle

Enable residents to access all amenities and services within a fifteen-minute travel time.



##### Integrate Water Conserving Landscapes and Infrastructure

Utilize "Sage Green" native plants and introduce rainwater retention infrastructure.



##### Anticipate Flexible Future Uses for Big Box Spaces

Improve streetscapes by internalizing big boxes and parking, allowing for future repurposing.



##### Create a Sense of Place

Establish a vital urban center that serves surrounding neighborhoods.

Connectivity is a limited theme in this proposal. Beyond connecting to the existing street grid, Panorama Station does not look at connecting ecological systems or create a diversity of spatial type. The regional context and its connectivity are also limited, although the proposal does address how the site connects to regional transportation networks. Understanding how this connectivity may influence social and biological diversity is absent. In fact, natural systems are hardly addressed at all except for tightening feedback loops on the water cycle. Generally this proposal does not take a holistic approach to the development, which is of interest because they ultimately won the competition.

Some other proposed strategies do overlap with resilience, however. The orientation of public space towards critical viewsheds of the mountain context does promote social memory, but these views are also not lacking throughout the Denver metro area. One of the goals is to create a sense of place, but it is not apparent as to how this development responds to the regional or metro context. In the analysis of the neighborhood context, the proposal looks to become part of the historic Baker neighborhood but the context shows that the site is a doughnut hole surrounded by very different and diverse communities. If Panorama Station seeks to leverage the historical qualities of the Baker neighborhood to promote social memory, then it does not manifest itself in the quality and character of the architecture or sense of place.



#### 4.46

### Connectivity

(left)

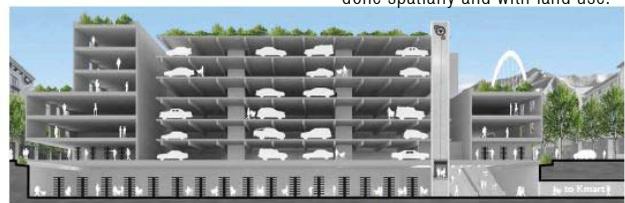
Open space connectivity is limited to pass-by spaces and does not emphasize how ecological systems connect to promote strategies like biodiversity. Transportation connectivity focuses on multiple modes in anticipation of a shift in vehicular use.

#### 4.47

### Big Box Adaptivity

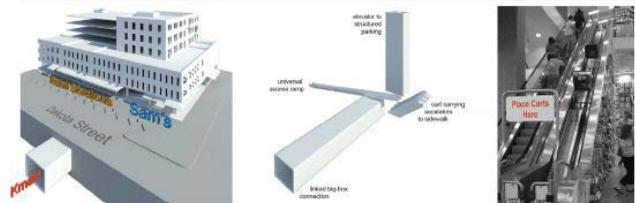
(below)

The proposal is designed to adapt to an economic threshold that shifts big box retail away from being a major economic driver. This is done spatially and with land use.



### Big Box Retail

Accessible via a prominent street-level lobby, as well as from the parking structure at the center of the block, and through a below-grade pedestrian street crossing to additional retail, the space functions as a conventional big box retail building. The space receives indirect sunlight through lightshafts and lightwells, and the roof of the structure is vegetated as part of the Panorama Station's rainwater conservation system. Same-day home delivery service is offered to customers to help reduce automobile dependency.



### Distribution

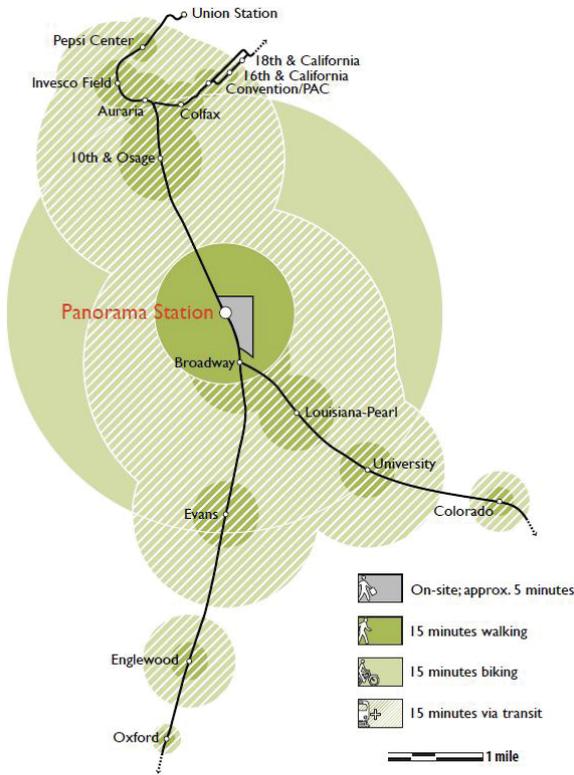
As new retail business models emerge, the below-grade space is converted to a distribution facility for goods ordered online. Deliveries are made using a fleet of electrically-assisted, human-powered cargo bikes. The loading docks continue to function conventionally, but as the demand for private automobile parking has dropped dramatically, the parking structure may be disassembled and re-used elsewhere. The roof surface becomes a vegetated courtyard, for use by residents of the buildings at the block's perimeter.



### Production + Community Use

An advantage of reusing big box space is its ability to be subdivided and reconfigured to suit new uses. The proposal for Panorama Station anticipates long-term reuse of former big box spaces for a variety of new functions, including:

1. Hydroponic Greenhouse + Grocery Store [above]
2. Fitness Center + Clinic
3. Natatorium + Spa



#### 4.49 Metro Connectivity (left)

Connectivity via public transit allows for a variety of destinations based upon mode of transportation.

#### 4.50 Water Cycle (above)

One strategy to accommodate decreasing water supply is tightening the water cycle loop. This is mainly achieved through holding stormwater on site for adaptive reuse.

#### 4.48 Social Memory

Social memory and adaptivity are the weakest points of this submission. Although it is a main goal, it is unclear how this development fits within the regional vernacular or promotes social diversity.



4.51  
Analysis Matrix

REGIONAL

METRO

SITE

SPATIAL  
SCALE



|              |            |  |    |    |
|--------------|------------|--|----|----|
| THRESHOLDS   | SOCIAL     |  | 1  | 2  |
|              | ECOLOGICAL |  |    | 3  |
|              | ECONOMIC   |  |    | 4  |
| DIVERSITY    | SOCIAL     |  |    |    |
|              | ECOLOGICAL |  |    |    |
|              | ECONOMIC   |  |    | 5  |
|              | SPATIAL    |  | 6  | 7  |
| REDUNDANCY   | SOCIAL     |  | 8  |    |
|              | ECOLOGICAL |  |    | 9  |
|              | ECONOMIC   |  |    | 10 |
|              | SPATIAL    |  |    | 11 |
| CONNECTIVITY | SOCIAL     |  | 12 |    |
|              | ECOLOGICAL |  | 13 |    |
|              | ECONOMIC   |  |    | 14 |
| PLANNING     | ECOLOGICAL |  |    |    |
|              | ECONOMIC   |  |    |    |

TEMPORAL  
SCALE

5 Y

10 Y

50 Y

100 Y

150+ Y

## EXTRACTED METHODS

- 1 • Alternative transportation modes, primarily bicycle, to respond to a shift after fossil-fuel vehicles are not viable- a car free lifestyle
- 2 • Focus on views to the mountains promotes social adaptivity and memory
- 2 • Establish the development as part of the Baker neighborhood, creating a development that fits existing characteristics and identity
- 3 • Water-conserving landscapes in anticipation of limited future water supply
- 3 • Tighten water cycle feedback loops thru reuse of greywater on site
- 4 • Adaptive building use strategies for the shift in commercial models away from big box retail
- 5 • Diversity in land use with an economic focus
- 5 • Multiple funding sources
- 6 • Create a dense node within the metro context
- 7 • Many types of open spaces, clear hierarchy within the development
- 8 • Creates a retail-focused redundancy with an emphasis on big box stores
- 9 • Multiple alternative energy sources increases resilience to energy shocks and fossil fuel use threshold
- 10 • Multiple water sources including rainwater catchment cisterns
- 10 • Retail redundancies adjacent to current Broadway Blvd. corridor
- 10 • Multiple funding sources
- 11 • Redundancies in building use create adaptive futures for big box locations
- 11 • Redundant open space typologies on site- courtyards, quadrangles
- 12 • Walking, biking, and public transit connections to key nodes
- 13 • Establish connections to adjacent open space network
- 14 • Connect land use to existing Broadway Blvd. core

# ULI HINES COMPETITION 2012 / BAYOU COMMONS



## 4.52 Location

The site is located on the northern periphery of downtown Houston, TX. In the existing condition, a postal service building is the single use. Heavy highway infrastructure borders the site on the north and west.

## 4.53 Masterplan

The masterplan removes the postal building and creates a unique development that works to engage the riverfront, promote social diversity, and create appropriate edges against infrastructure.





#### 4.54

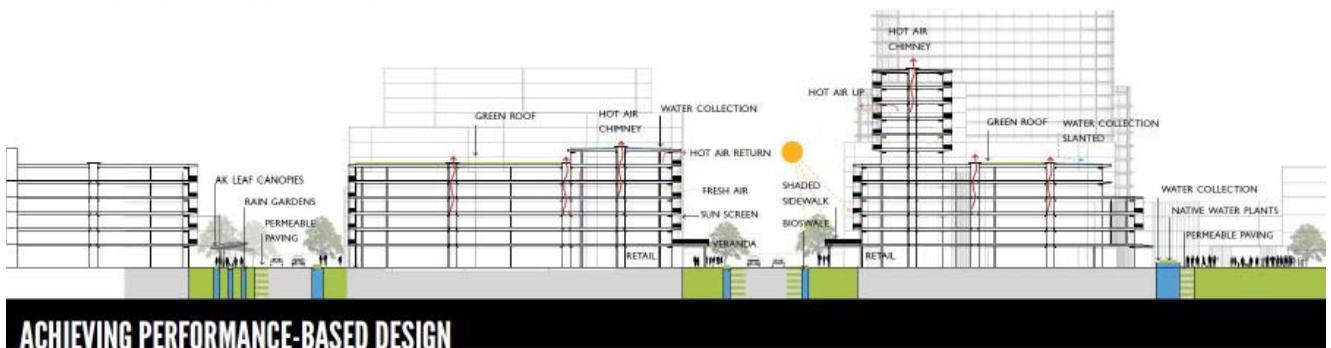
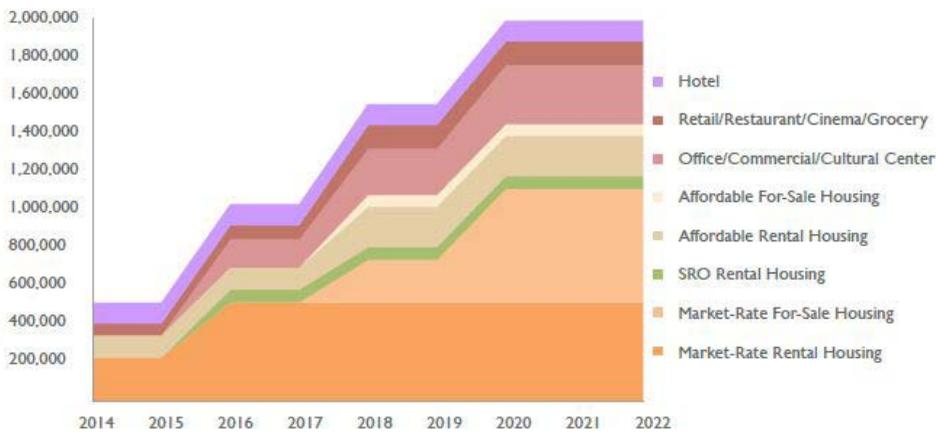
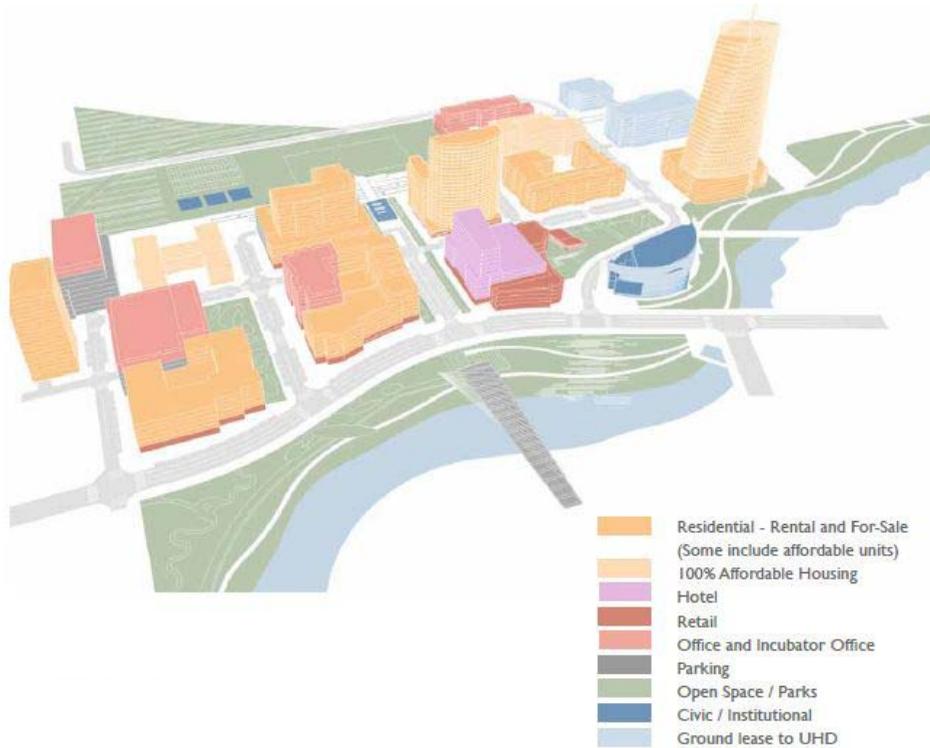
#### Performance

Bayou Commons seeks to measure ecological performance through stormwater collection, bayou frontage, and carbon sequestration through tree canopy cover. These strategies promote ecological resilience and also combine social and ecological benefits.

Bayou Commons is a very site-oriented proposal that employs many strategies that overlap with resilience theory at this scale. At the heart of the project is a holistic approach that focuses on nature, community, new economy, and creativity. Socio-economic diversity is paramount in Bayou Commons as well as promoting connectivity with the adjacent waterfront. There is, however, limited reference in analysis of the regional scale and how the development fits into this context. Metro connections and adjacencies are established, primarily through a public transit train station and an iconic pedestrian bridge. The bridge acts as the symbol of identity for the development and along with the unique character of the site, it promotes social memory and adaptivity.

There is a diversity of economic land use, target resident demographics, open space, and building type. This diversity inherently creates redundancies that are central to the phasing sequence. The proposal is a testament to the theory that small-scale resilience influences resilience at larger scales. Some of the site-specific strategies including performative buildings that tighten water and energy feedback loops, economic diversity, and strong social identity create resilience to shocks that operate at larger spatial and temporal scales. Areas specific to the fostering of innovation and entrepreneurship promote resilience by tightening the adaptive cycle and emphasizing the rapid growth phase after shocks occur.

A network of performative buildings couples social and ecological goals while tightening feedback loops. Diversity in building use within the structures themselves also increases resilience. A key point that this project identifies is that there are viable spatial strategies for increasing economic resilience- with diversity in building use within the structures being one of them. Again, a lacking component to both economic and ecological resilience is the inclusion of adaptive planning and management strategies. While it is not the focus of the competition, they could be important parts to a better design. Overall, Bayou Commons employs a holistic approach to the development that overlaps many strategies for resilience at the site scale, but generally lacks regional analysis and strategies.



|   |  |   |  |  |   |  |   |   |  |   |
|---|--|---|--|--|---|--|---|---|--|---|
| <p><b>RESIDENTS</b></p> <ul style="list-style-type: none"> <li>-Young professionals</li> <li>-Empty nesters</li> <li>-Retirees</li> <li>-Reverse commuters</li> <li>-Some families with small children</li> </ul>   | <p><b>TARGET BUSINESS</b></p> <ul style="list-style-type: none"> <li>-Small Startups</li> <li>-Government-funded and research-based</li> <li>-Alternative energy</li> <li>-Unique retail and restaurants</li> </ul>                        | <p><b>GUESTS</b></p> <ul style="list-style-type: none"> <li>-Individual business travellers</li> <li>-Leisure travellers</li> <li>-Performing arts interest</li> </ul>  |  |  |   |  |   |   |  |   |
|  <p><b>John and Nancy</b><br/>Late 50s<br/>-Linda's career<br/>-Jane retired teacher and interior designer<br/>-Rogge attorney in Parkway Area<br/>-Lovers of urban architecture</p> |  <p><b>Jennifer</b><br/>33 years old<br/>-Lives in Market Apartments<br/>-Architect - works downtown<br/>-Pet dog Brady<br/>-Loves urban architecture</p> |  <p><b>Avish</b><br/>32 years old<br/>-Lives in Market Apartments<br/>-Engineer at alternative energy<br/>-Moved from India<br/>-Wants to work</p> |  <p><b>Shawn</b><br/>41 years old<br/>-New Hope Housing Resident<br/>-Active member at BAYOU Restaurant<br/>-Loves the Bayou open space and Community gardens</p> |  <p><b>Bryce</b><br/>29 years old<br/>-Lives in Affordable rentals<br/>-CEO of Fitness Studio<br/>-Loves being downtown<br/>-Socializes, hanging with friends</p> |  <p><b>Karina</b><br/>28 years old<br/>-Lark Condo owner<br/>-Production Sales, Retail Director<br/>-Wants to work<br/>-Loves music and visiting the Bayou</p> |  <p><b>Ryan</b><br/>Owner of BANGO Restaurant<br/>-32 employees<br/>-Loves "Patrol" Space</p> |  <p><b>Tom</b><br/>Founder of a Bio-based Company<br/>-40 employees<br/>-Loves Commercial Office Space</p> |  <p><b>Paige</b><br/>Founder - Startup Internet Company<br/>-12 employees<br/>-Loves Commercial Office Space</p> |  <p><b>Ken</b><br/>Shipping at Bayou Hotel<br/>-Individual Business Traveller (IBT)<br/>-Works for national distribution company<br/>-Visiting Houston branch</p> |  <p><b>Kristin and Brian</b><br/>Shipping at Bayou Hotel<br/>-Leisure travellers<br/>-Love seeing different cities<br/>-Pete and theater</p> |

**4.57 Social Diversity (above)**

Promoting social diversity is a central component to the proposal. Social diversity inherently increases resilience to social shocks at a range of scales.

**4.58 Project Goals (right)**

Nature, community, new economy, and creativity are the four goals that the proposal revolves around. These goals fit into the three systems explored in resilience theory: social, ecological, and economic.

**DOWNTOWN BAYOU CRITICAL SUCCESS FACTORS**

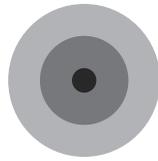
|   |  |
|---|--|
|  | <p><b>NATURE</b>   Reclaiming Buffalo Bayou<br/>‘Peel-back’ road infrastructure<br/>Energize the waterfront<br/>Cleanse water before re-entering the river</p>   |
|  | <p><b>COMMUNITY</b>   Cultural Diversity<br/>Variety of housing encouraging diversity<br/>Clear connectivity to surrounding districts and Buffalo Bayou<br/>Re-defining outdoor experience in downtown Houston</p> |
|  | <p><b>NEW ECONOMY</b>   Forward Progress<br/>Market-driven plan, feasible for all stakeholders<br/>Diversity of product mix<br/>Entrepreneurial-focused office space</p>   |
|  | <p><b>CREATIVITY</b>   Inspired, Innovative Spaces<br/>Places designed to adapt and change over time<br/>Iconic bridge defining the Bayou Commons brand<br/>Distinctive and unique retail and social spaces</p>    |

**4.59 Social Memory**

Bayou Commons creates a unique identity within the Houston context, and uses the iconic pedestrian bridge as the guiding element for this goal. Here, a diversity of users- both residents and visitors- enjoy a shopping experience and a vibrant open space.



REGIONAL



METRO



SITE



SPATIAL  
SCALE

|              |            |  |    |    |
|--------------|------------|--|----|----|
| THRESHOLDS   | SOCIAL     |  |    | 1  |
|              | ECOLOGICAL |  |    | 2  |
|              | ECONOMIC   |  |    | 3  |
| DIVERSITY    | SOCIAL     |  | 4  | 5  |
|              | ECOLOGICAL |  |    | 6  |
|              | ECONOMIC   |  |    | 7  |
|              | SPATIAL    |  |    | 8  |
| REDUNDANCY   | SOCIAL     |  | 9  | 10 |
|              | ECOLOGICAL |  | 11 | 12 |
|              | ECONOMIC   |  | 13 | 14 |
|              | SPATIAL    |  |    | 15 |
| CONNECTIVITY | SOCIAL     |  | 16 | 17 |
|              | ECOLOGICAL |  |    | 18 |
|              | ECONOMIC   |  | 19 | 20 |
| PLANNING     | ECOLOGICAL |  |    | 21 |
|              | ECONOMIC   |  |    | 22 |

TEMPORAL  
SCALE

5 Y

10 Y

50 Y

100 Y

150+ Y

## EXTRACTED METHODS

- 1
  - Promote social memory by engaging the community with the waterfront
  - Increase social adaptivity by promoting creativity and innovation
- 2
  - Monuments promote social memory based on local culture
  - Cleanse water on site before entering the river- addressing stream contaminant threshold
- 3
  - Performative buildings tighten feedback loop in water and energy cycle
- 4
  - Diversity increases resilience to larger scale economic shocks
  - Iconic bridge creates a unique identity within the metro context, establishes a sense of social place
- 5
  - A diversity of use in terms of economic draws, working opportunities, learning institutions, and contextual destinations leads to greater social diversity
  - Promote resident diversity through multiple viable housing options
- 6
  - Increased tree canopy cover and bayou frontage promotes biodiversity through habitat
  - Bundled infrastructure
- 7
  - Diversity of product mix within the development, services offered
  - Rely on a mixture of government funded and research-based partnerships to foster economic resilience
  - Bundled infrastructure decreases economic cost and is more efficient in creating resilience
- 8
  - Diversity of open space and buildings, both grand and small scale, public and semi-private
- 9
  - Another economic, residential, and entertainment destination in Houston context
- 10
  - Multiple housing options of the same variety
- 11
  - Reduces flood stress by creating another flood-safe node along the riparian corridor
- 12
  - Alternative energy collection reduces dependence on single non-renewable energy sources
- 13
  - Another dense economic node within the Houston context
- 14
  - Repetition of land use on site during phasing sequence
- 15
  - Repetition of open space and building typologies- multiple instances of large and small public open space and smaller scale semi-private space
  - Clear hierarchy in connectivity
- 16
  - Connect to the neighborhoods within the context while retaining a unique identity
- 17
  - Create a walkable five minute loop within the site and into the adjoining central business district
- 18
  - Establish a performative edge with the waterfront
  - Understand the role that the site can play in the greater riparian system, i.e. not an ideal location to retain floodwaters
- 19
  - Connect to key destinations within the downtown context
- 20
  - Linking key economic drivers on site through walkability and metro transportation network
- 21
  - Create flexibility for the river to flood while still retaining ecological function
- 22
  - Entrepreneurship and creativity are fostered as viable economic drivers within the development



# CASE STUDY RESULTS

Figure 4.61 represents an overlay of the five case study analyses identified through the literature review: Resilient Rangelands; Willamette River Valley; Albano Resilient Campus; Henna, Finland; and CASE Downsvew. The overlay gives a transparency to the cells filled in each case study. When combined it reveals patterns about which of the five methods for promoting resilience were used more or less frequently in terms of social, ecological, and economic systems as well as regional, metro, or site specific spatial scales. These patterns are discussed in the following paragraphs and conclude with a comparison to an overlay of the ULI/Hines Competition analyses (Fig. 4.62). This comparison informs the framework for engaging in the 2013 ULI/Hines Competition entry and projective design of this thesis.

## **Findings / Scales**

The overlay synthesis shows that generally the case studies tend to focus more on the metro and site scales than the regional, with an emphasis on the metro. This result indicates that strategies for promoting resilience tend towards a “mid-range” scale that perhaps influences the scales above and below it. The site or small scale is also a strong emphasis, which reveals promising implications for an application to site specific landscape architecture and urban design practice. It should also be noted that strategies identified for the metro scale during the case study analysis overlapped with the site scale and vice versa. When this overlapping occurred, the method was noted twice—once for the metro and once for the site scale. This also occurred between the regional and metro scales, but less frequently. It makes sense that there are fewer regional scale strategies for resilience identified because these tend to be much broader and have less of a directed attention. Although the regional scale methods are fewer, they tend to have greater implications for the scales below. (Refer to Fig. 1.3 and compare to how large scale factors of climate change operate and much larger spatial and temporal scales, but have far greater impacts to the scales below as an example).

It is of great interest that of the five case studies analyzed, there was not a great deal of attention on temporal scales despite it being a critical component of resilience. The most comprehensive case study, the Albano Masterplan, failed to mention a specific time scale at all and the others were very vague with the exception of Emergent Ecologies which included a detailed phasing strategy. Of the five case studies, the Rangelands and Willamette River Valley looked at the largest time scales of approximately 50 years. This also suggests a correlation between the length of temporal scale and the size of the spatial scales analyzed. In general, both relatively large spatial and temporal scales were not focused on which alludes to a more mid-range set of strategies for promoting resilience as being the most effective. Nevertheless, it seems important that greater time scales are considered even if the results are not what was originally predicted.

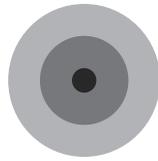
## **Findings / Identify and Respond to Thresholds**

The identification and response to critical thresholds focus primarily on the metro and site scales in terms of social and ecological systems. This is significant because it implies that these identified thresholds have direct effects on design decisions at these scales.

REGIONAL

METRO

SITE



SPATIAL  
SCALE

|                |            | 5 Y        | 10 Y       | 50 Y       | 100 Y      | 150+ Y     |
|----------------|------------|------------|------------|------------|------------|------------|
| THRESHOLDS     | SOCIAL     | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | ECOLOGICAL | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | ECONOMIC   | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Light Gray |
| DIVERSITY      | SOCIAL     | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | ECOLOGICAL | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | ECONOMIC   | White      | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | SPATIAL    | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
| REDUNDANCY     | SOCIAL     | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | ECOLOGICAL | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | ECONOMIC   | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Light Gray |
|                | SPATIAL    | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
| CONNECTIVITY   | SOCIAL     | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | ECOLOGICAL | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | ECONOMIC   | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Light Gray |
| PLANNING       | ECOLOGICAL | Light Gray | Light Gray | Dark Gray  | Dark Gray  | Dark Gray  |
|                | ECONOMIC   | Light Gray |
| TEMPORAL SCALE |            | 5 Y        | 10 Y       | 50 Y       | 100 Y      | 150+ Y     |

REGIONAL



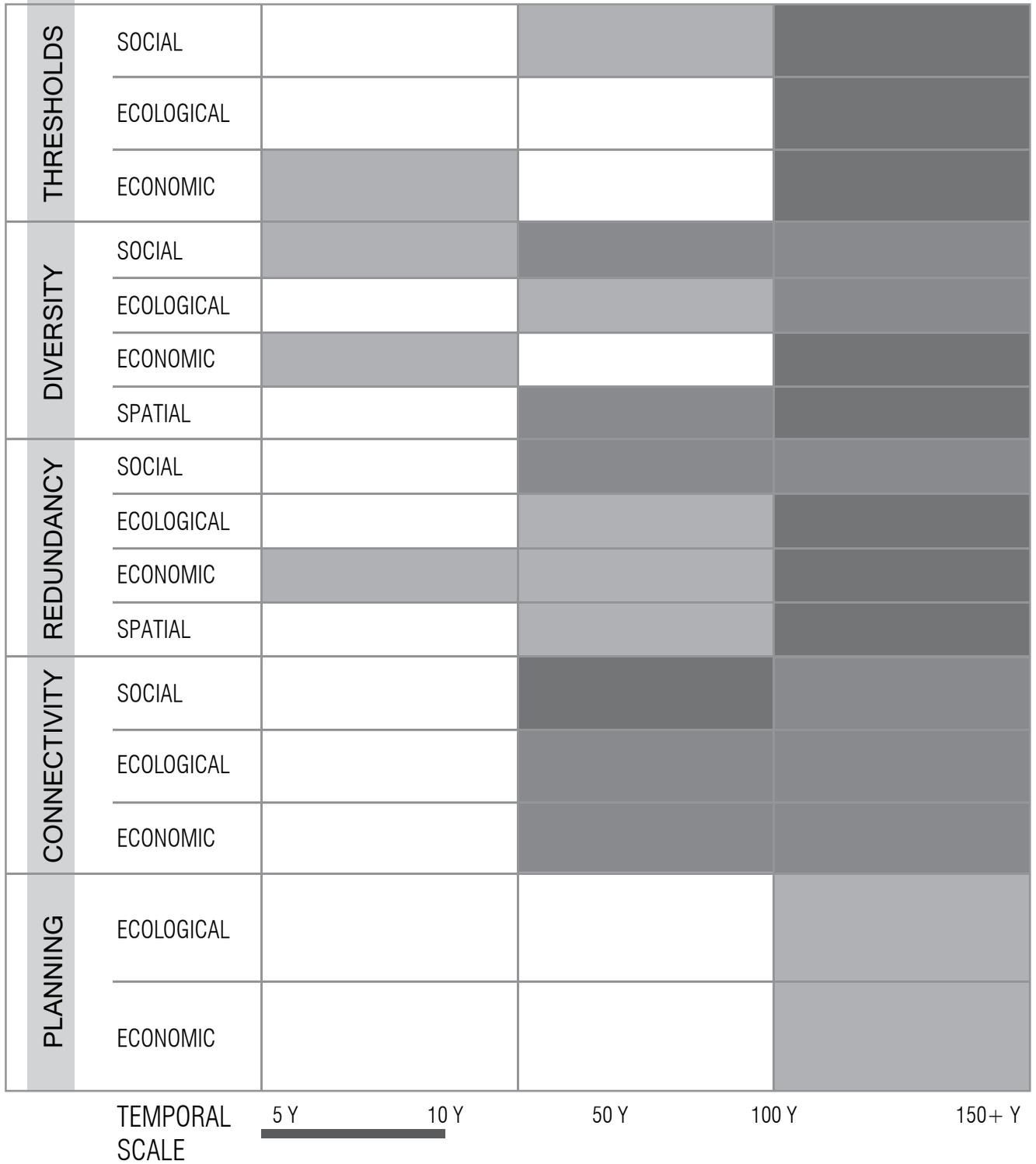
METRO



SITE



SPATIAL  
SCALE



Regional thresholds in ecological and economic scales also had a comparatively greater showing than the other four resilience strategies. This is expected because thresholds at larger scales will have significant impacts on smaller scales and systems. It is important to note that the category with the fewest strategies was at the economic site scale. This may seem logical because economic systems tend to operate at somewhat larger scales, but it leaves the question of how small scale economic strategies might inform larger scale resilience to shocks and disturbances.

Few specific thresholds were identified in any of these five case studies, with the exception of flooding, climate change, and the dependence on fossil fuels. It appeared that in most cases strategies were proposed to generally increase adaptivity in the face of unknown future thresholds through such methods as increasing socio-cultural memory, tighten feedback loops in the waste and water cycles, and reestablish human connections with natural systems, to name a few. In the case of the Willamette River case study, that research was focused on one critical threshold which was flooding. Other strategies for resilience to thresholds in this case study were secondary to flooding or were interrelated, such as the increase of social memory through increased recreational opportunities in restored floodplain areas. Conversely, the Albano Resilient Campus case study is an example of a more holistic approach to a masterplan and identified strategies for much more general thresholds such as reducing fossil fuel dependency, and tightening water cycle feedback loops in case of increasing shortages. The Resilient Rangelands case study is similar in providing solutions for a number of different thresholds including drought and an aging rural population.

### **Findings / Promote Diversity**

This category was fairly evenly dispersed among scales and systems. The most frequent was spatial diversity at the metro and site scales. Again, the regional scale was addressed the least and economics were comparatively ignored. In the cases of Albano, Henna, and Emergent Ecologies, economics was not explicitly addressed and the extracted methods were secondary effects of other methods. Similar to other categories, the metro and site scales were emphasized. The Albano Masterplan provided the most extracted methods with a focus on social and ecological systems at the metro and site scales.

The methods for each system and scale were surprisingly similar amongst the case studies, despite the differences in project type. Methods for social diversity were characterized by identity and uniqueness, attracting a range of demographics, encouraging the interface of cultural influences, and creating a diversity of experiences within the project. It is noteworthy that the two more science-driven case studies, Resilient Rangelands and the Willamette River, had the fewest social diversity methods with the Willamette River having none. Resilient Rangelands was more concerned with demographics and diversifying age structure, and at the large scales. This is of interest because the Resilient Rangelands shares a similar holistic approach as Henna, Albano, and Emergent Ecologies, but is less concerned with social diversity.

Ecological diversity was primarily concerned with habitat and species diversity at a range of scales. Economic diversity was again, limited, but the methods dealt with land use as a way to create a diversity of markets and a range of housing prices. Spatial diversity was a much more complex set of methods than the previous two. The underlying concept with these methods is the nexus of spatial types including land use, spatial size (hierarchy), and land systems (i.e. agriculture, urban, wetlands). Each of these case studies works towards developing spatial diversity as a secondary or complimentary component to social and ecological diversity.

### **Findings / Develop Redundancies**

The redundancy category tends to overlap with the diversity category due to the fact that by definition, they complement each other. The number of methods extracted from the case studies was the most even across scales and systems amongst all categories. Regional redundancies focus on situating the site as a redundant component of the greater context (i.e. a unique component of a regional educational institution network, ecosystem type amongst natural systems). Another common theme was creating redundant connections whether it was between habitats, social connections to features such as waterfronts, or creating multiple connection sources for food/water/energy systems. This category can be summarized as increasing complexity and reducing homogenization. Through the extracted methods, this is achieved evenly across scales by creating a unique but fitting socio-ecological identity based upon the context, and creating multiple connections for a range of systems.

### **Findings / Create Multi-Scale Networks and Connectivity**

This category is unique amongst the others in that the site scale was relatively neglected compared to the regional, with the metro scale having the primary emphasis. This is a significant difference because it demonstrates that regional and contextual connectivity is more important than connections within a site. Generally, social and ecological connectivity had a much greater emphasis than economics, with most economic strategies relating to reducing large scale connectivity to economic systems and refocusing on local resources and land uses.

Social and ecological connectivity dealt with entirely physical connections, with the exception of social communication networks assisting in the spread of ideas and memory. Physical connections to socially significant destinations in the regional and metro context create a viable function for the site. Similarly, physical ecological connections link significant destinations but in terms of natural species movement between habitat patches through corridors. An important concept derived through these case studies is also the creation of multi-modal connections in terms of rapid and slow human transport (i.e. pedestrians, bicycles, and public transport) but also ecological transport. By coupling social and ecological movement with the same physical connections, it establishes a visual interaction of systems across scales that can have a great impact on socio-ecological resilience.

### **Findings / Adaptive Planning + Management Strategies**

Ecological strategies at the metro and site scales were overwhelmingly the most frequent in this category. The specific methods varied widely but have a common theme of allowing smaller scale responses influence adaptation over time in a “safe-to-fail” type of mentality. The general concept of adaptive planning is to learn from the way that systems respond to disturbance in order to more effectively manage the physical components that we can control into a desirable state. Emergent Ecologies completely leaves the physical manifestation of Downsview Park to evolve based upon ecological responses, while the Albano Masterplan calls for a more active governing approach that couples both formal institutions with local, grass-roots groups. The Resilient Rangelands case study takes an approach that allows local observation at smaller scales to inform decision making at the regional level, which also deals with slower processes (i.e. climate change, resource management). All of the case studies seek to achieve greater flexibility with governance so that plans change over time in response to the interactions of systems, rather than attempt to control systems through optimization and rigid approaches.

### **ULI/Hines Competition Case Study Findings**

The ULI/Hines Competition case study overlay reveals an overwhelming focus on site specific strategies, with some emphasis at the mid-range metro scale. The regional scale is almost entirely neglected, and was only a part of the Touch case study. In general, there are limited strategies for promoting resilience in this set of case studies in comparison to the five case studies coming from the literature. The Panorama Station case study was almost completely devoid of resilience methods and seemed to embody a “business as usual” approach. Buffalo Bayou had more strategies but was almost entirely focused on the site itself. Touch employed a more holistic approach with more regional and metro strategies. This general focus on the site scale is not wholly unexpected, because it is a very site specific design and the competition brief does not explicitly call for analysis and solutions at larger scales. All of the case studies include a ten year plan in accordance with the competition requirements, and there were limited strategies that looked beyond this time span.

### **Findings / Identify and Respond to Thresholds**

The threshold category has a good representation at the site scale, but it is important to point out that most of the proposed strategies dealt with climate change thresholds. These strategies included brown roofs, tightening water cycle feedback loops, flexible building typologies to accommodate future technological advances, and utilizing passive solar techniques in structures. One threshold that was specifically identified in the Panorama Station case study was a shift away from the big box commercial retail model, and how a building would adapt after a change in the economic model.

### **Findings / Diversity + Redundancy**

Diversity and redundancy methods were primarily concerned with creating unique mixed-use urban developments. A diversity of building types and scales, land use, open space program and size, attracting a diverse residential population, and creating a diverse/redundant balance of human experience on site were some of the methods used. It is evident that economic systems feature more prominently in these categories,

especially because economic feasibility is a required component of the competition. There is, however, less of a focus on ecological systems in comparison to the previous five case studies. Most of the ecological diversity and redundancy strategies focus on water and energy rather than flora and fauna.

Connectivity was not evident at the regional scales in any of the case studies, but physical connections beyond the metropolitan area are unnecessary for the competition. Generally, this category was well-covered in terms of creating multi-modal transportation networks that facilitate flows of matter and energy in a hierarchical manner. Touch and Buffalo Bayou both had tertiary strategies for linking hydrological systems and providing corridors that could facilitate species movement, but again habitat networks and biodiversity were not central to any case study.

### **Findings / Adaptive Planning + Management Strategies**

The only adaptive planning/management strategy present was in the Buffalo Bayou case study, which allowed for more flexibility in flooding on site and encouraged entrepreneurship as a primary economic driver. Management and especially institutional management is not a primary focus of the competition, which explains the absence of strategies in this category.

In general the ULI/Hines Competition case studies have an emphasis on socio-economic systems and not socio-ecological. Site specific strategies are more prevalent than metro and regional scales, which is a product of the requirements of the competition, but it does not demonstrate how cross-scale interactions across systems influence the site and the proposed designs. In comparison to the previous five case studies stemming from the literature, there is an overall lack of a holistic approach to urban design. That is not to say that these competition case studies are not successful or “good” designs, but that they do not inherently embody an approach that parallels the use of resilience theory as a framework for engaging urban design. This finding lends significance to an application of resilience theory to the 2013 ULI/Hines Competition as a projective design for testing a resilience theory framework.

The methods that are identified in each of these case study groups serve as the basis for the projective design experiments. The Drylands Competition was done prior to the case study analysis so the applied framework is not the one shown in this thesis. The ULI/Hines Competition projective design uses the methods found in the case study analysis through the resilience framework (Fig. 5.1).

# RESILIENCE FRAMEWORK

A resilience framework (Fig. 5.1) was derived from the methods extracted from the case study analysis. This framework identifies each cell in the analysis matrix by a number that corresponds to a goal and potential methods. The goals and methods are derived from the case studies themselves. This framework serves as an active design guide to suggest methods for promoting resilience in a broad range of project types. While the resilience framework looks the same as the analysis framework used in the case study analysis, they are two different tools. The analysis matrix is a passive tool that is meant for post-design analysis. The resilience framework is an active mechanism for applying abstract and highly complex theoretical ideas to actual design tactics and methods.

5.1  
Resilience Framework

REGIONAL



METRO



SITE



SPATIAL  
SCALE

|              |            |    |    |    |
|--------------|------------|----|----|----|
| THRESHOLDS   | SOCIAL     | 1  | 2  | 3  |
|              | ECOLOGICAL | 4  | 5  | 6  |
|              | ECONOMIC   | 7  | 8  | 9  |
| DIVERSITY    | SOCIAL     | 10 | 11 | 12 |
|              | ECOLOGICAL | 13 | 14 | 15 |
|              | ECONOMIC   | 16 | 17 | 18 |
|              | SPATIAL    | 19 | 20 | 21 |
| REDUNDANCY   | SOCIAL     | 22 | 23 | 24 |
|              | ECOLOGICAL | 25 | 26 | 27 |
|              | ECONOMIC   | 28 | 29 | 30 |
|              | SPATIAL    | 31 | 32 | 33 |
| CONNECTIVITY | SOCIAL     | 34 | 35 | 36 |
|              | ECOLOGICAL | 37 | 38 | 39 |
|              | ECONOMIC   | 40 | 41 | 42 |
| PLANNING     | ECOLOGICAL | 43 | 44 | 45 |
|              | ECONOMIC   | 46 | 47 | 48 |

TEMPORAL  
SCALE

5 Y

10 Y

50 Y

100 Y

150+ Y

## RESILIENCE FRAMEWORK METHODS

- 1** **Goals:** Respond to regional thresholds operating at larger scales, including climate change, availability of water, fossil fuel dependence etc. and understand the social consequences.

**Potential Strategies:** Promote understanding and mental models of biophysical resilience in human-dominated ecosystems to establish greater adaptivity and prevent repetitious mistakes; respond to climate change by anticipating how open space use will shift in hotter temperatures; understand how social networks might present thresholds in information flows – emphasize information flows on site through informal and face-to-face meetings, disconnecting from larger regional and global social networks
- 2** **Goals:** Create a development that promotes social memory within the metropolitan context; respond to critical social thresholds (i.e. an aging demographic, a cultural stratification)

**Potential Strategies:** utilize an appropriate vernacular that fits into the metropolitan context (or perhaps breaks the norm if creating a unique identity); provide a socio-cultural amenity through appropriate housing types land use types; establish an appropriate urban density that can respond to shifts in social systems; alternative transportation modes diffuses shock of shift after fossil fuels are depleted (car-free lifestyle); emphasize the importance of art and technology in increasing social memory; potentially tie-in to existing neighborhood identities; engage the development with natural site features to promote memory; foster an environment that encourages creativity and innovation
- 3** **Goals:** Respond to local historical disturbances (i.e. crime issues, lack of identity/ character, demographic issues)

**Potential Strategies:** Increase socio-cultural memory of the metropolitan area through monuments, historical references, and contextual vernacular; create recreational opportunities coupled with ecological systems to promote social memory; connect to community-managed food networks to tighten feedback loops; encourage multi-cultural influences; provide adequate amenities for a range of demographic groups; establish connections with adjacent schools/learning institutions
- 4** **Goals:** Respond to regional thresholds operating at larger scales including climate change, availability of water; large scale flooding; species population levels

**Potential Strategies:** Utilize large-scale planting and maintenance strategies that rely on smaller water supplies; reduce CO<sub>2</sub> emissions through efficient building typologies, more effective solid waste management, and facilitation of wetlands and other water filtration methods to relieve stress on water treatment facilities; promote adaptivity in hydrologic systems in response to flooding; connect critical habitat to promote species diversity and richness
- 5** **Goals:** Respond to thresholds operating at the city scale including climate change variability; availability of water; flooding; species population levels

**Potential Strategies:** Utilize planting and maintenance strategies that rely on smaller water supplies; reduce CO<sub>2</sub> emissions through efficient building typologies, more

## RESILIENCE FRAMEWORK METHODS (CONT'D)

effective solid waste management, and facilitation of wetlands and other water filtration methods to relieve stress on water treatment facilities; promote adaptivity in hydrologic systems in response to flooding; create critical habitat to promote species diversity and richness

6

**Goals:** Respond to thresholds operating at the site scale including climate change variability; availability of water; flooding; species population levels

**Potential Strategies:** Utilize planting and maintenance strategies that rely on smaller water supplies; reduce CO<sub>2</sub> emissions through efficient building typologies, more effective solid waste management, and facilitation of wetlands and other water filtration methods to relieve stress on water treatment facilities; promote adaptivity in hydrologic systems in response to flooding; create critical habitat to promote species diversity and richness; alleviate flash flooding by replenishing groundwater – collect and treat stormwater on site in response to water capacity thresholds; performative buildings promote adaptivity to changes in temperature and climate; reuse existing materials on site when possible

7

**Goals:** Respond to thresholds in terms of national and regional economic trends; historic disturbances; regional economic drivers

**Potential Strategies:** Establish multiple economic connections and partnerships with an emphasis on regional drivers; leverage successful regional development trends in order to establish short term resilience

8

**Goals:** Respond to economic thresholds operating city scale; historic disturbances; local economic drivers

**Potential Strategies:** Leverage on-site fertilizers/biogas as an economic commodity; establish hierarchical economic connections; connect to local food networks; provide amenities for niche businesses in need of a location

9

**Goals:** Respond to economic thresholds operating site scale; historic disturbances; local economic drivers

**Potential Strategies:** Access to off-site jobs; larger land holding yields economies of scale, lower debt and more savings, better credit, and more options in responding to disturbances; diversity of economic producers increases resilience to larger scale shocks; adaptive building use strategies for a shift in commercial models away from big box retail; flexible building typologies allow for seamless retrofit for new technologies-increases economic adaptivity and feasibility in the future; leverage natural site features as economic draws

10

**Goals:** Create a unique development within the regional context that serves a clear socio-cultural purpose, contributing to regional diversity

**Potential Strategies:** The development serves as a node of intensification within the region, attracting greater social diversity; create a unique regional and international (if appropriate) identity; establish the development as a contributing and diverse component to the regional socio-cultural network

## RESILIENCE FRAMEWORK METHODS (CONT'D)

- 11** **Goals:** Create a unique development within the metropolitan context that serves a clear socio-cultural purpose, contributing to diversity within the city  
**Potential Strategies:** Create partnerships with adjacent social groups/institutions; use of bridges, other iconic or civic features to create a unique and recognizable identity in the urban context; a balanced age structure enhances the capacity for the development to respond to disturbances and create opportunities; creating diverse edge conditions enhances resilience among social structures; a heterogeneous mix of household prices and types attracts a range of social groups; create a metropolitan destination for a diverse social program such as recreation, the exchange of knowledge, and natural/cultural experiences
- 12** **Goals:** Create unique spaces within the development that serve a clear socio-cultural purpose  
**Potential Strategies:** Diverse open space creates a variety of human experience; diverse housing options promote a diverse collection of social groups; diversity in land use with an economic focus; a diversity of use in terms of economic draws, working opportunities, learning institutions, and contextual destinations leads to greater social diversity; a maximized workforce with a mix of sexes and ages expands adaptive opportunities; performative buildings help facilitate a diversity of use and social program
- 13** **Goals:** Establish the development as a unique and functional component of the regional ecological context, contributing to regional diversity  
**Potential Strategies:** Connecting to adjacent habitat networks; providing connectivity/habitat for migratory species; understand the hydrologic systems within the regional context in terms of flooding and water quality issues; generally increase ecological complexity within the urban environment
- 14** **Goals:** Promote ecological diversity at the metropolitan scale  
**Potential Strategies:** Expand habitat corridors to accommodate the flow of key species; diversify fuel sources (i.e. geothermal, biogas, wood fuel); increase hydrologic system complexity – remove channelization where possible; create diverse edge conditions with plantings and habitat type to promote flora and fauna diversity (ecotones);
- 15** **Goals:** Promote ecological diversity of flora and fauna at the site scale  
**Potential Strategies:** Brown roofs increase biodiversity through the use of recycled substrate materials that self-organize into habitats; bioswale network promotes biodiversity through habitat connections; increased tree canopy cover promotes species diversity; create small scale habitat for mushrooms, micro-organisms, butterflies, and insects; a network of performative buildings create small scale habitat patches; utilize habitat diversity where applicable (i.e. wetlands, forest, meadow, riparian); utilize an appropriate and diverse planting palette
- 16** **Goals:** Create a unique economic intensification within the regional context  
**Potential Strategies:** Leverage successful regional and national trends but accomplish something different within the development to contribute to regional diversity

## RESILIENCE FRAMEWORK METHODS (CONT'D)

- 17** **Goals:** Create a unique economic intensification within the metropolitan context  
**Potential Strategies:** Heterogeneity of land use; small commercial spaces compliment adjacent land uses and economic drivers; provide for existing needs within the metropolitan area; leverage local businesses/trends whenever possible;
- 18** **Goals:** Promote economic diversity within the development  
**Potential Strategies:** Diverse enterprises linked to a variety of markets; a range of energy sources widens resource-use opportunities; small grass roots markets can provide small income and tighten economic feedback loops; diversity of product and service mix within the development; rely on a mixture of public and private funding sources; bundled infrastructure reduces cost and is more efficient; provide a diversity of development type, being sure to include strong competitors (civic institutions, corporations) and quick growth (retail chains, local small business)
- 19** **Goals:** Establish the development as a diverse component in the spatial regional context  
**Potential Strategies:** Establish a regional nexus of multiple systems; foster a diversity of relevant regional transportation options
- 20** **Goals:** Establish the development as a diverse component in the spatial metropolitan context  
**Potential Strategies:** Multi-modal transportation corridors into the development (i.e. rail, car, bike, pedestrian); create a dense spatial node within the metro context; access to diverse land systems at this scale offers a range of opportunities in time and space; create a heterogeneous pattern of development including natural ecosystems, agriculture, and urban development; hierarchy of development with primary urban structures adjacent to transportation infrastructure
- 21** **Goals:** Promote spatial diversity within the development  
**Potential Strategies:** Diversity of use within the buildings; a variety of open space types with a clear hierarchy – grand and small scale, public and semi-private; performative borders diversify and facilitate ecological processes and connectivity through space
- 22** **Goals:** Verify the appropriateness of creating a regional redundancy in the character, type, use, and demographic of the development  
**Potential Strategies:** Base the development on successful precedents in the region, assuming that such a development applies to a relevant demographic; providing housing opportunities that are unique, but a redundant typology in the region
- 23** **Goals:** Verify the appropriateness of creating a redundancy within the metropolitan context in the character, type, use, and demographic of the development  
**Potential Strategies:** Create a retail (or other land use type) focused redundancy with an emphasis on a certain building typology; a mixed use node connecting to a larger socio-economic network

## RESILIENCE FRAMEWORK METHODS (CONT'D)

- 24** **Goals:** Create social redundancies on site, while avoiding stratification/homogenization  
**Potential Strategies:** Multiple housing options, shopping destinations, open space program; overlapping programs within public spaces – food production, community development, reducing energy, etc.; multiple governing institutions; multiple social programs located at different areas within the development
- 25** **Goals:** Verify the appropriateness of creating a regional redundancy in terms of ecological function, habitat type, and connectivity  
**Potential Strategies:** Increase regional flood adaptive capacity by increasing local flood storage; create a redundant open space typology within the regional context that merges ecological and social systems
- 26** **Goals:** Verify the appropriateness of creating a metropolitan redundancy in terms of ecological function, habitat type, and connectivity  
**Potential Strategies:** Reduce metropolitan flood stress by create a redundant flood-safe node along existing riparian corridors; create a network of diverse, but redundant performative buildings to establish an ecological network
- 27** **Goals:** Create ecological redundancies on site, while avoiding stratification/homogenization  
**Potential Strategies:** Establish redundant energy sources – geothermal, passive solar, electric grid; create redundancies in water sources; multiple habitat connectivity points at major infrastructure intersections
- 28** **Goals:** Verify the appropriateness of creating a regional economic redundancy in terms of land use, primary economic drivers, and target market  
**Potential Strategies:** Establish multiple economic connections and partnerships with an emphasis on an economic redundancy based upon a regional market trend
- 29** **Goals:** Verify the appropriateness of creating a metropolitan economic redundancy in terms of land use, primary economic drivers, and target market  
**Potential Strategies:** Create a dense economic node within the urban context; high level of services encourages capable people to stay and innovate; incorporate local food sources as a supplement and an alternative to regional and global food sources to keep prices stable
- 30** **Goals:** Create economic redundancies on site, while avoiding stratification/homogenization  
**Potential Strategies:** Bundled street infrastructure increases ease of access for maintenance cost by creating redundant accessibility; multiple institutional influences on the development; multiple funding sources; creating retail type redundancies; repetition of land use during the phasing sequence
- 31** **Goals:** Verify the appropriateness of creating a regional spatial redundancy in terms of landscape type, spatial use, and program

## RESILIENCE FRAMEWORK METHODS (CONT'D)

**Potential Strategies:** How does the development spatially link within the region in terms of transportation, flows of energy and protein? What characterizes the site spatially in the regional context, and is this redundant? If so, is that the best scenario for the site?

- 32** **Goals:** Verify the appropriateness of creating a metropolitan spatial redundancy in terms of landscape type, spatial use, and program  
**Potential Strategies:** Multiple access points through multi-modal transportation corridors into the development; socio-ecological “melting areas” throughout the development; how does the site fit within the spatial hierarchy of the city?
- 33** **Goals:** Establish spatial redundancies within the development  
**Potential Strategies:** Bundled street infrastructure increases ease of access for maintenance and creates redundancy in spatial use; redundancies in building use create adaptive futures for big box locations; redundant open space typologies – courtyards, quadrangles, plazas, parks; clear hierarchy in connectivity; access to a mix of complementary land systems at a finer scales promotes adaptability; building structures with a common grid system accommodates a diversity of program and building type while creating uniformity; multi-functioning landscapes (i.e. open space acts as food production but also meeting areas and flood control); multiple flood-holding areas
- 34** **Goals:** Connect to the regional socio-cultural context, and assess where reductions in connectivity are necessary  
**Potential Strategies:** Communication networks assist in the spread of ideas; connect to regional destinations through innovative and energy efficient public transportation; reduce solid waste transportation connectivity; create a regional destination for a diversity of users
- 35** **Goals:** Connect to the metropolitan socio-cultural context, and assess where reductions in connectivity are necessary  
**Potential Strategies:** Situate the development within the open space network to create critical social connections; multi-modal connections to the metro context; establish connections to adjacent neighborhoods while retaining a unique identity; bundle ecological and social infrastructure to accommodate species flows
- 36** **Goals:** Establish relevant social connections within the development  
**Potential Strategies:** Open space acts as a social network across the development – connecting people with businesses, institutions, and residences; create a walkable loop from the site to relevant destinations in the immediate context; multiple spatial typologies accommodate flexible social programs; create social gathering locations or “sticky points”; leverage civic icons as connecting people together through a common identity
- 37** **Goals:** Connect to the regional ecological context, and assess where reductions in connectivity are necessary  
**Potential Strategies:** Create and enhance corridor linkages between critical habitat patches at the regional scale

## RESILIENCE FRAMEWORK METHODS (CONT'D)

- 38** **Goals:** Connect to the metropolitan ecological context, and assess where reductions in connectivity are necessary  
**Potential Strategies:** Establish connections to natural hydrologic systems; connect to adjacent habitat patches; create appropriate buffers between land uses to facilitate the flows of key species
- 39** **Goals:** Establish relevant ecological connections within the development  
**Potential Strategies:** Bioswales and open space link habitat across the site; establish a performative edge with existing hydrology; development remains permeable to ecological flows of species; alternative energy use reduces connectivity to electric grid; establishing habitat connections across or under infrastructure
- 40** **Goals:** Connect to the regional economic context, and assess where reductions in connectivity are necessary  
**Potential Strategies:** Reduce connectivity to regional food and energy networks; what are major economic draws that will be competing and what is an appropriate response?
- 41** **Goals:** Connect to the metropolitan economic context, and assess where reductions in connectivity are necessary  
**Potential Strategies:** Establish multiple connections and partnerships with metropolitan based institutions that are primary economic drivers; create an economic connection between adjacent neighborhoods with varying income levels and commercial uses; connect and compliment adjacent land uses
- 42** **Goals:** Establish relevant economic connections within the development  
**Potential Strategies:** Diverse enterprises linked to different markets within the development; connect to existing economic cores either adjacent to or on the development site; create a walkable network to economic drivers on site
- 43** **Goals:** Implement adaptive planning/management strategies that will respond to large scale, regional ecological disturbances  
**Potential Strategies:** Leverage existing adaptive management practices by city and resource planners; model regional scenarios to understand possible disturbances and subsequent implications
- 44** **Goals:** Implement adaptive planning/management strategies that will respond to metropolitan ecological disturbances  
**Potential Strategies:** Use burning or other safe-to-fail management strategies; local governance networks manage socio-ecological demands; exchange of knowledge through pedagogical activities, field studies, and experiments contribute to the knowledge of governing bodies and promotes adaptivity;
- 45** **Goals:** Implement adaptive planning/management strategies that will respond to small, site scale ecological disturbances

## RESILIENCE FRAMEWORK METHODS (CONT'D)

**Potential Strategies:** Property rights defined by habitat type within the development – imbedding ecological management as a part of institutional entities; strong social networks arranged around institutional meeting facilitates the transfer of knowledge and information, creating well-informed decision processes that effectively manage the ecological systems within the development

**46** **Goals:** Implement adaptive planning/management strategies that will respond to large scale, regional economic disturbances

**Potential Strategies:** Community structures and projects that bring innovative approaches and outside resources; increase complexity of mental models held by agencies to stress adaptation and uncertainty rather than command and control

**47** **Goals:** Implement adaptive planning/management strategies that will respond to metropolitan economic disturbances

**Potential Strategies:** Provide a variety of community-managed food production networks, which promote socio-economic adaptivity;

**48** **Goals:** Implement adaptive planning/management strategies that will respond to small, site scale economic disturbances

**Potential Strategies:** Foster entrepreneurship and creativity as viable economic drivers within the development; Active ground is managed by a diverse user group in order to increase resilience; strong social networks arranged around institutional meeting facilitates the transfer of knowledge and information, creating well-informed decision processes that effectively manage the economic systems within the development

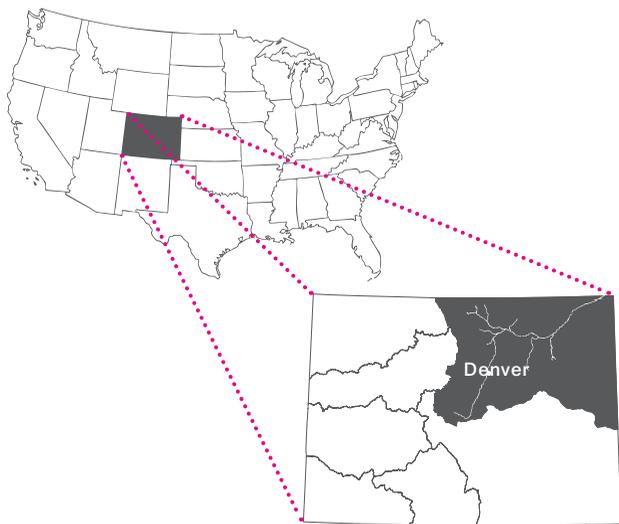


# PROJECTIVE DESIGN / DRYLANDS COMPETITION

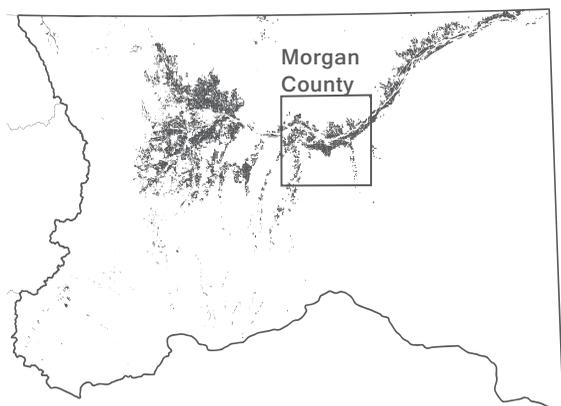
The 2012 Drylands Design Competition was sponsored by the California Architectural Foundation, and was an open ideas competition for retrofitting the American West. The challenge of the competition focuses on water scarcity in the history and future of the American West, especially in the face of critical thresholds related to climate change. Retrofitting the American West for “survival” of these thresholds requires the collaboration of disciplines in dealing with increased hydrologic variability and water scarcity. The competition sought proposals from architects, urban designers, landscape architects, planners, and engineers to generate ideas for strategic structures, infrastructures, and urbanisms that promote adaptation and resilience. Overall, the competition was very open-ended and allowed for a variety of creative approaches.

The competition entries were required to address the following objectives and priorities: the water-energy nexus, scarcity + variability, localized resources, and social equity. The water-energy nexus refers to the relationship between water, energy use, and greenhouse gas emissions in respect to the water cycle and how current systems waste finite energy resources. This also relates to scarcity and variability of water resources, both of which are increasing as extreme flood events, drought, and diminished snow pack become more frequent. The social equity objective recognizes the importance of the built environment achieving success by promoting active participation across demographic and social groups. The competition seeks both ecological and socio-cultural vitality. These objectives were sited at three scales being the local, regional, and global in terms of specificity and also replicability.

# RECALIBRATING RESILIENCE: AN ECORESERVE NETWORK IN THE SOUTH PLATTE RIVER BASIN



The American West is facing a critical threshold in water use. As urban populations grow, municipal water demands are forcing the reallocation of agricultural water rights. It is estimated that by 2050 more than 70% of Denver's water needs will be met through the process of "buy and dry," leaving 40% of the state's total irrigated agricultural lands without water. The ramifications of this situation could result in the collapse of the South Platte River Basin's (SPRB) social, ecological, and economic systems. In order to mitigate a potential "dooms-day" scenario, the urban/rural water allocation threshold must be determined and the current irrigation strategies, water rights transfers, and agricultural practices must be recalibrated for the river basin to reach a resilient state.



Guided by principles of resilience theory, this project seeks to balance the allocation of water use in the South Platte River Basin in order to support increasing urban demands, without compromising its agrarian vitality. A suitability model was generated to effectively manage the loss of irrigated agriculture for social, economic, and ecological adaptability and identify the water reallocation threshold. Through this modeling process, it is determined that the agrarian system cannot sustain resiliency beyond a 34% reallocation of its current water use. This threshold coupled with a recalibration of irrigation strategies, agricultural practices, and water rights transfers balances the gap between urban water demand and agricultural irrigation.

## 6.1 Location

The site is located in Colorado, west of the hundredth meridian, in the South Platte River Basin. At the county scale, Morgan County was chosen because of its variability in landscape type including agriculture, rangeland, riparian systems, and rural cities. The use of three scales (site, county, region) was used to demonstrate the replicability of the proposed ideas in the West and globally.

This project was viewed as an opportunity to explore the application of theory to design. The principles of resilience theory as developed by C.S. Holling were used to understand the cross-scale interactions of the systems central to the dilemma faced by the South Platte River Basin: social, economic, and ecological. From this theoretical base, the project goals were built with the intention to increase the resilience of this river basin. Currently the basin is late in the conservation stage, where due to a variety of factors the system is prone to undergo a bifurcation, or an event where the system is undone completely.

## 6.2 Framework

This framework was created to organize the design proposal around the goals of the competition as well as the systems involved with using resilience theory (social, ecological, economic). This was the first effort by the author in organizing resilience theory into a framework that serves as the guiding force behind a landscape architecture project.

|  | Social  | Economic  | Ecological   |
|--|---|---|--|
| <b>Water   Energy Nexus</b>            | <ul style="list-style-type: none"> <li>Decrease diesel consumption of water pumps by strategically limiting or eliminating irrigated agriculture</li> </ul>                         | <ul style="list-style-type: none"> <li>Shift economic focus away from energy intensive agricultural practices and diversify economy of the river basin</li> </ul> | <ul style="list-style-type: none"> <li>Decrease harmful emissions from farm implements and water pumps used for irrigation</li> </ul>                                |
| <b>Water Scarcity and Availability</b> | <ul style="list-style-type: none"> <li>Increase social awareness of the importance of water by increasing water bills to compensate farmers for transferred water rights</li> </ul> | <ul style="list-style-type: none"> <li>Develop strategies for making the transfer of water rights more economically viable for all parties involved</li> </ul>    | <ul style="list-style-type: none"> <li>Limit the use of water consumed by irrigated agriculture to recalibrate the ecological function of the river basin</li> </ul> |
| <b>Localized Resources</b>             | <ul style="list-style-type: none"> <li>Instill social value of local water and ecological resources to increase social memory and social adaptive capacity</li> </ul>               | <ul style="list-style-type: none"> <li>Decrease agricultural exports to create local importance for food and establish diversity in local resources</li> </ul>    | <ul style="list-style-type: none"> <li>Enlarge habitat networks and resources through recalibration of agricultural land to EcoReserve areas</li> </ul>              |
| <b>Social Equity</b>                   | <ul style="list-style-type: none"> <li>Mitigate the impacts of rural to urban migration and the aging farm population</li> </ul>  | <ul style="list-style-type: none"> <li>Develop strategies for keeping agriculture a viable practice in light of water shortages</li> </ul>                        | <ul style="list-style-type: none"> <li>Create social responsibility for the management of ecosystem services for both urban and rural populations</li> </ul>         |

## 6.3 Future of “Buy and Dry”

This conceptual image demonstrates the possibility of the South Platte River Basin going through a dramatic release phase after crossing a critical water use threshold. The landscape becomes subject to drought, dust storms, and extreme flood events while the city of Denver looms in the background as the cause of this effect. While this is not entirely likely to occur in the near future, it is not impossible if municipalities continue to purchase water rights from farmers to supplement an increasing urban population.



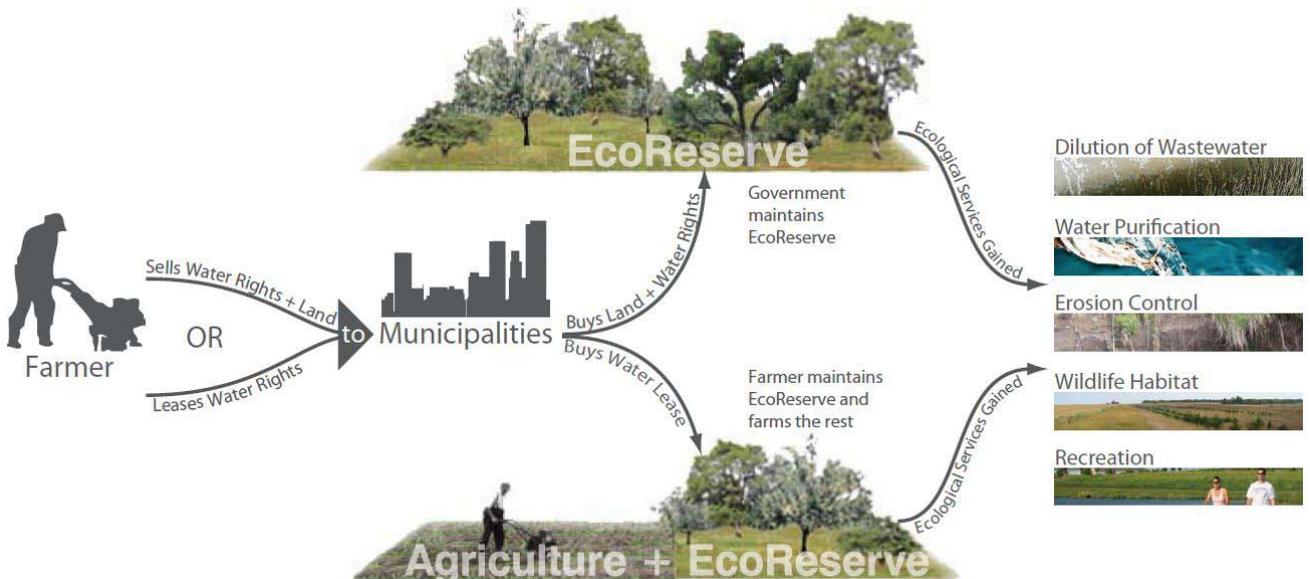


#### 6.4 Recalibrate Land Types (above)

Five land types were identified with plant species that need to be promoted in order to reduce water consumption and increase drought tolerance across the river basin.

#### 6.5 Recalibrate Water Use (below)

A diagram showing the recalibrated process for transferring water rights to municipalities. In this process, cities still gain water supply without compromising the future of the agrarian landscape.



Agriculture has a dominant monopoly on Colorado's water supply. It is projected that agriculture will account for 82% of Colorado's water use by 2050. The proposed recalibration will significantly decrease this percentage, thus providing a larger percent of water for M&I use and ultimately mitigating the need to sell water rights.

The current trend in the transfer of agricultural water rights to municipalities is the "buy and dry" effect. This occurs when a farmer sells his senior water rights to a municipality because it is more economically viable than to continue to practice agriculture. In this case, the agricultural land is not irrigated and unmaintained which has serious ecological implications. Topsoil erosion, soil degradation, rural to urban migration, food production loss, and even dust storms are all negative impacts of this buy and dry trend. If this current process continues across a large scale, the impacts will only continue to increase. It is predicted that by 2030, the economic loss in the South Platte River Basin alone will be \$123,616,763 due to decrease in agricultural production and indirect effects on other economic sectors such as livestock and farm implement production.

An alternative to the current "buy and dry" method to transfer agricultural water rights is a leasing strategy. A majority of farmers in the SPRB expressed a willingness to lease part of their water rights rather than sell off completely, and preferred a compensation of \$300-500 per acre lost. Concurrently, municipal households are willing to pay a higher water bill (about \$300 annually) to compensate farmers for leasing their water rights and maintaining the resulting lost land for five ecosystem services: dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation opportunities. Coupled with alternative agriculture practices, significant water can be saved while also supplying the growing need of Denver and other urban areas in the SPRB.

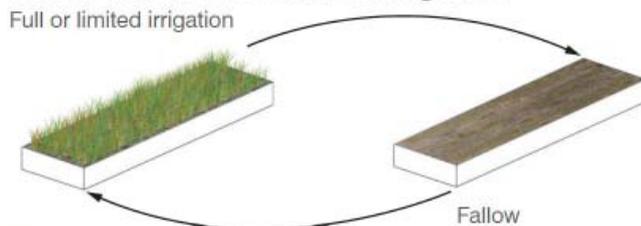
**6.6**

**Recalibrate Agriculture (below)**

Current agriculture practices in the SPRB rely heavily on center pivot and ditch irrigation. By adopting rotation and limited irrigation practices, water use is reduced by 30-40%, with only a -\$30/acre in revenue loss for farmers.

**Fallow Rotation + Limited Irrigation**

Full or limited irrigation



**Most Suitable Limited Irrigation Crops**

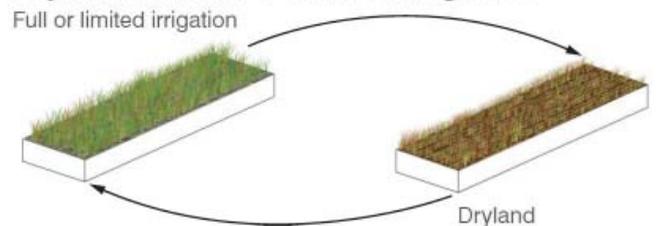


Alfalfa \$388/Acre  
 Corn \$650/Acre  
 Soy \$845/Acre  
 Sugar Beets \$1,590/Acre

**Economic Value per Acre**

**Dryland Rotation + Limited Irrigation**

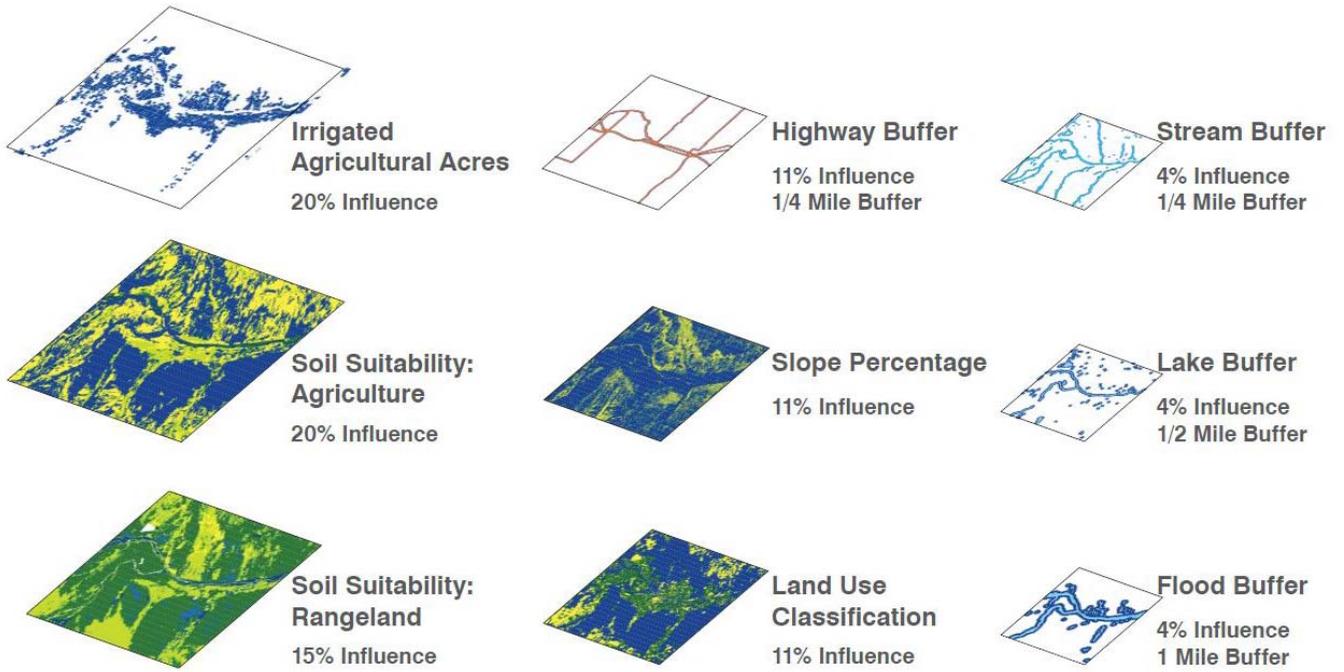
Full or limited irrigation



**Suitable Dryland Rotation Crops**



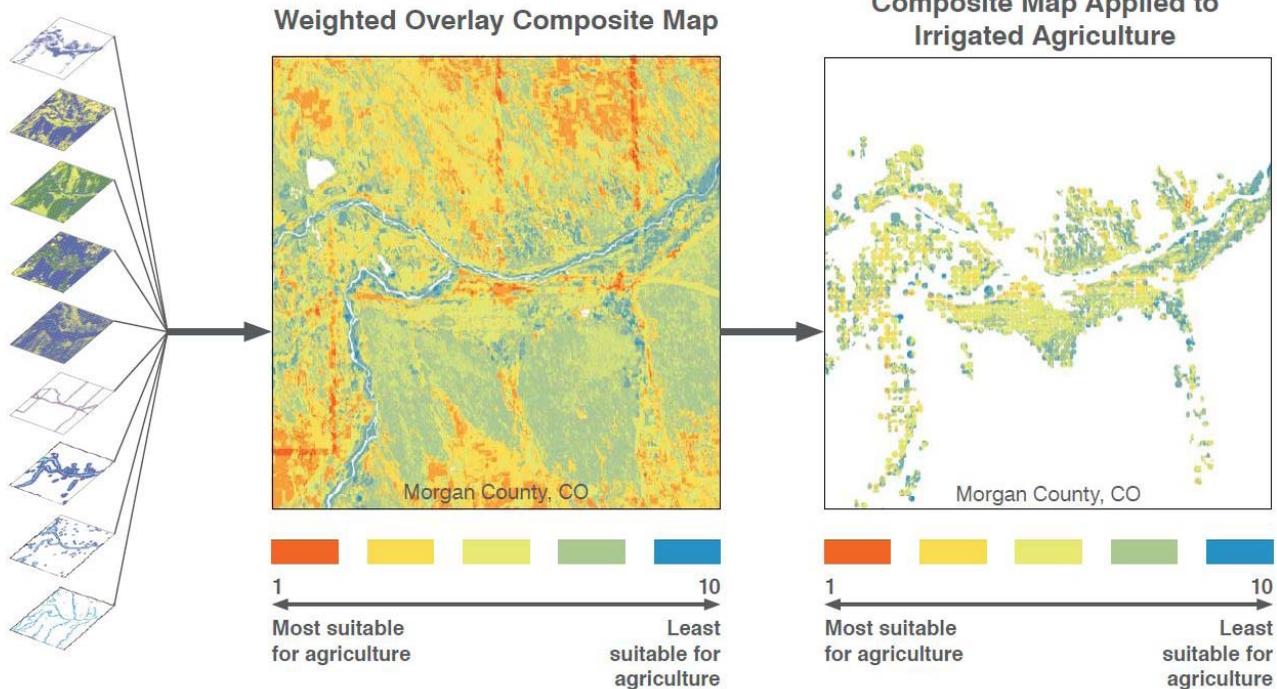
Millet \$133/Acre  
 Sunflower \$287/Acre  
 Winter Wheat \$331/Acre  
 Corn \$650/Acre



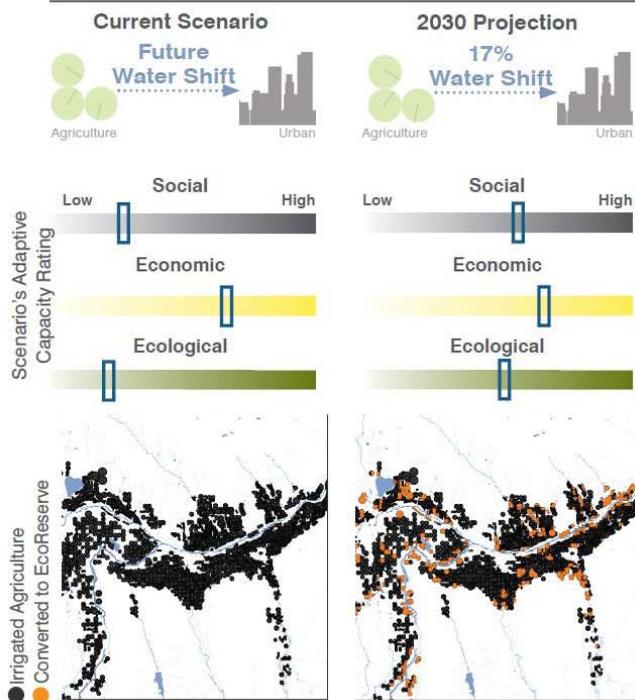
## 6.7 Modeling Process

A suitability model prioritizes areas that are more suitable as EcoReserve than agriculture. Nine factors are overlaid to produce a composite map. This process may be replicated for other

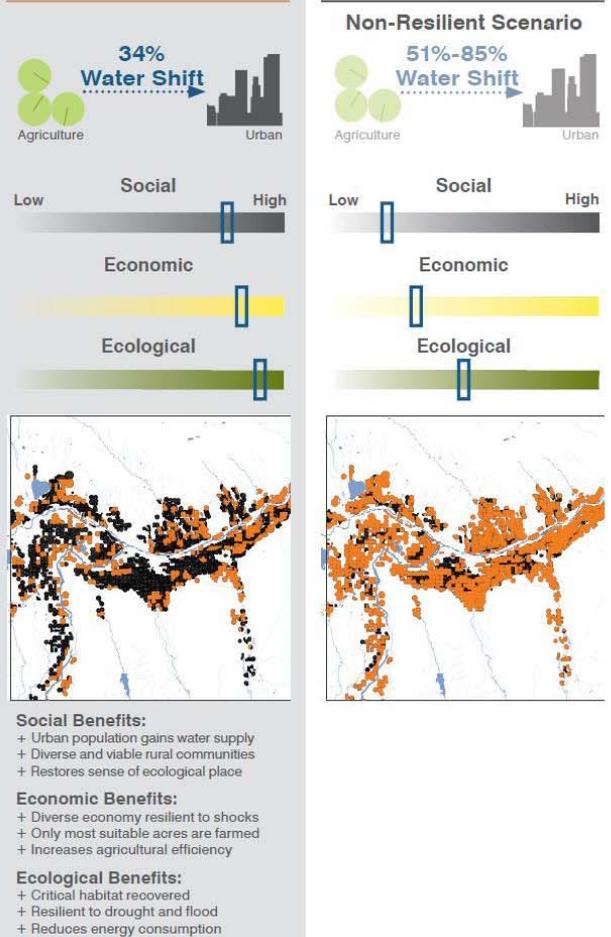
counties in the future, which is an appropriate scale based upon data availability.



## Non-Resilient Scenarios



## Resilient Scenario



### 6.8 Scenarios

Three scenarios and the current projection were then modeled based upon this suitability, where irrigated acres that are least suitable for agricultural production are removed and converted to EcoReserve. The 34% water rights transfer scenario is found to be the resilient water threshold. Going above this percentage tips the landscape over a threshold and results in the loss of basic identity and function.

A suitability model was used at the county scale to prioritize areas that were more suitable as EcoReserve than for agriculture. The model utilized nine different factors that were overlaid to produce a composite map. After the composite map was created, it was clipped to the irrigated agriculture. The result shows which irrigated acres are suitable to be removed and converted to maintained EcoReserve. The three scenarios were then modeled based upon this suitability, where irrigated acres that are least suitable for agricultural production are removed and the most suitable areas are converted to EcoReserve. The model is capable of being replicated for other counties, which is an appropriate scale based upon data availability. Morgan County was chosen because it included a diversity of land use including urban areas, significant hydrologic systems, and a large irrigated acreage.

Current agriculture practice in the South Platte River Basin relies heavily on center pivot and ditch irrigation.

# ECORESERVE NETWORK IN MORGAN COUNTY



**Dryland:**  
existing dryland  
continues to be  
profitable in the basin

**EcoReserve:**  
34% of previously  
irrigated agriculture  
is converted to an  
ecologically performing  
EcoReserve network

**Irrigated Ag:**  
66% remains using  
limited irrigation,  
crop rotation, dryland  
and fallow rotation  
practices

6.9  
EcoReserve Network



**Ft. Morgan:**  
growth and economic prosperity supported by economically viable surrounding agrarian rural communities

**Riparian Buffer:**  
Portions of the 34% of irrigated acres converted to EcoReserve serve as the buffer for the South Platte River

## SOCIAL ADAPTIVE CAPACITY

### 6.10

#### Social Adaptivity

Social adaptive capacity is increased by celebrating the importance of rural agrarian communities, promoting agritourism, creating alternative land uses, diversifying economic opportunities for workers, and instilling a new sense of social memory in younger generations.



- Recreation
- Ecotourism
- Increase Social Memory
- Agritourism
- Viable Agrarian Communities

## ECOLOGICAL ADAPTIVE CAPACITY

### 6.11

#### Ecological Adaptivity

Through the creation of the EcoReserve network, ecological resilience and adaptive capacity is increased. This is achieved by removing agricultural acres that are more suitable for the restoration of critical ecologies, especially riparian areas in proximity to the South Platte River.



- Phytoremediation & Nutrient Cycling
- Groundwater Recharge
- Increase Water Quality through Filtration
- Allowing for Lateral Stream Migration
- Bank Stabilization through Vegetated Banks

# ECONOMIC ADAPTIVE CAPACITY

## 6.12

### Economic Adaptivity

Economic adaptive capacity is also increased by diversifying income sources, practicing more efficient farming techniques on highly suitable lands, decreasing dependence on fossil fuels and chemicals, and prioritizing water as a commodity good.



Region's EcoReserve: Cropland Ratio Supports Own Population

Hunting and Fishing in EcoReserves Supplements Food Revenue

Decreases Costs for Insecticides and Fertilizers

Higher Quality of Product Increases Agriculture Value

Both methods use large amounts of water, with center pivot also consuming mass amounts of diesel fuel (24 gallons per acre inch of irrigation). Alternative practices currently being investigated include rotational strategies and limited irrigation. Both of these methods can reduce water consumption by 30-40%. Significant water savings can occur while seeing little decrease in farmer revenues of only -\$30 per acre. Large-scale implementation of these strategies would also increase resistance to drought and soil erosion.

The resilient scenario provides greater social, economic, and ecological adaptive capacity. Socially, urban populations gain significant water supply, rural communities become more diverse and viable, an important sense of ecological place is restored, and the importance of agriculture is maintained in the basin. The economy becomes more diverse and resilient to shocks such as drought, agriculture remains viable where only the most suitable acres are farmed, and agricultural efficiency is increased without sacrificing redundancies. In terms of ecological resilience, critical habitat is restored, hydrologic buffers promote key ecosystem services, adaptability to drought is increased, and energy consumption is greatly reduced.

Overall, the project seeks to achieve resilience at a large scale, while maintaining a balance between the targeted systems and scales. It is an exploration into how a region responds in a resilient manner to one shock or disturbance: a threshold in water supply.

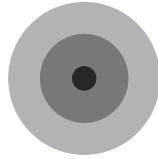
6.13  
Analysis Matrix

REGIONAL

METRO

SITE

SPATIAL  
SCALE



|                |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |
|----------------|------------|-----|------|------|-------|--------|
| THRESHOLDS     | SOCIAL     | 1   |      | 2    |       | 3      |
|                | ECOLOGICAL | 4   |      | 5    |       |        |
|                | ECONOMIC   | 6   |      | 7    |       | 8      |
| DIVERSITY      | SOCIAL     | 9   |      | 10   |       |        |
|                | ECOLOGICAL | 11  |      | 12   |       | 13     |
|                | ECONOMIC   | 14  |      | 15   |       |        |
|                | SPATIAL    | 16  |      | 17   |       |        |
| REDUNDANCY     | SOCIAL     | 18  |      | 19   |       |        |
|                | ECOLOGICAL | 20  |      | 21   |       |        |
|                | ECONOMIC   | 22  |      |      |       |        |
|                | SPATIAL    | 23  |      | 24   |       |        |
| CONNECTIVITY   | SOCIAL     | 25  |      |      |       |        |
|                | ECOLOGICAL | 26  |      | 27   |       |        |
|                | ECONOMIC   | 28  |      |      |       |        |
| PLANNING       | ECOLOGICAL | 29  |      | 30   |       | 31     |
|                | ECONOMIC   | 32  |      |      |       | 33     |
| TEMPORAL SCALE |            | 5 Y | 10 Y | 50 Y | 100 Y | 150+ Y |

## METHODS USED

- 1
  - Aging rural population creates a social threshold- create viable reasons for younger population to remain
  - A 64% increase in urban population by 2030 creates a threshold where water supply does not meet municipal and industrial demand
  - Municipal household water users pay more for their water bills in order to be managed for providing key ecological services in Eastern Colorado for the land no longer used for agriculture
- 2
  - Importance of an rural-agro identity is emphasized
- 3
  - Rural communities remain viable intensifications of social memory and adaptivity
- 4
  - Individual farms are being consolidated with larger corporations, creating a stratification in management and ownership
- 5
  - The growing sale of agricultural water rights to meet municipal demands decreases water quality, destroys critical habitat, and leaves the land un-managed for ecological benefits
  - Recovery of critical habitat and the establishment of hydrologic buffers promote resilience to drought
  - Significantly reduces harmful emissions
- 6
  - Recovery of critical habitat and the establishment of hydrologic buffers promote resilience to drought
- 7
  - 70% of the municipal and industrial water demand of Denver and other municipalities will be met through the sale of agricultural water rights by 2030
  - The sale of agricultural water rights will result in a \$123,616,763 economic loss by 2030
  - Diversity in economy promotes resilience to economic shocks such as drought
  - Significantly reduces energy consumption (20,284,128 gallons of diesel/ year) through a decrease in the use of pumps for irrigation
- 8
  - Diversity in economy promotes resilience to economic shocks such as drought
- 9
  - Individual farms are being consolidated with larger corporations, stratifying the agricultural market and reducing diversity in Eastern Colorado
- 10
  - An EcoReserve network provides a diversity of social activities through recreation
- 11
  - A diversity of economy and increase in agro-tourism creates social variability and viability for communities within the South Platte River Basin
  - Diversification of crop type reduces water demands and provides protection against soil erosion and nutrient loss
  - Buffer zone of EcoReserve network increases channel complexity of the South Platte River and diversifies habitat
  - Decrease harmful fuel emissions from farm implements and water pumps used in irrigated agriculture practice
  - Enlarge habitat networks and resources through recalibration of agricultural land to EcoReserve network

## METHODS USED (CONT'D)

- 12 • Diversification of crop type reduces water demands and provides protection against soil erosion and nutrient loss
- Buffer zone of EcoReserve network increases channel complexity of the South Platte River and diversifies habitat
- 13 • Diversification of crop type reduces need for artificial fertilizers and decreases non-point source pollution for the South Platte River Valley
- 14 • Diversify the economy by localizing exports and tightening feedback loops, promoting value in local resources
- 15 • Rural communities remain viable economically through a diversification-shifting away from agriculture to agro-tourism and light industry
- 16 • EcoReserve network creates a diversity of corridors, patches, and ecotones both in size and type
- Balance is achieved between managed land (EcoReserve) and other land types including agriculture and rangeland
- 17 • EcoReserve network creates a diversity of corridors, patches, and ecotones both in size and type
- 18 • Multiple community nodes throughout the river basin
- 19 • Urban population gains a significant water supply in the resilient scenario
- 20 • Multiple agricultural practices (dryland, irrigated, fallow, rangeland, and EcoReserve)
- 21 • Multiple ecological typologies
- 22 • Retain viability of agricultural practice while creating other economic opportunities in the river basin
- 23 • EcoReserve network creates a network of corridors, patches, and ecotones both in size and type
- 24 • EcoReserve network creates a network of corridors, patches, and ecotones both in size and type
- 25 • Municipal water users gain social connectivity to local water resources and the ecological services provided by the rural river basin
- 26 • EcoReserve network establishes ecological connectivity at a large scale for flows of species and water
- 27 • EcoReserve network establishes ecological connectivity at a large scale for flows of species and water
- 28 • Tightening of feedback loops reduces economic connectivity with economies of scale
- 29 • Create social responsibility for the management of ecosystem services for both urban and rural populations
- An EcoReserve network managed at the regional and local scales provides an adaptive response to the impacts of the current “buy and dry” trend
- Alternative agricultural practices reduce water consumption by 30-40%, reducing ecological effects of intensive irrigation

## METHODS USED (CONT'D)

- 30
  - An EcoReserve network managed at the county scale focuses on local needs for habitat type and other key ecological issues
  - Recalibrate irrigated agricultural practices through a modeling analysis that prioritizes which land is most suitable for continued irrigation and which is most suitable to be converted to EcoReserve
- 31
  - Farmers who sell their water rights are trained to manage their land using viable practices to promote ecosystem services including water dilution and purification, erosion control, wildlife habitat, and recreation while remaining economically viable
- 32
  - Shift economic focus away from energy intensive agricultural practices and diversify economy of the river basin
  - Alternative agricultural practices reduce water consumption by 30-40%, reducing costs associated with irrigation
- 33
  - Shift economic focus away from energy intensive agricultural practices and diversify economy of the river basin
  - Alternative agricultural practices reduce water consumption by 30-40%, reducing costs associated with irrigation

# PROJECTIVE DESIGN / ULI/HINES COMPETITION

The 2013 ULI/Hines Competition is located on a 17 block site in Downtown Minneapolis, Minnesota between the Central Business District and the Minnesota Vikings football stadium. The competition brief highlights several key issues along with a detailed set of parameters for the site. Among the key issues are plans for a new Vikings Stadium, recent investment and planning for large-scale light rail transit networks, creating a model for urban living, increasing the downtown population, a lack of pedestrian experience in part because of an elevated network in the Central Business District called the Skyway, and continuing to promote the use of bicycles throughout the metropolitan area. The site for the competition is in an area called Downtown East, which is primarily surface parking and smaller buildings. Most of the parcels in question have experienced a dilemma of a weak real estate market and high property values (generated by surface parking users who commute to work Downtown on a daily basis). Therefore, the brief generally calls for innovative ideas related to infill development and creating market value over the short and long term.

Extensive preparation was undertaken prior to the start of the competition. Besides the logistics of assembling Team 1155, there were two main components to the preparation in terms of this thesis: the making of an analysis framework (Fig. 7.1) and the resilience framework (Fig. 5.1). The purpose of both was to develop a set of results compiled from the literature review and case study analysis and arrange them into a usable framework for the competition. Neither the analysis framework nor the resilience framework were specific to a site; they served as a point of departure from which site-specific solutions and strategies could be derived. They were broad enough to be applicable to many different situations dependent on the location of the competition.

The analysis framework uses two matrices: one for the regional/metro scale and one for the site scale. The regional and metro site scales are combined because they overlap at many levels and it was not necessary to differentiate between the two. It was more important to distinguish the site scale. Both matrices look at four systems that are central to socio-ecological systems. These are connectivity, social, ecological, and economic. These categories are specific enough to deduce useful information for each, but broad enough to cover any given site or area of interest. Nested under each of these categories are a series of key issues that pertain to generally any urban socio-ecological system. These systems and key issues were derived through the experience of the author and not based on any one external source. The purpose of the analysis framework is to identify what the critical issues are within the site of the competition that will need to be responded to in terms of methods for promoting resilience.

Once the critical issues were identified, the composite case study methods were analyzed to see what might be most relevant to the Minneapolis site and to generate other ideas. The composite methods were compiled by going through each of the case studies and choosing what methods for resilience would be the most applicable to this competition based upon past competition sites. These extracted methods are not intended to be a representation of the only applicable methods, rather they are meant to serve as a way to generate ideas that are specific to the competition site. For instance if it was identified that ecological systems at the regional scale had not been addressed, then the composite methods could be referenced to generate ideas about what methods could be applicable. It could also be decided that methods for certain scales or systems are not applicable.

The following pages document the design that Team 1155 generated in the two weeks of the first round of the ULI/Hines Competition. The design proposal is discussed in terms of the resilience framework and which scales and systems were addressed and with what methods.

The ULI/Hines Competition consisted of two phases. The first phase was two weeks in duration from January 14-28, where the projective design competed against 149 entries from 70 graduate programs in the US and Canada. After being reviewed by a nationally recognized jury, the design proposal was chosen as a finalist with three other entries to compete for the grand prize. This second finalist phase lasted approximately one month.

The second phase of the competition involved further refinement of a more detailed design proposal. This included a more refined argumentation for a resilience approach to design with clearer graphic communication. This second phase is not included here due to time constraints, but it is important to acknowledge the significance that it had in terms of the development of the ideas of this thesis.

Out of four finalist proposals from Ball State/Purdue University, Yale University, and Harvard University, this projective design from Kansas State University/University of Kansas/University of Missouri - Kansas City was chosen as the winner of the 2013 ULI/Hines Competition.

# ANALYSIS FRAMEWORK / REGIONAL + METRO SCALE

## CONNECTIVITY

VEHICULAR  
PUBLIC TRANSIT

PEDESTRIAN  
OPEN SPACE

- Determine street hierarchy and potential traffic issues
- Determine effectiveness of current systems and potential for future connections
- Determine walkability of the city
- Analyze current park network for possible connections, needs

## SOCIAL

DEMOGRAPHIC STRUCTURE  
DIVERSITY  
OWNERSHIP

INCOME

NEIGHBORHOOD/DISTRICT IDENTITY

- What are the predominant genders, races, and ages within the city area
- Is there a diverse demographic structure within the city area
- Is there a hierarchy of ownership amongst demographic units in the city area
- Are there current missing needs for a diversity of employment opportunities
- What are the identities of adjacent areas, demographic makeups, vernacular

## ECOLOGICAL

HYDROLOGY  
TOPOGRAPHY

HABITAT

CLIMATE  
RAINFALL

TEMPERATURE + SOLAR

- What are the local fluvial systems and how will this influence the site
- Identify the optimum building orientation, eliminate non-suitable slopes on site
- Identify possible areas of protection or habitat corridors to preserve or create
- What is the climate classification
- Impacts on areas susceptible to flooding, peak flows for rainfall capture or detention
- Influence on architectural form, open space, plant palette

## ECONOMIC

RECENT DEVELOPMENT PROJECTS  
RELEVANT INSTITUTIONS  
FUNDING SOURCES  
NATIONAL TRENDS  
CITY TRENDS

- What precedents can be derived that will influence the design
- Possible connections to higher education or governmental entities
- What sources can promote the design
- What trends will shape the design, especially in an economic slump
- How will they influence the design and how can the design influence positive change

7.1

Analysis Framework

# ANALYSIS FRAMEWORK / SITE SCALE

## CONNECTIVITY

VEHICULAR  
PUBLIC TRANSIT

PEDESTRIAN  
OPEN SPACE  
LAND USE  
DENSITY

FIGURE GROUND

- Determine street hierarchy and potential traffic issues
- Determine effectiveness of current systems and potential for future connections
- Determine walkability of the city
- How can the site connect to the open space network
- How will the design compliment and fill voids within the context
- How will the design effectively transition into the contextual density and building height
- How will the design fit into the urban fabric

## SOCIAL

DEMOGRAPHIC STRUCTURE

DIVERSITY  
OWNERSHIP  
NEIGHBORHOOD/DISTRICT IDENTITY  
VERNACULAR AND FORM

AREAS OF HIGH POTENTIAL  
AREAS OF HISTORICAL SIGNIFICANCE

- What are the common genders, ages, and races in the immediate context
- Are there any stratifications present
- Are there any stratifications present, public-private partnerships
- How do these identities influence the promotion of social memory
- How do these get tied into the urban form and influence the promotion of social memory
- Vacant land, ecological or social stress, educational opportunities
- Role in promoting social memory

## ECOLOGICAL

HYDROLOGY  
TOPOGRAPHY  
HABITAT  
FLORA + FAUNA  
SLOPE

ASPECT  
LOCAL CLIMATE  
INFRASTRUCTURE

- Drainage influence on form, stormwater management strategies
- Site lines to improve human experience, influence urban form
- Specific opportunities for endangered species, influence biodiversity
- What are local plants that will promote ecological resilience
- What areas are unsuitable for development, require special attention for connectivity
- Influence on building orientation, formation of open space
- Wind, peak sun exposure, rain events, and microclimate
- Possibilities for closing water cycle loops

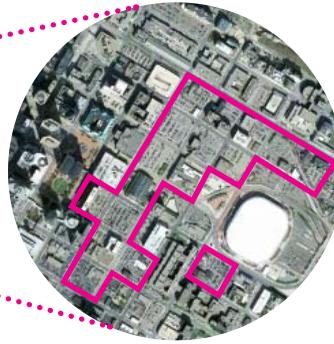
## ECONOMIC

RECENT DEVELOPMENT PROJECTS  
RELEVANT INSTITUTIONS  
FUNDING SOURCES

NATIONAL TRENDS  
CITY TRENDS

- Recent developments within the immediate context
- Where is the site within the adaptive cycle, what is driving the economy
- Potential catalysts for influencing positive economic growth in the context
- Are there stratified trends present
- What are the important factors in the local economy, how will this influence the development

# ULI HINES COMPETITION 2013 / THE ARMORY



## 7.2 Location

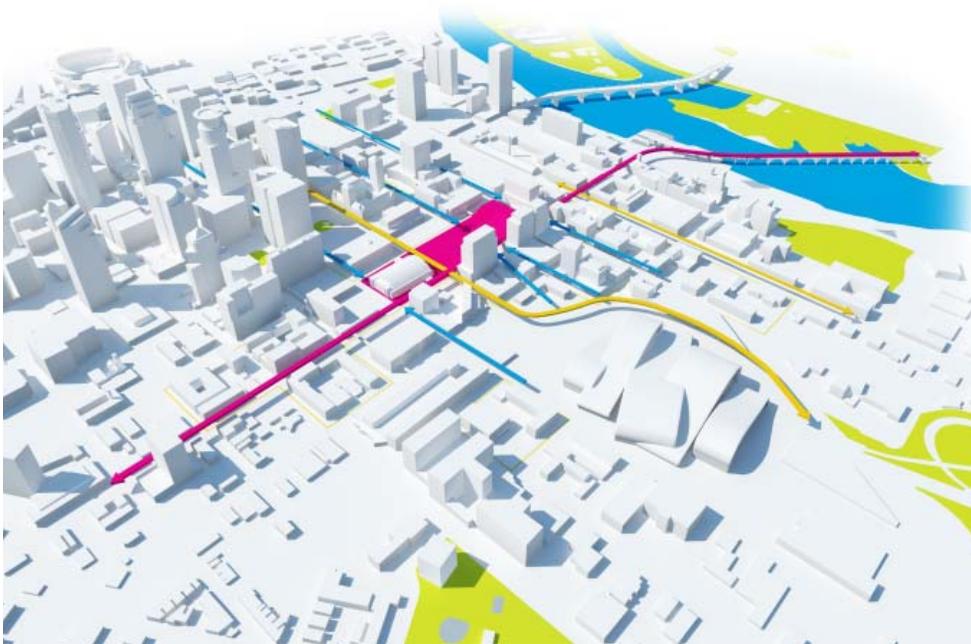
The site is located in Downtown Minneapolis between the Central Business District and the Minnesota Vikings football stadium. The Mississippi River is two blocks north. The current site use is primarily surface parking with a few historic buildings.

The Armory is an urban development that seeks to reorganize a stratified area of Downtown Minneapolis under a new basin of attraction. In its existing condition, the 17 block site in Downtown East is a series of surface parking lots and a scattering of historic buildings and light industry adjacent to the Minnesota Vikings football stadium. This suggests a late K phase, where the function of the site is a degraded urban condition that relies on the football stadium and daily commuting as a socio-economic identity.

The focus of the proposal is to create a new urban district within Downtown that leverages the historic character of The Armory and reinterprets it as a civic identity for a new neighborhood. In terms of resilience, The Armory emphasizes the metro scale, thresholds, diversity, and connectivity. A lesser focus is on the regional scale, creating redundancies, and adaptive planning/management. The design proposal uses a holistic approach that addresses a range of social and economic issues within the urban context, but ecological strategies were not used.

## 7.3 Design Framework

The masterplan focuses on The Armory as a vibrant urban amenity that connects across the river via Portland Ave. and the existing pedestrian/vehicular connections perpendicular to the park. A new light rail transit line connects downtown past the Vikings Stadium to St. Paul, the airport, and other destinations. The site also focuses on creating a pedestrian-oriented district that makes connections at smaller scales than the light rail, bus lines, and bicycle corridors.

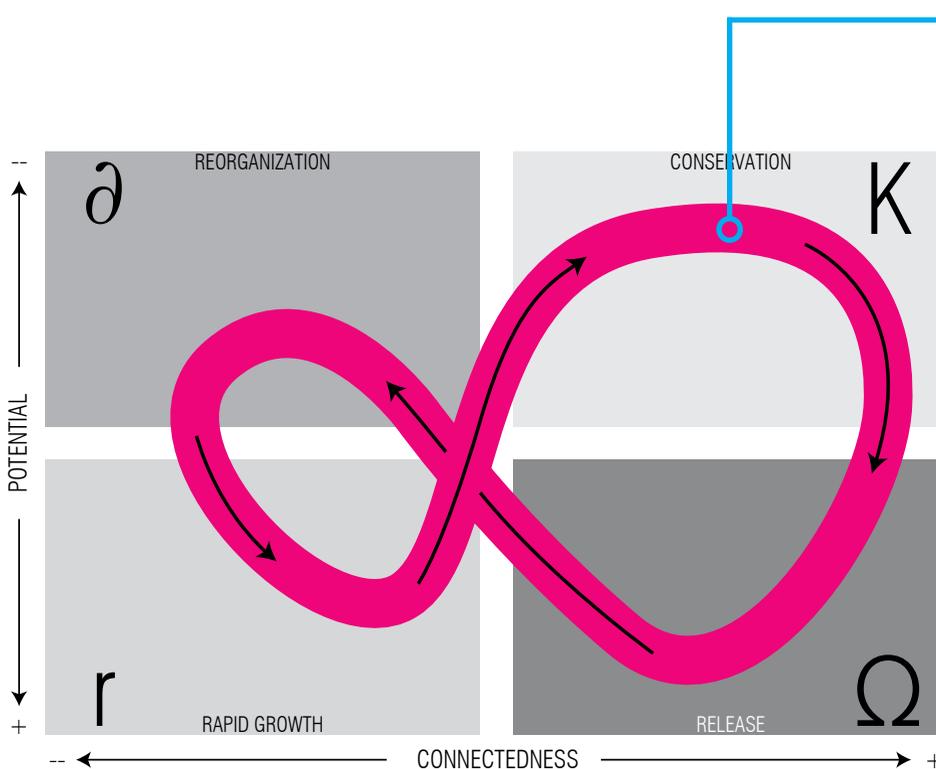
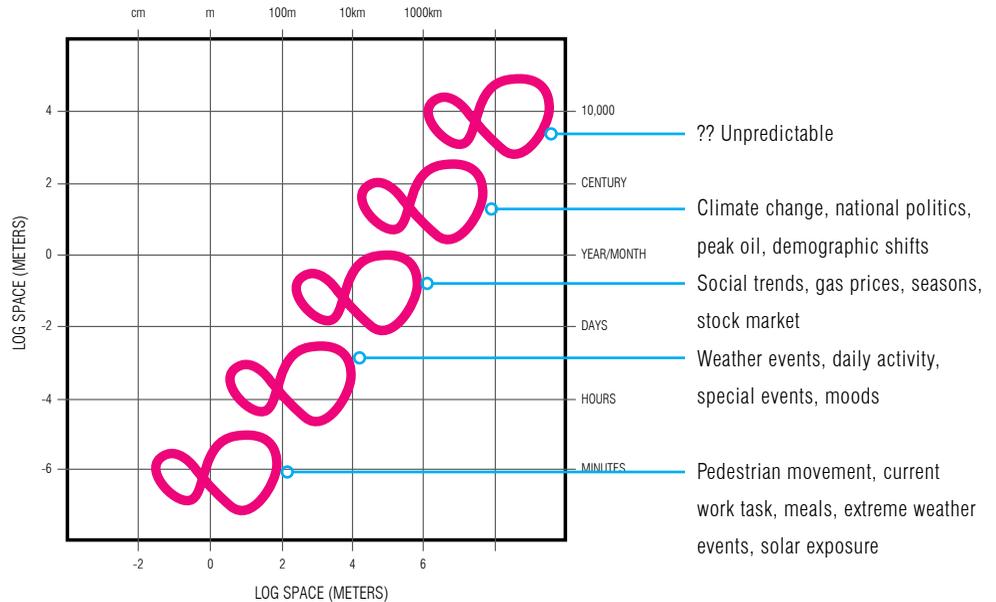


# RESILIENCE AND MINNEAPOLIS

## 7.4

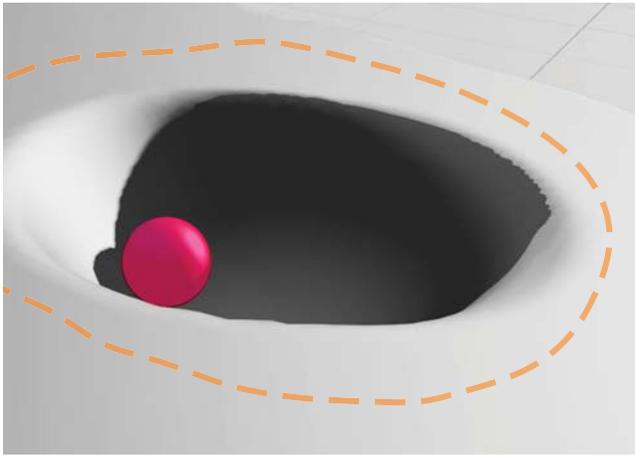
### Panarchy Map

The map at right demonstrates a brief set of examples of some of the social, ecological, and economic activities that occur in a hierarchical temporal scale in an urban environment. The way that these interact through time and space have implications at the site scale, specifically in Minneapolis. It is important to develop an understanding of these interactions in order to have a well-informed design.



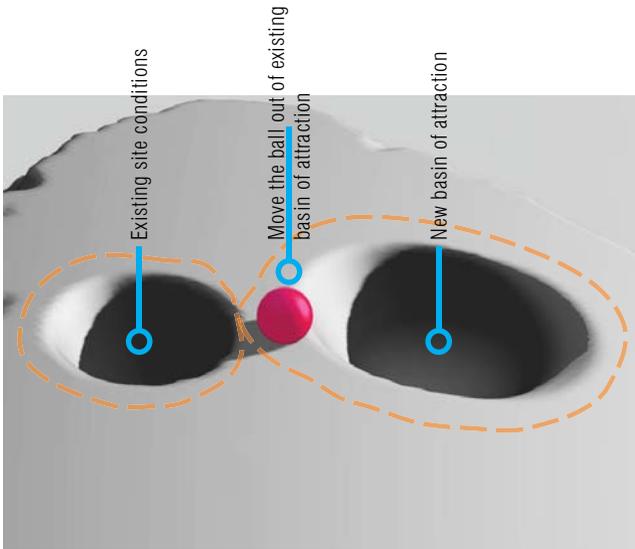
## 7.5 Adaptive Cycle Position

The site in Minneapolis is currently in the middle of the conservation phase. A stratified land use of surface parking coupled with low variability in spatial use and activity have resulted in a highly stable, resilient site. With current land values staying stable and relatively high, it does not indicate that a release phase is in the near future. In order for the adaptive cycle to move into the release phase, there will need to be a significant disturbance in multiple systems, primarily social and economic. Ecologically, the site is entrenched in a very strong K phase.



## 7.6 Current Basin of Attraction

The current basin of attraction is based upon a stratified economic activity (surface parking) with little other identity besides a handful of underutilized buildings. This basin is highly resilient, but there is an opportunity to move the ball out of this basin and into a new one with the new Vikings stadium providing economic incentive for development.



## 7.7 Two Basins

The purpose of leveraging The Armory as a strategy for urban infill and development is to exert enough change in order to move the ball (the site) into a new basin of attraction. This change is orchestrated through economic investment and the creation of a new district identity, which instills a greater social value.

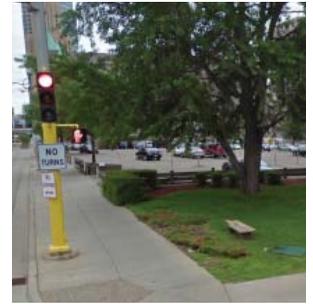
Through a detailed inventory and analysis of the Minneapolis-St. Paul region, the city, and the site there were several critical thresholds identified. The slowest and largest scale variable threshold identified was socio-economic in an aging Midwest baby-boomer population that is seeking to retire in an urban environment that provides the activity of the city with similar amenities offered in the suburban communities they have lived in for so long. This tipping point of a large demographic retiring was seen as an opportunity to provide a stable living community within Downtown Minneapolis that accommodates this shift in lifestyle. Another population that The Armory seeks to adapt to is a 160,000 daily commuter influx to Downtown. The assumption was made that roughly 20% of this population would be willing to live in Downtown rather than the suburbs if the opportunity was provided. The Armory provides the infrastructure and living amenities needed to accommodate this shift in population growth.

Other social thresholds identified were identified including a social stratification of predominately white young residents and a complete lack of identity within the Downtown East neighborhood. The development responds to this social stratification by providing amenities for a greater diversity of people to increase adaptive capacity. These

## 7.8

### Existing Site

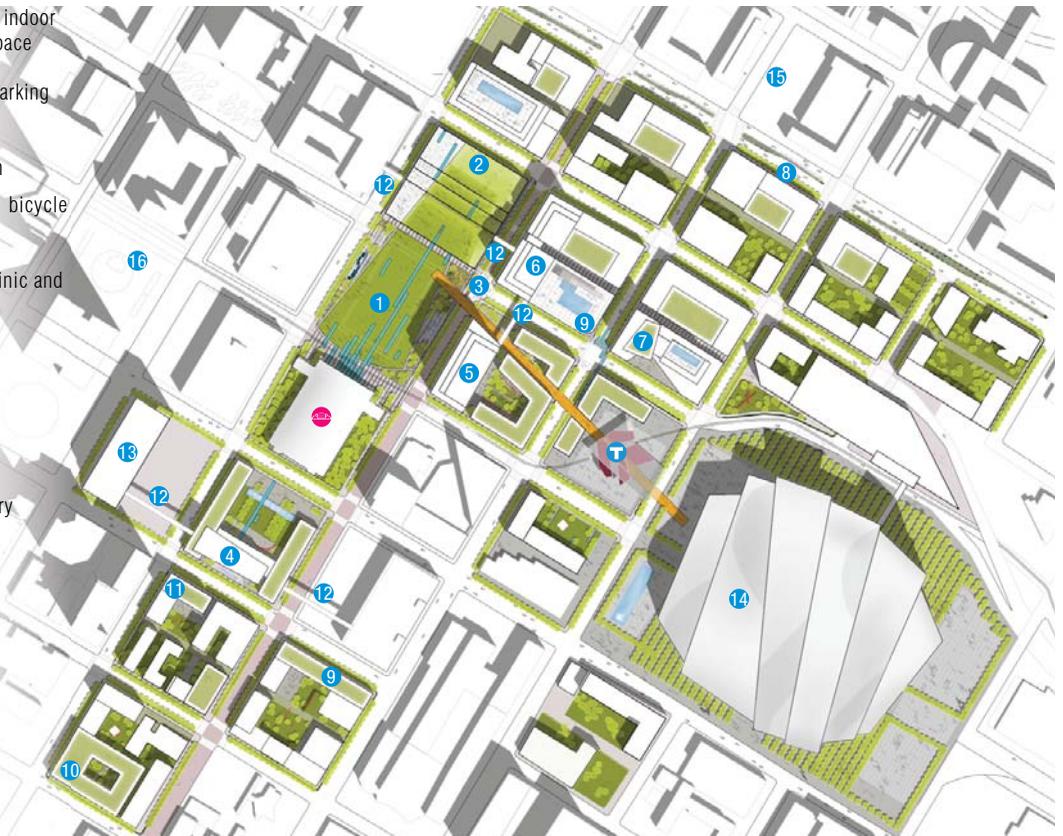
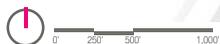
The purpose of leveraging The Armory as a strategy for urban infill and development is to exert enough change in order to move the ball (the site) into a new basin of attraction. This change is orchestrated through economic investment and the creation of a new district identity, which instills a greater social value. The goal with the new basin is to create as much resistance and latitude as possible.



## 7.9

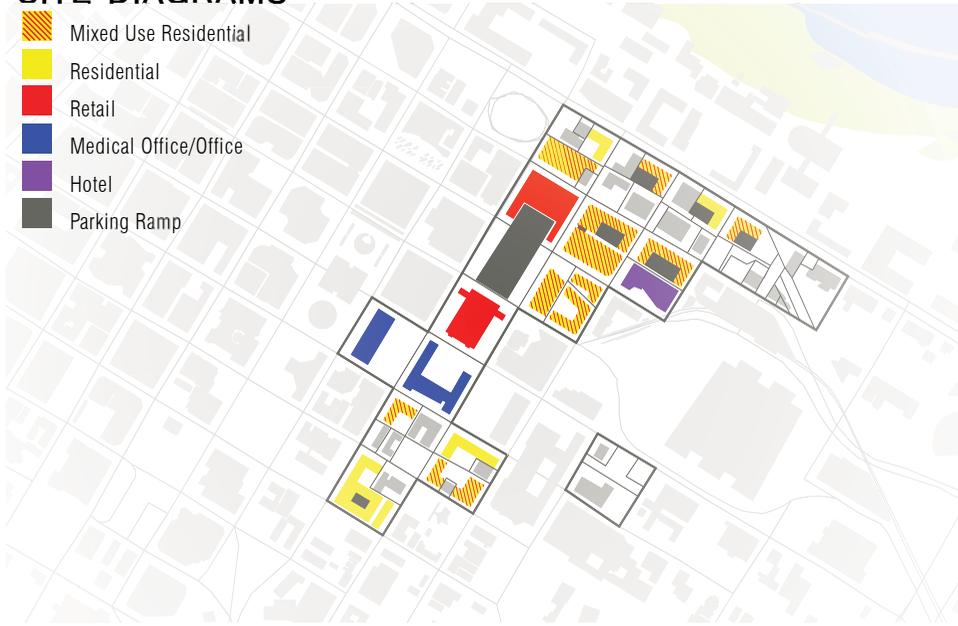
### Masterplan

- Armory - repurposed as an indoor market and flexible civic space
- ① Armory Green + 500 car parking ramp
- ② The Shops at Armory Green
- ③ Portland Ave. pedestrian + bicycle experience
- ④ Armory District Medical Clinic and Research Facility
- ⑤ Star Tribune Terrace
- ⑥ Armory Towers
- ⑦ Armory Hotel
- ⑧ Washington Ave. infill
- ⑨ AMC Theaters at The Armory
- ⑩ Senior-oriented living
- ⑪ Affordable housing
- ⑫ Skyway connection
- ⑬ Existing Thrivent building
- ⑭ New Vikings stadium
- T Light rail stop
- ⑮ Mill District
- ⑯ Central Business District



## SITE DIAGRAMS

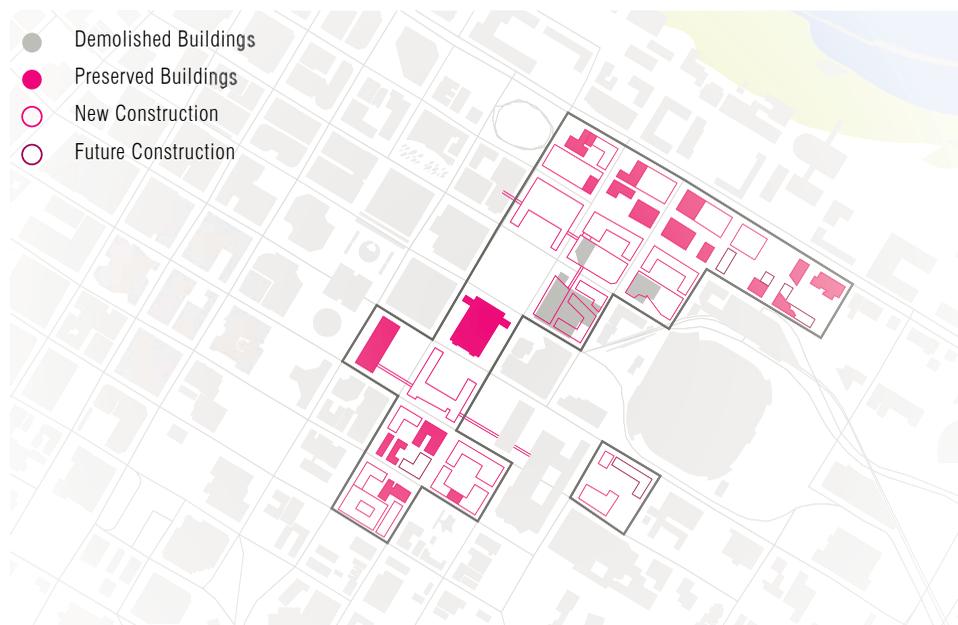
- Mixed Use Residential
- Residential
- Retail
- Medical Office/Office
- Hotel
- Parking Ramp



### 7.10 Land Use Diversity

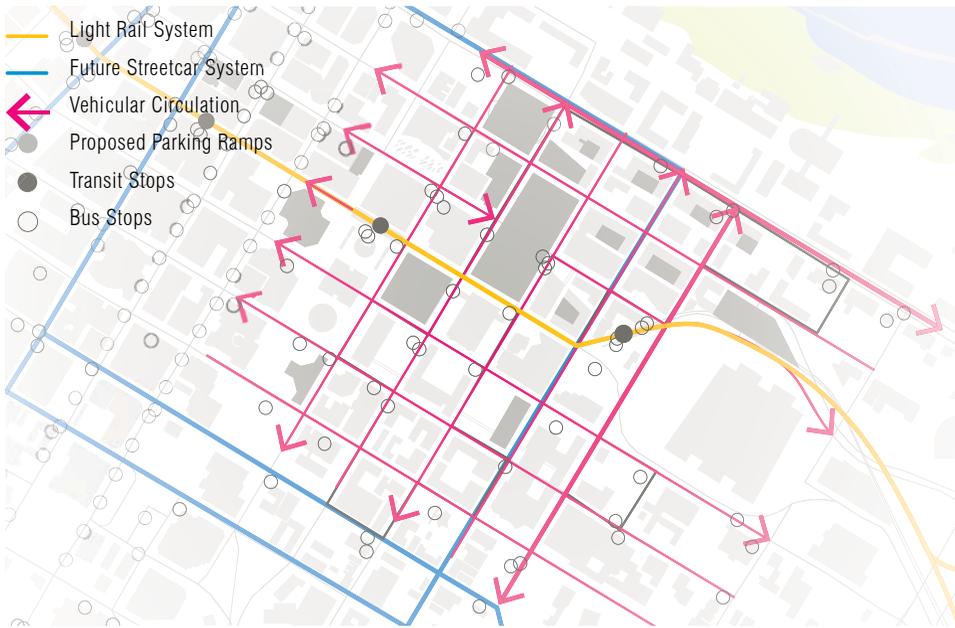
The site is located in Downtown East between the Central Business District and the Minnesota Vikings football stadium. The Mississippi River is two blocks north. The current site use is surface parking with some historic buildings.

- Demolished Buildings
- Preserved Buildings
- New Construction
- Future Construction



### 7.11 Figure Ground

The site is located in Downtown East between the Central Business District and the Minnesota Vikings football stadium. The Mississippi River is two blocks north. The current site use is surface parking with some historic buildings.



### 7.12 Transit Connectivity

The site scale connectivity emphasizes current transit stops and optimizing efficiency of access. Traffic circulation is rerouted around Armory Green, created more walkable adjacent spaces.



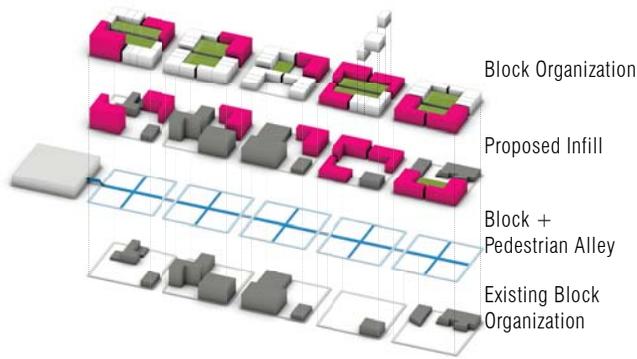
### 7.13 Pedestrian Connectivity

The site is located in Downtown East between the Central Business District and the Minnesota Vikings football stadium. The Mississippi River is two blocks north. The current site use is surface parking with some historic buildings.

## 7.14

### Infill Strategies

|                             |                             |
|-----------------------------|-----------------------------|
| Internalized Parking        | Internalized Parking        |
| Pedestrian + Service Alleys | Pedestrian + Service Alleys |
| Wind Relief                 | Wind Relief                 |
| Variable Facades            | Variable Facades            |
| Cellular Parcel Division    | Cellular Parcel Division    |



amenities are intended for people who might move to the new district, but also commuters and people coming for events at the Minnesota Vikings stadium. This fluctuation of people on a daily and occasional basis also needed to be addressed in the spatial structure of the development. The Armory serves as a civic identity that the residents of the district, city, and region can identify with. The name refers to the structure itself and the historical qualities that it possesses but also refers to the proposed park, Armory Green, which acts as the first civic open space within the Downtown. The Armory is repurposed from a parking structure to a flexible civic amenity, housing an indoor market as well as special events. Armory Green accommodates a range of program including daily activity during the summer months, railgating during Vikings football games, sledding in the winter, retail shopping, and specialty stores (Niketown, Google Play, restaurants/clubs, a daycare, a gym).

Ecological and economic thresholds were not identified as being particularly relevant to the design. Ecological strategies in general were limited because of a flat site (1-5% slope), no proximity to major habitat patches, lack of flooding of the Mississippi River at this particular section, and the location of the site which was in a dense urban area. Therefore all of the ecological strategies were limited in this design. Economic thresholds pertained mainly to a lack of for-sale housing in the Downtown and a lack of stable population with most people commuting every day.

## 7.15

### Sustainable Strategies

|                                |                             |
|--------------------------------|-----------------------------|
| Daylighting                    | Internalized Parking        |
| Green Roof Terraces            | Pedestrian + Service Alleys |
| Electric Car Charging Stations | Wind Relief                 |
| Grey Water Storage             | Variable Facades            |
| Solar Energy Collection        | Cellular Parcel Division    |



In terms of diversity, the emphasis was again on social systems. The primary strategy to increase social diversity was to leverage The Armory and Armory Green as common civic identities for the district, while creating a variety of housing types and amenities to cater to a range of demographic groups. These groups include permanent and transient populations of: the elderly, an aging baby boomer population, LGBT, single parent/non-traditional households, commuters, recent college graduates, and low income. Ecological diversity is promoted through a redefined Portland Ave., which serves as the primary north/south bicycle corridor through the site connecting Elliot Park to the south up to The Armory and north to the River. Bioswales and an increased tree canopy capture stormwater and promote species diversity. Economic

Retail + Residential + Parking Ramp

diversity is achieved by tailoring the urban form to a variety of retail and commercial types. The Shops at Armory Green provide specialty and high-end retail, while the adjacent streets provide convenience retail and other amenities. Integrating diversity into The Armory District is one of the primary goals of the development proposal.

Redundancy is a category of strategies that is generally avoided in The Armory. This is because it was identified that the vision for this new district would need to possess qualities that currently do not exist or are missing in the greater downtown area. Therefore the redundancies that were established in the design were either not central to the overall concept or were highly selective. The primary use of redundancy was in Armory Green, which bundles many different functions within one space. These functions include: parking, park, retail, specialty retail, a market, civic space, transit, and a diversity of social program. By bundling these uses, if one store or functionality of the Green fails, there are many more that can absorb the disturbance and reorganize effectively.

Other of significant redundancies were to create an open space redundancy within the greater parks system of Minneapolis (which is rated one of the best in the US, but does not currently have a significant civic park in Downtown), cater amenities and housing to the existing stable demographic in Downtown (young, white population), and to utilize building and block typologies that mimic other successful adjacent neighborhoods including the Mill District and Loring Park. By using a redundant typology of urban form, it retains consistency within the Downtown in terms of character and quality of space. As far as using redundancies, The Armory is an example of a situation where it is more appropriate to develop diversity with fewer redundancies than vice versa.

## 7.16

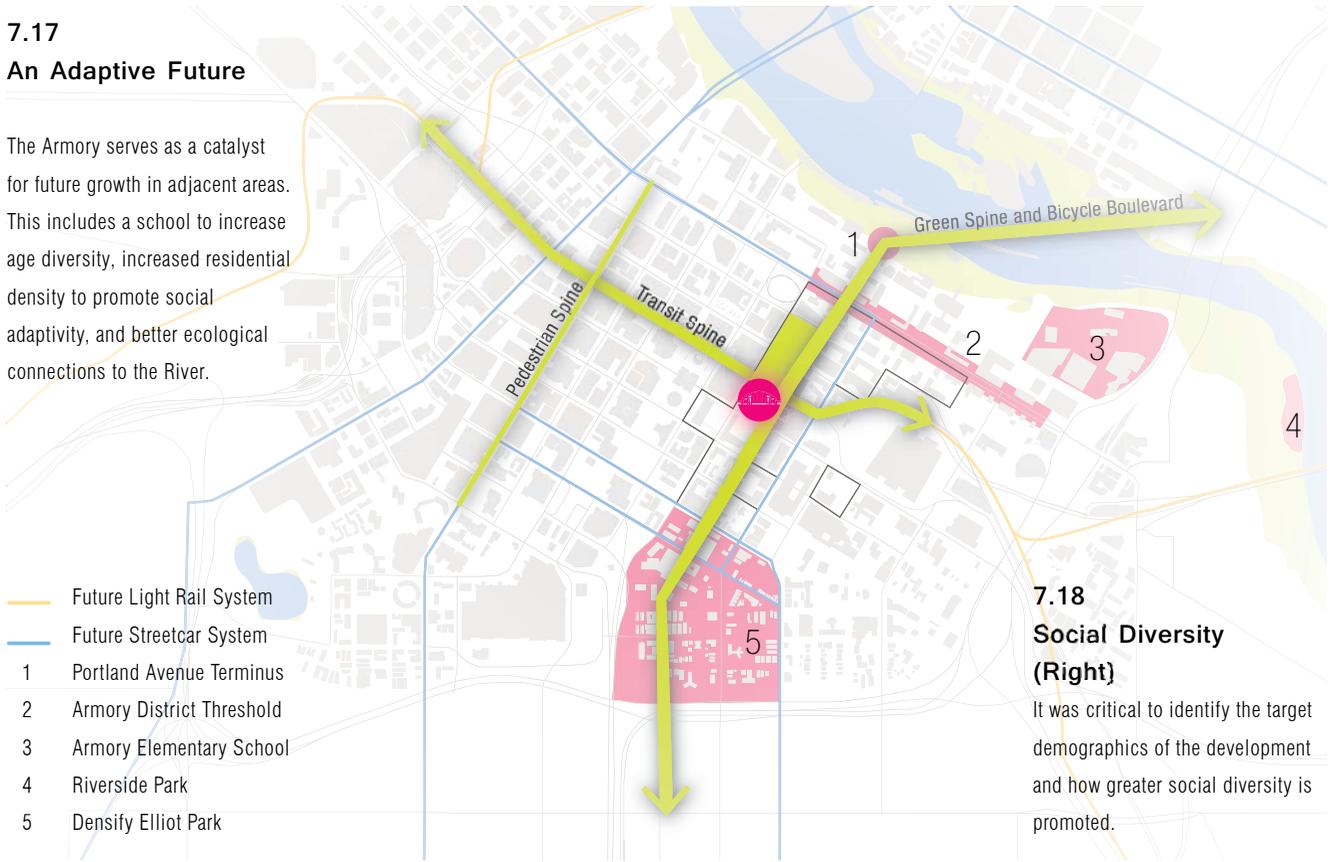
### A District Identity

The Armory is a complex identity that refers to the historic structure itself, but it also becomes the focal point of football game days. The urban design seeks to accommodate the increase in pedestrian flows during these peak events, responding in a resilient capacity. In this image, football fans march down 4th St. to bars, restaurants, and a special event at a large tent set up at Armory Green.



## 7.17 An Adaptive Future

The Armory serves as a catalyst for future growth in adjacent areas. This includes a school to increase age diversity, increased residential density to promote social adaptivity, and better ecological connections to the River.

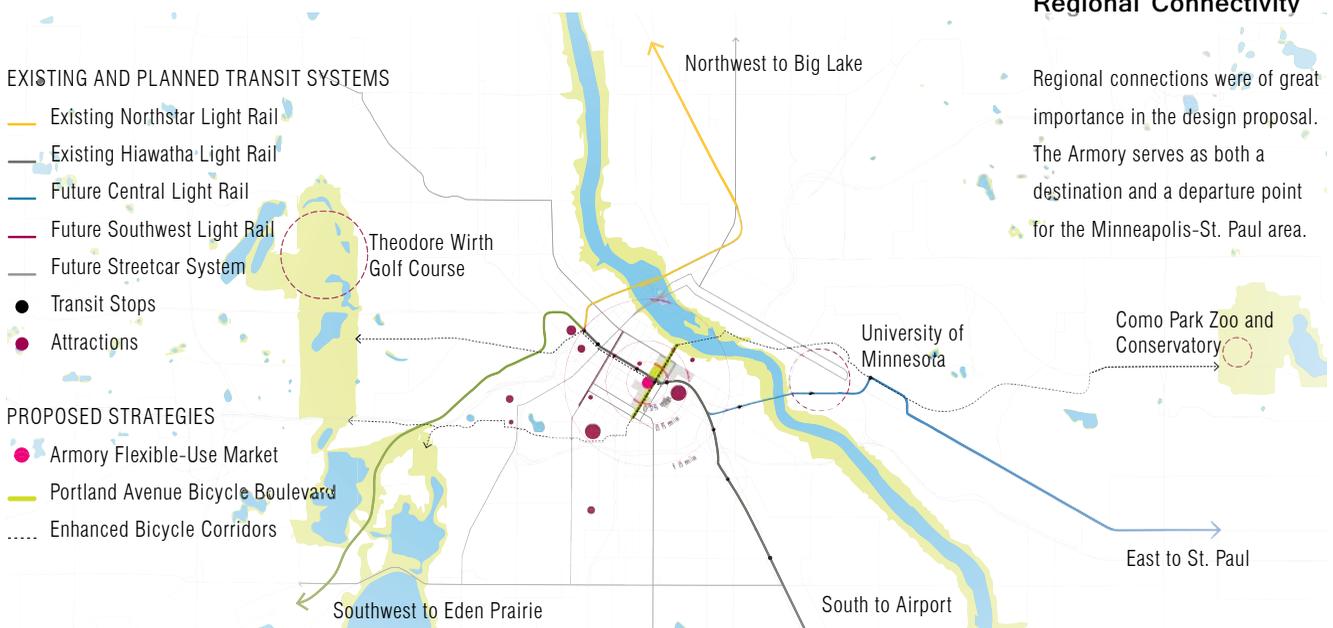


## 7.18 Social Diversity (Right)

It was critical to identify the target demographics of the development and how greater social diversity is promoted.

## 7.19 Regional Connectivity

Regional connections were of great importance in the design proposal. The Armory serves as both a destination and a departure point for the Minneapolis-St. Paul area.





**Dusty**

An avid cyclist and graduate student at the University of Minnesota, Dusty lives in Dinkytown and works at the Armory Medical Clinic. He enjoys having lunch at the Armory, the ease of his daily commute, and proximity to his favorite biergarten, the Gjallarhorn.



**Bruce + Sara**

Bruce and Sara recently purchased a condo at Armory Towers. They frequently buy a bottle of wine and overlook the park from their balcony. Bruce is a director of technology at Target, while Sara is an active volunteer in the community.



**Amoon**

A single mom, Amoon has worked for years at City Hall. She commutes from the suburbs with her daughter who attends nearby De La Salle High School. Amoon often picks up a few things for dinner at the Armory on her way home.



**Don + Ashley**

Don decided to move to independent living off of Portland Ave. to be closer to his love for the performing and visual arts. This weekend he is going to St. Paul via light rail to visit his granddaughter and attend her piano recital.



**Jason + Wendy**

Jason and Wendy came into town for the Vikings vs. Packers game. While railgating at Armory Green, Wendy was surprised by the variety of retail nearby. She convinced Jason to plan another visit soon to do Christmas shopping.



**Dave + Michael**

Dave walks via Skway to his job at a marketing firm downtown and Michael commutes by light rail to a law firm in Bloomington. As Mill District residents, they enjoy proximity to Armory Green and frequenting their favorite restaurants.



**Cai**

Cai lives in a studio apartment in the Armory District where she works nearby as a bartender and is finishing her degree at Minneapolis Community College. Most weekends she meets her friends at the Armory Market to enjoy a fresh brioche and coffee.



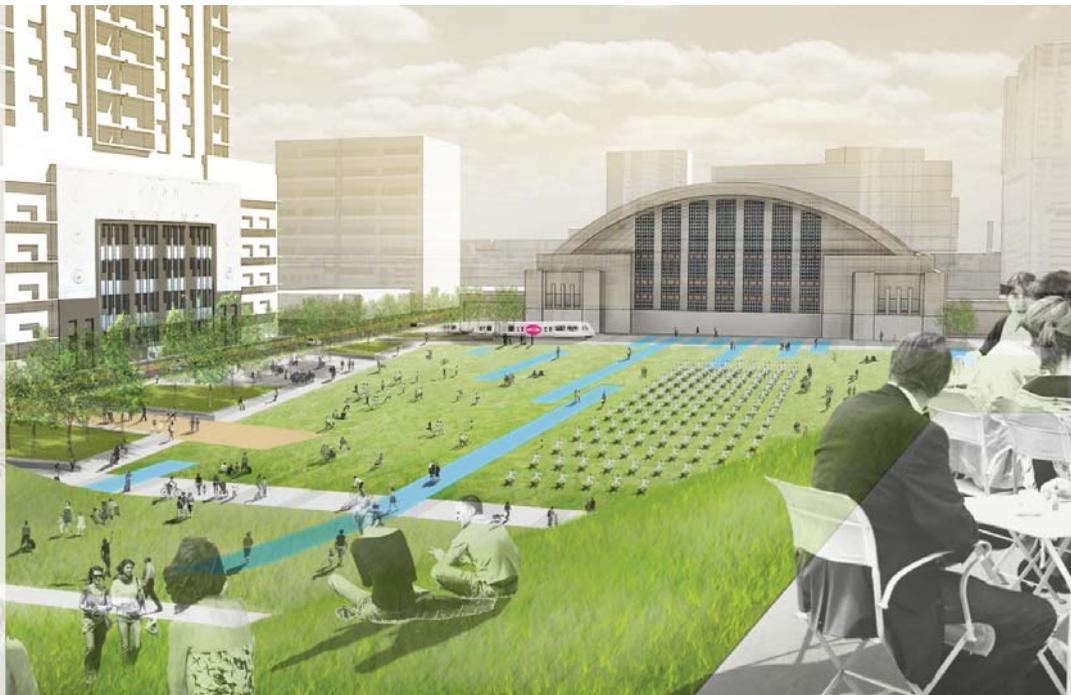
**Elijah**

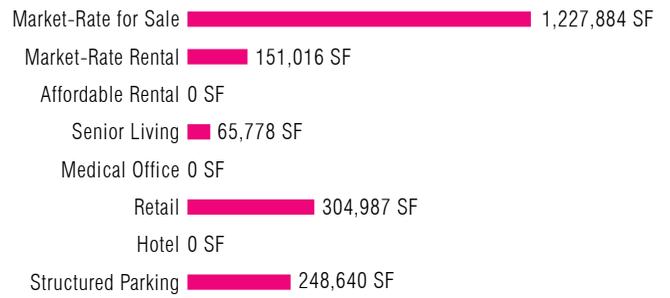
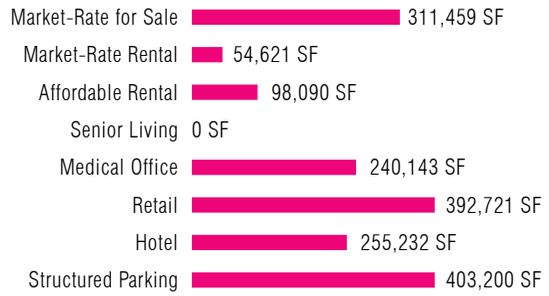
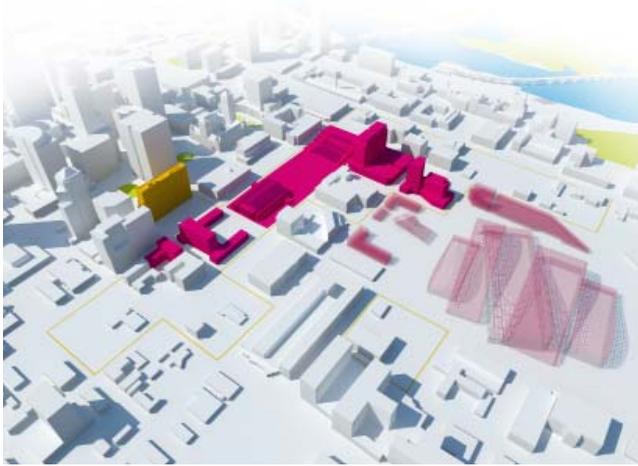
Elijah is a recent graduate from culinary training courses at the nearby Catholic Charities Center after looking for a way out of homelessness. He now works at an Armory District restaurant that specializes in using local food sources.

**7.20**

**The Armory Green**

The Armory Green serves as a response to the Armory itself and functions at many levels. Retail as part of the Green provides consistent activity and the scale of the park accommodates a range of people and activities that function during all times of the year. The Green serves as the primary civic open space of Downtown and connects people to people, businesses, residences, and institutions. Here a summer lunch hour plays host to a greater social diversity and activity.





## 7.21

### Phasing Strategy (Left)

Phasing is a required component of the competition. The design proposal used a strategy that leveraged intense development in the first phase, with The Armory and Armory Green being established along with the new Vikings Stadium. Phases two and three focus on increased infill and more residential development. In terms of resilience, the phasing leverages financial feasibility while allowing The Armory to act as the catalyst for a new release phase for the district, with it continuing to reorganize and establish into a conservation phase towards the end of the ten year hold.

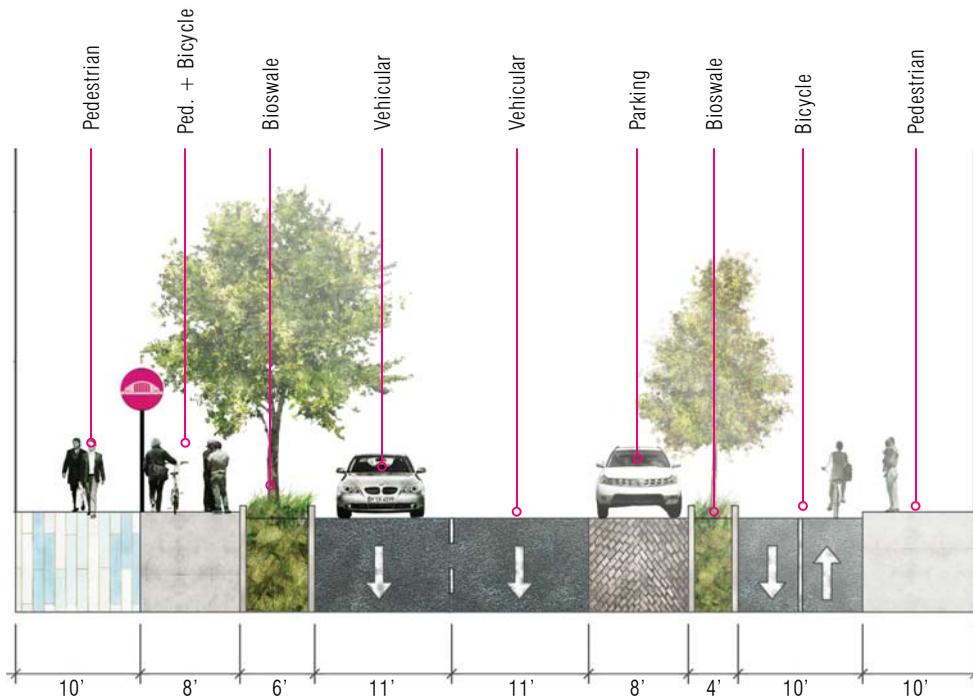
In order for The Armory to be a successful development, it was critical to establish connections at a range of scales. Social connectivity surfaced as the greater focus of this connectivity, using Armory Green, The Armory Market, transit networks, and a greater pedestrian focus as a way to connect people together through identity and greater interaction. It was again difficult to promote ecological connections because of the limitations of the site boundaries, but Portland Ave. serves as a new street typology that if adopted in the future at a greater scale could facilitate better connections for urban flora and fauna, especially to the Mississippi River Corridor. Armory Green does connect to the greater parks system through light rail and bicycle networks, but the effects of these connections are mostly social as the distances are too far to promote real ecological benefits. Economic connectivity was secondary to the social connections created through the Armory District. The types of economic connectivity created were centered on linking to other successful economic drivers including Nicollett Mall, the Warehouse District, the Target Center, and the Central Business District. By connecting these economic drivers with social infrastructure such as pedestrian networks, transit, and bicycle corridors it set up the development to accommodate the flows necessary for a resilient economy.

Adaptive planning and management is not a category of resilience that is not represented well in The Armory. This is in part because the competition does not facilitate this kind of strategy well within the bounds of the competition brief and the scope of the design. The two methods that were used in this category pertained to economic adaptivity. The first is leveraging The Armory as a resilient district that over time will catalyze greater change and reorganization in adjacent areas, including a new school, greater focus on managing the Mississippi River Corridor, and increasing density and adaptive capacity in Elliot Park to the south. The second is using an adaptive infill strategy for Washington Ave. which is primarily a vehicular corridor with some historic buildings fronting the street. As financial feasibility allows, new construction will infill blocks that are currently fragmented and unify the urban edge to create a diverse experience and allow for slow economic gain. So while The Armory is about reorganizing a blighted urban area around a new set of functions and a new identity, it will also create greater potential for surrounding areas to move into more desired basins of attractions as well.

The Armory uses a holistic approach of resilience theory to engage a design for a new urban development. Despite this holistic approach, several systems and scales are neglected in terms of resilience. Ecological methods were generally lacking, in part due to the limitations of the site boundaries and scope of the competition. It is clear how the District fits into the immediate metropolitan scale context, but not as clear as to how the development fits within the region in terms of methods for promoting resilience. The site scale is generally covered well. Adaptive planning and management strategies are almost entirely neglected, which is a critical component to long-term resilience. The time scale of ten years remains consistent with what the competition specifies (a ten year ownership hold), but what happens beyond the first ten years of development is also unclear.

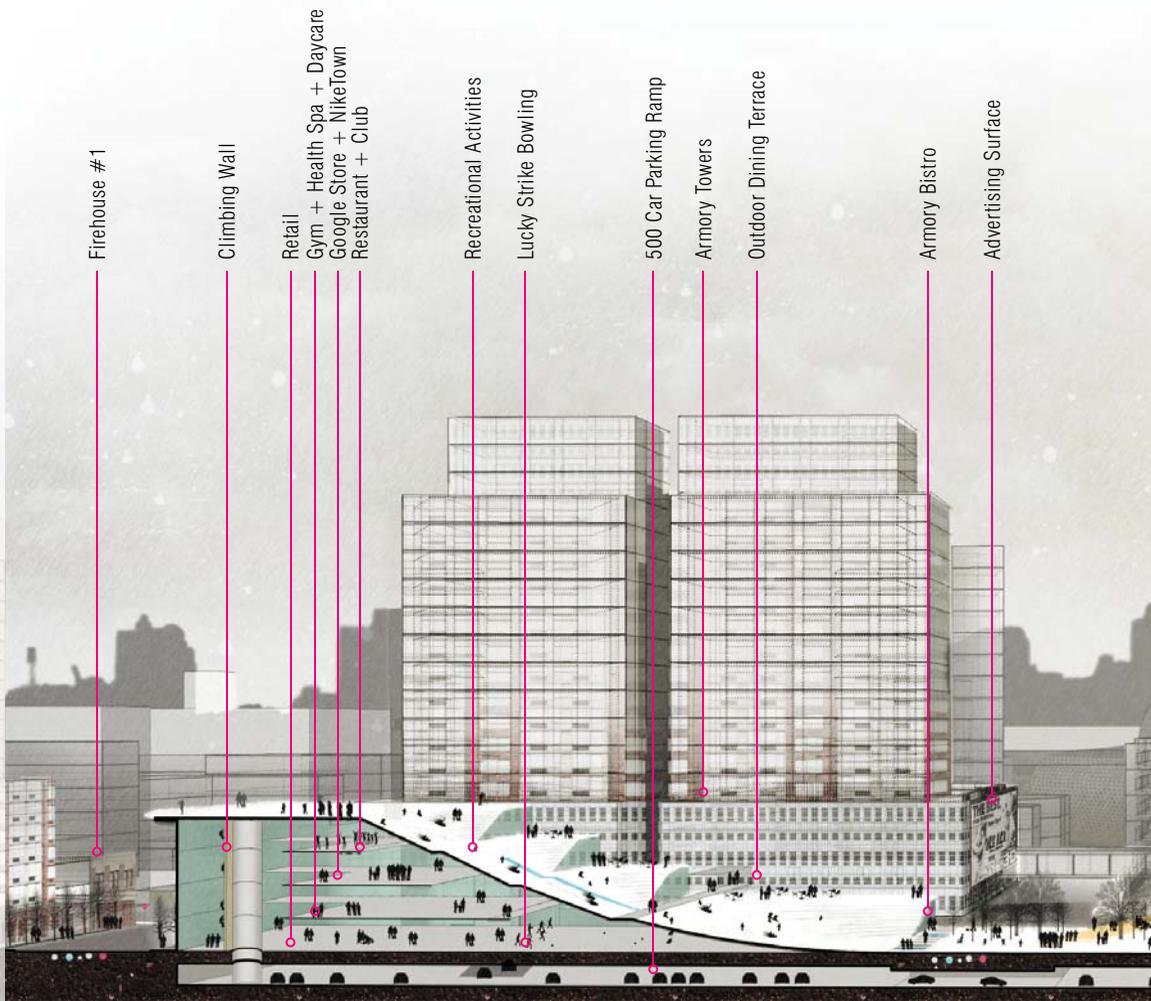
## 7.22 Portland Ave.

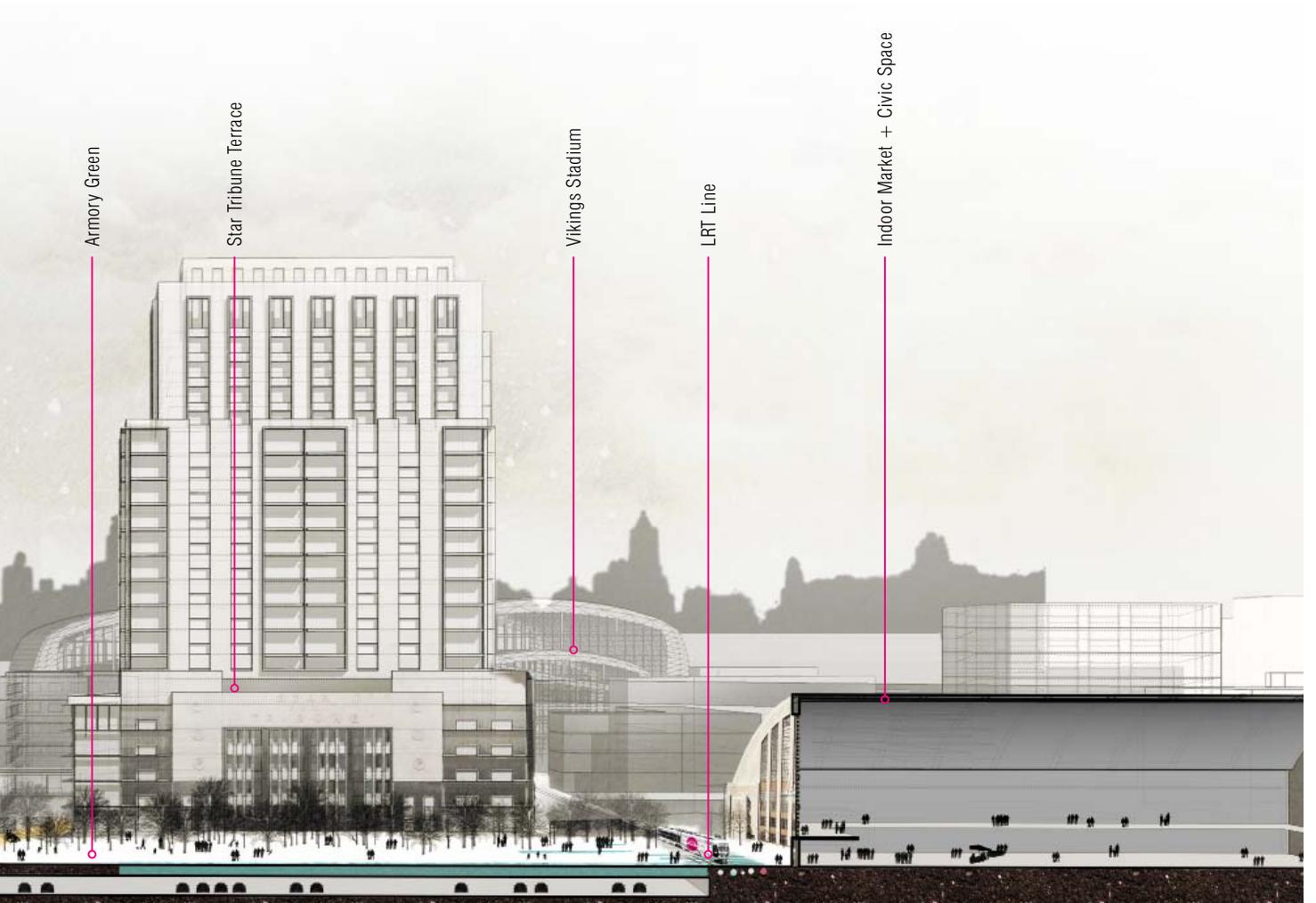
Portland Ave. serves as the primary north/south bicycle and pedestrian connection that spans from Elliot Park to the south across the River to Marcy-Holmes neighborhood. Bundling social and hard infrastructure creates redundancies and allows other street networks to accommodate vehicular and bus transit traffic.



## 7.23 The Armory

The Armory + Armory Green functions at many different levels, combining retail, specialized retail, parking, park, a market, and civic space. By combining these uses, it ensures consistent activity as well as the ability to accommodate a range of activity. The Armory connects transit lines, neighborhoods, people, businesses, and institutions and acts as the central gathering space for Downtown Minneapolis.





Armory Green

Star Tribune Terrace

Vikings Stadium

LRT Line

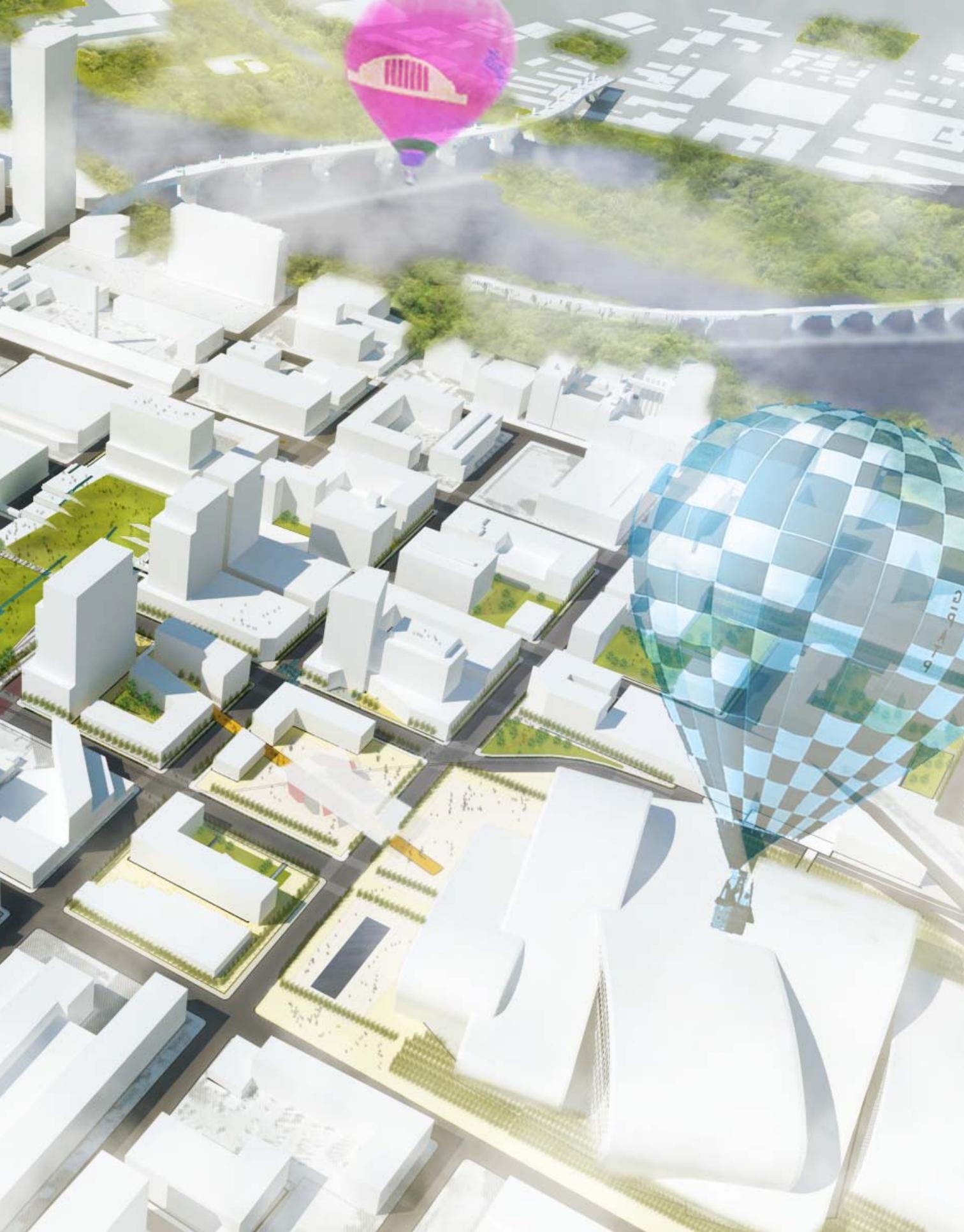
Indoor Market + Civic Space

## 7.24

### A Resilient Future

The Armory is a vision for a resilient future in Downtown Minneapolis. This District is one that responds to the socio-economic needs of an increasing urban population that seeks an adaptive lifestyle. Such a lifestyle provides the amenities that focus on alternative transportation and walking as a way to connect with businesses, people, and local and regional destinations. This vision is also one for a city that establishes a standard of living in a mid-size urban environment- one that sets a precedent in this nation and abroad.





# KEY ISSUES / REGIONAL + METRO SCALE

## CONNECTIVITY

VEHICULAR  
PUBLIC TRANSIT

PEDESTRIAN  
OPEN SPACE

- Connect to major highway infrastructure, provide minimum parking
- Leverage existing plans for regional/metro transit including light rail and bus, opportunities to enhance current bicycle corridors
- Currently a lack of pedestrian experience in Downtown
- MPLS has one of the greatest park systems in the US, but there is a visible lack of open space in the Downtown area, connect to greater context through alternative transportation

## SOCIAL

DEMOGRAPHIC STRUCTURE  
DIVERSITY  
OWNERSHIP  
INCOME

NEIGHBORHOOD/DISTRICT IDENTITY

- Some European influence, predominately white (63%)
- Some Hmong and Somali immigrants, fairly stratified
- Unknown
- Most work in the Downtown area, large corporations have headquarters (Target, US Bancorp, Xcel Energy, Ameriprise Financial, Thrivent)
- Distinct urban neighborhoods, but less defined in the Downtown area

## ECOLOGICAL

HYDROLOGY  
TOPOGRAPHY  
HABITAT

CLIMATE

RAINFALL  
TEMPERATURE + SOLAR

- Mississippi River is the major corridor
- The site is almost flat, 2-5% slope
- The River corridor is the best opportunity, city has a well-established park system
- Climate is known for harsh winters, beautiful summers (continental climate)
- Flooding is not an issue despite presence of River
- Maximize solar gain in winter, minimize in summer

## ECONOMIC

RECENT DEVELOPMENT PROJECTS  
RELEVANT INSTITUTIONS  
FUNDING SOURCES

NATIONAL TRENDS  
CITY TRENDS

- Most successful in the last five years are for-sale condos
- Connections to University of Minnesota, Minnesota Vikings
- TIF's are hard to come by in the city, tax incentives possible for historic structures, most equity will come from land value
- Trend of baby-boomers moving to urban areas as they retire
- Most people commute to work in the city- potential for capturing a new residential market in the Downtown area

7.25

Analysis Results

# KEY ISSUES / SITE SCALE

## CONNECTIVITY

VEHICULAR  
PUBLIC TRANSIT

PEDESTRIAN  
OPEN SPACE  
LAND USE  
DENSITY

FIGURE GROUND

- Good street hierarchy, will want to maintain efficiency
- One transit stop on site, many bus stops, bike share locations could be implemented throughout
- Currently a lack of pedestrian experience, very wide streets + blocks
- Opportunity for a greater hierarchy of public and private open space
- Overlap with CBD and adjacent neighborhoods
- Can go up to FAR (floor/area ratio) of 12, very high, but should fit more to a neighborhood scale
- Will need to implement innovative infill strategies to fill voids

## SOCIAL

DEMOGRAPHIC STRUCTURE  
DIVERSITY  
OWNERSHIP  
NEIGHBORHOOD/DISTRICT IDENTITY  
VERNACULAR AND FORM  
AREAS OF HIGH POTENTIAL  
AREAS OF HISTORICAL SIGNIFICANCE

- Predominately young, white population in Downtown
- Wide opportunity to provide amenities for a greater range of people
- Most people rent, but there is some ownership in adjacent areas
- Mill District, Loring Park, Dinkytown, Elliot Park all adjacent
- Will need to combine modern and historical aesthetics
- Vacant land serves as a great opportunity for new development
- The Armory among other historic structures can serve as a new identity for this neighborhood and leverage the site's existing qualities

## ECOLOGICAL

HYDROLOGY  
TOPOGRAPHY  
HABITAT  
FLORA + FAUNA

ASPECT  
LOCAL CLIMATE  
INFRASTRUCTURE

- Almost no opportunities for large-scale stormwater capture
- Very flat site (2-10%)
- Almost no adjacent habitat patches besides River corridor
- Some street tree presence, need to increase urban forest, no unique fauna because in urban environment
- Maximize solar exposure in winter, minimize in summer
- Very harsh winters, need to accommodate snow removal
- Recycling network present, some farmers markets/local food, a few stormwater incentives

## ECONOMIC

RECENT DEVELOPMENT PROJECTS  
RELEVANT INSTITUTIONS  
FUNDING SOURCES

NATIONAL TRENDS  
CITY TRENDS

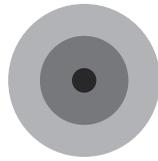
- For-sale developments, hotel appropriate, movie theater vacancy
- Connections to corporations, University of Minnesota
- TIF probably not relevant, some federal tax incentives for historic structures (The Armory, two other buildings that are optional parcels)
- Leverage local farm produce, small business
- The city is doing many good things, the economy is stable, but Downtown is lacking economic spark

REGIONAL

METRO

SITE

SPATIAL  
SCALE



|              |            |    |    |    |
|--------------|------------|----|----|----|
| THRESHOLDS   | SOCIAL     | 1  | 2  | 3  |
|              | ECOLOGICAL |    | 4  | 5  |
|              | ECONOMIC   | 6  | 7  | 8  |
| DIVERSITY    | SOCIAL     | 9  | 10 | 11 |
|              | ECOLOGICAL |    | 12 | 13 |
|              | ECONOMIC   | 14 | 15 | 16 |
|              | SPATIAL    | 17 | 18 | 19 |
| REDUNDANCY   | SOCIAL     | 20 | 21 |    |
|              | ECOLOGICAL |    | 22 |    |
|              | ECONOMIC   |    | 23 |    |
|              | SPATIAL    |    | 24 | 25 |
| CONNECTIVITY | SOCIAL     | 26 | 27 | 28 |
|              | ECOLOGICAL |    | 29 |    |
|              | ECONOMIC   |    | 30 | 31 |
| PLANNING     | ECOLOGICAL |    |    |    |
|              | ECONOMIC   |    | 32 |    |

TEMPORAL  
SCALE

5 Y

10 Y

50 Y

100 Y

150+ Y

## METHODS USED

- 1
  - Provide permanent living amenities for a Minneapolis regional population of 160,000 that commutes daily to downtown- decrease the commuter threshold
  - Create a livable community for an aging baby boomer population that is looking to retire in urban environments
- 2
  - Accommodate an influx of people for large events, including Minnesota Vikings games and daily commuting- retail, grocery, bars/restaurants, office/employment, apartments, for-sale condos
  - Decrease dependence on fossil fuels by promoting bicycling and pedestrian movement throughout the district
  - Provide the minimum parking required in order to encourage public transportation use and other alternative modes of travel
  - Respond to a cultural stratification (young, white) by promoting diversity and varying amenities in the district
  - Utilize an appropriate urban vernacular that enhances existing historical qualities, yet provides relevant modern aesthetics to increase social adaptivity
  - Overlap neighborhood identities, specifically the Mill District and the Central Business District to a lesser extent
- 3
  - Accommodate an influx of people for large events, including Minnesota Vikings games and daily commuting- creating larger spaces at the transit stop and the flexibility of Armory Green
  - Utilize The Armory as a civic identity that promotes social memory to a revitalized urban district- responding to a lack of identity and character in Downtown East
  - Increase socio-cultural memory through the preservation of historic buildings, including the Armory, the Star Tribune Building, and the diverse character of Washington Ave.
  - Provide adequate amenities for a range of demographic groups including the elderly (hospital/health, walkable streets, access to transit, protected open space) and children (open space, access to public transit, daycare, schools)
  - Establish connections with the University of Minnesota medical research to facilitate learning and innovation
- 4
  - Use appropriate street tree species that increase carbon sequestration and the urban forest of Minneapolis
- 5
  - Maximize efficiency for large snow events and the necessary cleanup of streets and pedestrian walkways
  - Utilize solar exposure through sustainable building typologies to increase solar gain for heat
  - Capture grey water and store in parking ramp structures for use in irrigation of green roof terraces and open space
  - Bioswales in Portland Ave. street typology capture stormwater runoff and cleanse before entering into the Mississippi River

## METHODS USED (CONT'D)

- 6 • Leverage a regional trend of commuting downtown from the suburbs as a strategy for creating a livable urban community
- 7 • Leverage a metropolitan trend of successful for-sale housing developments as a strategy for creating a livable urban community
- Establish the core of the development in Phase 1 to create a stable socio-economic entity that the surrounding development can grow around
- 8 • Flexible infill strategies allows for economic gain over time while utilizing the historic qualities of existing structures
- A common floorplate structure is used that allows the buildings built for condos can be renovated easily to apartments and vice versa, increasing the economic adaptive capacity of the development
- 9 • The Armory District serves a clear socio-cultural purpose within the region, as a destination, a livable community, and a prominent component of the greater parks system
- 10 • Promote diversity within the metro area, specifically catering to the Hmong and Somali immigrant populations
- Utilize the Armory building as a unique iconic and civic feature that creates a diverse experience within the metropolitan context
- Promotes a balanced age demographic structure within the context, enhancing the capacity for the development to respond to disturbances and create opportunities
- 11 • A heterogeneous mix of household types attracts a range of social groups
- Cater to a diverse demographic structure through housing typologies, including: an aging baby boomer population, LGBT, single parent/non-traditional households, commuters, recent college graduates, and low income
- Provide civic amenities for a diverse downtown population through the Armory and Armory Green
- A diversity of economic draws creates opportunities and leads to greater social diversity
- Performative buildings facilitate a diversity of use and social program
- 12 • Utilize Portland Ave. as an urban ecological corridor, connecting to the river and into the Elliot Park neighborhood
- 13 • Leverage the Armory Green as a location for urban wetlands and habitat to promote species diversity
- 14 • Create a diverse economic destination that provides an experience that differs from the Mall of America and other shopping locations in the region
- Leverage current economic trends including alternative retail destinations and a for-sale housing trend
- 15 • Promote a diversity of retail and commercial opportunities through a variety of street experiences and building types
- Leverage the Armory Medical Center as a partnership with academia through research and providing a stable economic entity on the site
- Create economic diversity by providing retail services that are currently not present on Nicollet Ave. and the downtown area

## METHODS USED (CONT'D)

- 16
  - Create a vibrant local economy by creating a market through mixed-use residential development
  - Encourage local retail owners and restaurant owners specializing in local food sources to tighten feedback loops on a global economy
  - Include larger, slow-moving economic competitors like the Armory Medical Center and Vikings-related retail as well as economic competitors moving at faster time scales like high-end retail
- 17
  - Establish the Armory as a nexus of multiple systems, primarily regional transit and bicycle
- 18
  - Multi-modal transportation corridors in the development, with an emphasis on bus, rail, bicycle (via Portland Ave.) and pedestrian
- 19
  - Utilize a heterogeneous pattern of urban form to create spatial diversity
- 20
  - Variable facades on Washington Ave. create diverse spatial qualities
  - Diversity of use within buildings (mixed-use retail)
  - Variety of open space types with a clear hierarchy (The Armory Green, plazas, semi-private balconies, protected courtyards)
- 21
  - Provide an open space amenity that serves the Minneapolis region as a part of the greater park system
- 22
  - Cater to a demographic that already exists and is stable in the downtown area, being the white 25-40 year old group
- 23
  - Utilize a street tree palette that maintains diversity but is consistent with the existing trees used
- 24
  - Create an economic retail redundancy (juxtaposing Nicollet Mall)
  - Create a redundancy through a new livable urban district in the downtown area amongst other, smaller districts including Elliot Park, the Mill District, and the Warehouse District
  - Maintain redundancy of street network to diffuse traffic flows and use Washington Ave. and Chicago Ave. as the major thoroughfares
- 25
  - Mimic building typologies found in adjacent neighborhoods including the Mill District and Loring Park to create redundancy and consistency in urban form and character
  - Combine uses within the Armory Green, including: parking, park, retail, specialty retail, a market, civic space, transit, and a diversity of social program.
- 26
  - Establish energy efficient connections to regional destinations including the Mall of America, the airport, the University of Minnesota, St. Paul, and the surrounding suburbs
  - Create a regional destination for a variety of users with an emphasis on retail, open space, and events at Viking Stadium
  - Leverage existing bike routes to regional destinations and suggest certain routes that could be improved to maintain key connections
  - Use the University of Minnesota as an effective strategy to maintain connections to new ideas and innovation in the medical field

## METHODS USED (CONT'D)

- 27
  - Leverage existing bike routes to metro destinations and suggest certain routes that could be improved to maintain key connections
  - Maintain traffic efficiency and effectively re-route traffic around the Armory Green
  - Establish better connections to the River via Portland Ave.
  - Link adjacent neighborhoods via the existing street network and a revitalized Portland Ave. typology
  - Link the Armory development to the existing Skyway system in downtown, while bringing the Skyway to the ground plane at Armory Green
  - Create a walkable district that links adjacent destinations including the Vikings Stadium, the Skyway system, the Mill District, Elliot Park, The Mississippi River, and Downtown
  - Portland Ave. becomes the major north/south bicycle thoroughfare linking across the river to the north and I35 south to the south
- 28
  - Create an effective pedestrian connection between Armory Green and the transit stop at Viking Stadium
  - Establish a protected pedestrian alleyway on Washington Ave.
  - Open space acts as a social network across the site- linking businesses, people, institutions, and residences
  - The Armory serves as a civic icon that connects people together through a common identity
- 29
  - Establish better connections to the River via Portland Ave., creating a habitat corridor for avian and other species
- 30
  - Connect to the economic stability of Downtown while providing a unique and diverse economic structure within the District
  - Connect to and compliment adjacent land uses through the urban form and land use strategy
  - Connect to the University of Minnesota both physically and by creating partnerships with The Armory Medical Center and business startups
- 31
  - Promote ease of pedestrian and vehicular access to economic drivers within The Armory by providing adequate parking and walkable streets
- 32
  - Leverage The Armory as a catalyst for new development in the area especially a new school, increased density in Elliot Park, and a better connection to the River
  - Utilize an adaptive infill typology for Washington Ave. unifying the urban form while remaining within economic feasibility



# FINDINGS

Through literature review, case study analysis, and projective design, this thesis explores the application of resilience theory as a framework for engaging urban design. It is an exploration that takes a highly complex theory and grounds it in concrete methods and strategies for generating resilient design. This application is relevant to both designers and resilience scientists. The former is a group that seeks to understand the complex, dynamic nature of urban environments and create designs that orchestrate positive change. In seeking to accomplish this, designers tend to move away from the concrete realities of how systems evolve and interact as seen with the landscape urbanism and ecological urbanism movements. Resilience theory is an accepted method of understanding that explains the nature of urban environments and other socio-ecological systems but has also seen limited application. Resilience scientists have sought to further efforts in applying the theory, with landscape architecture and urban design being professions that are primed to ally with further resilience research. Resilience theory addresses the challenges and complexities of urban environments and can serve as a theoretical basis for engaging urban design practice. The resilience framework proposed in this thesis provides a direct method for applying the theory to urban design.

## **Resilience Theory and Landscape Architecture**

In its current state, resilience theory is too complex and scientific to be widely accepted in the field of landscape architecture and urban design. This is evident in the primary sources category of the literature, which served as the basis of understanding for the thesis. Sources such as Holling 1973 and Panarchy 2001 provide an in-depth explanation of the theory but are not delivered in a way that is easily accessible for designers. The application of resilience theory group begins to get closer to how resilience theory might be applied to design practice. Particularly the Urban Resilience Research Prospectus lays out a solid foundation from which future research can be investigated that integrates a scientific approach to design. The Resilient Rangelands and Willamette River Valley case studies are very clear in their methodology and scope of research, but they ally more closely with planning than physical design.

There are also research efforts that are working more closely with the design disciplines. The adaptation of resilience category of literature consists of design-based research and resilience research, combining both design and theory. The work of Marina Alberti, Jack Ahern, and Nina-Marie Lister are critical sources in grounding resilience theory to planning and design. As researchers more closely related to design, they are able to distill the theory into more applicable and accessible terms. This adaptation category does have limitations as found in the case studies. The Albano Resilient Campus and A Resilient Social-Ecological Urbanity demonstrate that they theory can be used as a framework, but does not necessarily result in better design. Both designs are somewhat dubious in terms of the physical urban form, especially in terms of circulation, connectivity, and building structure. The Albano Campus plan has a rigorous approach that comprehensively applies the theory to design and is a good reference for further applications.

5.1  
Resilience Framework

REGIONAL



METRO



SITE



SPATIAL  
SCALE

|              |            |    |    |    |
|--------------|------------|----|----|----|
| THRESHOLDS   | SOCIAL     | 1  | 2  | 3  |
|              | ECOLOGICAL | 4  | 5  | 6  |
|              | ECONOMIC   | 7  | 8  | 9  |
| DIVERSITY    | SOCIAL     | 10 | 11 | 12 |
|              | ECOLOGICAL | 13 | 14 | 15 |
|              | ECONOMIC   | 16 | 17 | 18 |
|              | SPATIAL    | 19 | 20 | 21 |
| REDUNDANCY   | SOCIAL     | 22 | 23 | 24 |
|              | ECOLOGICAL | 25 | 26 | 27 |
|              | ECONOMIC   | 28 | 29 | 30 |
|              | SPATIAL    | 31 | 32 | 33 |
| CONNECTIVITY | SOCIAL     | 34 | 35 | 36 |
|              | ECOLOGICAL | 37 | 38 | 39 |
|              | ECONOMIC   | 40 | 41 | 42 |
| PLANNING     | ECOLOGICAL | 43 | 44 | 45 |
|              | ECONOMIC   | 46 | 47 | 48 |

TEMPORAL  
SCALE

5 Y

10 Y

50 Y

100 Y

150+ Y

Landscape urbanism and ecological urbanism are two groups that are prepared to apply resilience theory as a basis for engaging urban design. Because they share similar vocabulary and conceptual understanding, people like James Corner and Chris Reed can adopt resilience theory as an addendum to their current approach. As demonstrated in the Emergent Ecologies case study, the current landscape urbanism approach is too abstract and uses ecology simply as a metaphor for understanding. Resilience theory has the potential to bridge allied disciplines like engineering, ecology, and economics with landscape architecture as mediator. Landscape urbanism and ecological urbanism will be central to this transformation, but there needs to be a formal method for applying the theory to urban design.

### **Resilience Framework**

The primary finding is that the resilience framework proposed in this thesis functions as both a post-design analysis matrix and an active design/planning tool for engaging urban design practice (Fig. 5.1, pgs. 116-123). It is absolutely necessary to have an understanding of resilience theory in order to use the framework to its fullest potential. If the base knowledge of the theory is not present, as outlined in the background chapter of this thesis, then the framework is highly superficial.

The resilience analysis matrix serves as a guide for understanding which systems and scales the design is addressing. It establishes priority for which thresholds are more or less critical to address and also provides for significant flexibility. For instance the Willamette River Valley case study was a very specific approach, but the matrix also allows for a more holistic approach as in the case of Albano Resilient Campus. The matrix combines the thoughts of several groups of literature and builds upon existing research (i.e. Ahern 2011, Walker and Salt 2006). The analysis framework only represents a project in terms of resilience and not the success of the design. The intent is to not necessarily fill up all of the cells within the framework, but to do so strategically.

As an active design/planning tool, the resilience framework establishes methods for resilient urban design practice. It applies an abstract theory to design by generating concrete methods. If resilience theory is to be used as a basis for engaging urban design, then this framework is a point of departure and a guide for that effort. The primary case for such an application in this thesis is the ULI/Hines Competition projective design, The Armory. This project uses the framework to guide decision making for a highly complex urban environment, and resulted in winning the competition which validates the success of the framework by some measure. The framework identified which systems, scales, and methods were used or not used and was successful in applying specific strategies for a resilient design.

There are also limitations identified through the projective design. The primary component that is weakest is how time scales are integrated into the framework. Currently it is an all-inclusive time scale that looks at the furthest point the design was intended to function at. Specific methods, however, may require a different time scale in order to function. Therefore a future rendition of this framework may develop a different approach to including time than is presented here.

## **Future Applications and Research**

While resilience theory is demonstrated as a critical addendum to current landscape architecture and urban design theory, including landscape urbanism and ecological urbanism, this is only a part of further development in resilience theory's application to urban design practice. One of the areas that is lacking in this research is the quantification of resilience in a rigorous methodology. The framework presented in this thesis is a method of organizing a set of strategies and methods for designing resilient urbanisms but it does not attempt to quantify or measure the extent of each method. Such an effort will require greater interdisciplinary collaboration, as the literature suggests. The common language and concepts that resilience theory embodies can work towards greater collaboration between design, ecology, economics, real estate development, and planning.

The proposed resilience framework may be used as a point of departure for future case study analyses as well as projective design. It is intended that the form of the framework will be resilient in and of itself, adaptive and dynamic as it evolves. There is certainly great potential for using the framework in an academic environment with potential case studies as well as design education. It is a clear method for application in the professional design realm as well, which is central to the purpose of the framework. Research will be critical to the success of the continued development of the framework and efforts in resilience theory. A continued collaboration between research and design is necessary for resilience theory to advance to its potential.

Hopefully the design world will be accepting of resilience theory. With so much current research and topics of interest related to sustainability, resilience is definitely a relevant discussion. As with any theory, there are limitations but it is evident that it has the potential to become more prominent. The Stockholm Resilience Center will continue to operate as a hub of resilience research, and there is great potential for collaboration to occur with their efforts in conjunction with design. Design competitions such as the ULI/Hines are great methods for exploring theoretical applications, but hopefully there will be built projects in the near future so that we can begin to monitor them for success. The Albano Campus is a masterplan that should be closely monitored to see how it functions as an application of resilience theory. Collectively, these efforts will create a stronger presence in the design community and concepts of resilience will slowly integrate into our everyday thinking.

# REFERENCES

*A Research Prospectus for Urban Resilience: A Resilience Alliance Initiative for Transitioning Urban Systems Towards Sustainable Futures*. Research Prospectus. Resilience Alliance, February 2007.

Ahern, Jack. "From Fail-safe to Safe-to-fail: Sustainability and Resilience in the New Urban World." *Landscape and Urban Planning* 100, no. 4 (2011): 341–343.

Alberti, Marina, and John M. Marzluff. "Ecological Resilience in Urban Ecosystems: Linking Urban Patterns to Human and Ecological Functions." *Urban Ecosystems* 7 (September 2004): 241–265. doi:10.1023/B:UECO.0000044038.90173.c6.

Alberti, Marina, John Marzluff, Eric Shulenberger, Gordon Bradley, Clare Ryan, and Craig Zumbrunnen. "Integrating Humans into Ecology: Opportunities and Challenges for Studying Urban Ecosystems." *BioScience* 53, no. 12 (December 2003): 1169–1179.

Allen, Peter, Mark Strathern, and James Baldwin. "The Dynamics of Complex Urban Systems." 21–41. Physica-Verlag HD, 2008. <http://www.springerlink.com/content/mwk8n11231336186/abstract/>.

Allen, Stan. "Urbanisms in the Plural: The Information Thread." In *Fast-Forward Urbanism: Rethinking Architecture's Engagement with the City*, edited by Dana Cuff and Roger Sherman. Princeton Architectural Press, 2011.

"Archives | Urban Land Institute." Accessed March 9, 2013. <http://www.uli.org/programs/awards-competitions/hines-student-design-competition/archives/>.

Barthel, Stephan, Johan Colding, Henrik Ernstson, Hanna Erixon, Sara Grahn, Lars Marcus, Carl Karsten, and Jonas Torsvall. "Q Book, Albano 4. Hållbarhet." Stockholm Resilience Center, 2010. <http://www.stockholmresilience.org/research/researchnews/urbanplanningbasedonresilienceprinciples.5.e1a75a51296e05212a8000641.html>.

Barthel, Stephan, Sverker Sorlin, and John Ljungkvist. "Innovative Memory and Resilient Cities: Echoes from Ancient Constantinople." In *The Urban Mind, Cultural and Environmental Dynamics, Studies in Global Archaeology*. Sweden: Uppsala University Press, 2011.

Berrizbeitia, Anita. "Scales of Undecidability." In *Downsview Park Toronto CASE*, edited by Julia Czerniak, 116–125. Prestel Publishing, 2002.

Bonometti, Alessandra, Matteo Giusti, Marco Miglioranzi, and Niels Vauth. *A Resilient Socio-Ecological Urbanity*. Hanover, Germany: N2M Architektur, 2010.

Corner, James. "Not Unlike Life Itself." *Harvard Design Magazine* no. Fall/Winter 2004 (2004): 32–34.

Creswell, John W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 3rd ed. Sage Publications, Inc, 2008.

Cumming, Graeme S. *Spatial Resilience in Social-Ecological Systems*. 1st Edition. Springer, 2011.

- Cunningham, Kevin, and Elise Fagan. *Recalibrating for Resilience: An EcoReserve Network in the South Platte River Basin*. Manhattan, KS: Drylands Design Competition, 2011.
- Brown, Lauren, Kevin Cunningham, Kylie Harper, Derek Hoetmer, and Tyler Knott. *The Armory*. Minneapolis, MN: Urban Land Institute, 2013.
- Czerniak, Julia, ed. *Downsview Park Toronto*. Prestel Publishing, 2002.
- Deming, M. Elen, and Simon Swaffield. *Landscape Architectural Research: Inquiry, Strategy, Design*. 1st ed. Wiley, 2011.
- Deppisch, Sonja, and Mareike Schaerfliet. "Given the Complexity of Large Cities, Can Urban Resilience Be Attained at All?" In *German Annual of Spatial Research and Policy 2010*, by B Muller, 25–33, 25–33. Verlag, Berlin, Heidelberg: Springer, 2011.
- Dramstad, Wenche E., James Olson, and Richard T.T. Forman. *Landscape Ecology Principles in Landscape Architecture and Land-use Planning*. Island Press, 1996.
- Du Plessis, Chrisna. "Researchspace: Understanding Cities as Social-ecological Systems." r. Melbourne, Australia, 2008. <http://researchspace.csir.co.za/dspace/handle/10204/3306>.
- Ernstson, Henrik, Sander E. Leeuw, Charles L. Redman, Douglas J. Meffert, George Davis, Christine Alfsen, and Thomas Elmqvist. "Urban Transitions: On Urban Resilience and Human-Dominated Ecosystems." *AMBIO* 39, no. 8 (July 29, 2010): 531–545. doi:10.1007/s13280-010-0081-9.
- Fleischhauer, Mark. "The Role of Spatial Planning in Strengthening Urban Resilience." In *Resilience of Cities to Terrorist and Other Threats*, edited by Hans J. Pasman and Igor A. Kirillov, 273–298. Dordrecht: Springer Netherlands. Accessed October 7, 2011. <http://www.springerlink.com/content/x84t9l6x77388307/>.
- Gunderson, Lance H., and C. S. Holling. *Panarchy: Understanding Transformations in Human and Natural Systems*. 1st ed. Island Press, 2001.
- . "Resilience and Adaptive Cycles." In *Panarchy: Understanding Transformations in Human and Natural Systems*, 25–63. 1st ed. Island Press, 2001.
- Gunderson, Lance H., C. S. Holling, and Donald Ludwig. "In Quest of a Theory of Adaptive Change." In *Panarchy: Understanding Transformations in Human and Natural Systems*, 3–25. 1st ed. Island Press, 2001.
- Holling, C. S. "Resilience and Stability of Ecological Systems." *Annual Review of Ecology and Systematics* 4, no. 1 (November 1973): 1–23. doi:10.1146/annurev.es.04.110173.000245.
- Holling, C. S. "Understanding the Complexity of Economic, Ecological, and Social Systems." *Ecosystems* 4, no. 5 (2001): 390–405.
- Holling, C. S., and Gordon Orians. "Toward an Urban Ecology." *Bulletin of the Ecological Society of America* 52, no. 2 (June 1, 1971): 2–6.

- Hulse, David, and Stan Gregory. "Integrating Resilience into Floodplain Restoration." *Urban Ecosystems* 7 (2004): 295–314.
- De Landa, Manuel. *A Thousand Years of Nonlinear History*. Zone, 2000.
- Lang, Thilo. "German Annual of Spatial Research and Policy 2010." 15–24. German Annual of Spatial Research and Policy. Springer Berlin Heidelberg, 2011. <http://www.springerlink.com/content/rtw05g2373274xml/abstract/>.
- Lister, Nina-Marie. "Sustainable Large Parks: Ecological Design or Designer Ecology." In *Large Parks*, edited by Julia Czerniak and George Hargreaves. 1st ed. Princeton Architectural Press, 2007.
- . The Dirt: Interview with Nina-Marie Lister on Ecological Urbanism, June 7, 2011.
- Meadows, Donella H. *Thinking in Systems: A Primer*. Chelsea Green Publishing, 2008.
- Mostafavi, Mohsen, Gareth Doherty, and Harvard University. *Ecological Urbanism*. 1st ed. Lars Müller Publishers, 2010.
- Müller, Bernhard. *Urban Regional Resilience: How Do Cities and Regions Deal with Change?* Springer, 2011.
- Musacchio, Laura R., and Jianguo Wu. "Collaborative Landscape-scale Ecological Research: Emerging Trends in Urban and Regional Ecology." *Urban Ecosystems* 7, no. 3 (2004): 175–178. doi:10.1023/B:UECO.0000044034.55695.bd.
- Perry, John. "Compete: Urban Land Institute | Gerald D. Hines student urban design competition" (May 19, 2009). <http://krex.ksu.edu/dspace/handle/2097/1487>.
- Reed, Chris. "Agency of Ecology." In *Ecological Urbanism*, edited by Mohsen Mostafavi, Gareth Doherty, and Harvard University. 1st ed. Lars Müller Publishers, 2010.
- Steiner, Frederick. "Urban Human Ecology." *Urban Ecosystems* 7, no. 3 (2004): 179–197. doi:10.1023/B:UECO.0000044035.22316.d1.
- US EPA, Office of Research and Development, and Office US EPA. "Sustainability Information | EPA Research | EPA." Overviews & Factsheets. Accessed May 3, 2013. <http://www.epa.gov/sustainability/basicinfo.htm#sustainability>.
- Walker, Brian, and Nick Abel. "Resilient Rangelands- Adaptation in Complex Systems." In *Panarchy: Understanding Transformations in Human and Natural Systems*, edited by Lance H. Gunderson and C. S. Holling, 293–313. 1st ed. Island Press, 2001.
- Walker, Brian, and David Salt. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Island Press, 2006.

- Walker, Bryan, C. S. Holling, S.R. Carpenter, and A. P. Kinzig. "Ecology and Society: Resilience, Adaptability and Transformability in Social-ecological Systems." Accessed June 24, 2011. <http://www.ecologyandsociety.org/vol9/iss2/art5/>.
- Wall, Alex. "Programming the Urban Surface." In *Recovering Landscapes: Essays in Contemporary Landscape Architecture*, edited by James Corner, 222–249. Princeton Architectural Press, 1999.
- Weller, Richard, and Charles Waldheim. "Art of Instrumentality." In *Landscape Urbanism Reader*. Princeton Architectural Press, 2006.
- Woodward, Joan Hirschman. "Envisioning Resilience in Volatile Los Angeles Landscapes." *Landscape Journal* 27, no. 1 (January 1, 2008): 97–113. doi:10.3368/lj.27.1.97.

## APPENDIX A: DEFINITION OF TERMS

### **Resilience**

“the amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime—essentially retaining the same function, structure, and feedbacks” (Walker and Salt 2006, 164).

### **Adaptive Cycle**

“A way of describing the progression of social-ecological systems through various phases of organization and function. Four phases are identified: rapid growth, conservation, release, and reorganization. The manner in which the system behaves is different from one phase to the next with changes in the strength of the system's internal connections, its flexibility, and its resilience” (Walker and Salt 2006, 163).

### **Panarchy**

“is the term we use to describe a concept that explains the evolving nature of complex adaptive systems. Panarchy is the hierarchical structure in which systems of nature (for example, forests, grasslands, lakes, rivers, and seas), and humans (for example, structures of governance, settlements, and cultures), as well as combined human-nature systems (for example, agencies that control natural resource use) (Gunderson and others 1995) and social-ecological systems (for instance, co-evolved systems of management) (Folke and others 1998), are interlinked in never-ending adaptive cycles of growth, accumulation, restructuring, and renewal. These transformational cycles take place in nested sets at scales ranging from a leaf to the biosphere over periods from days to geologic epochs, and from the scales of a family to a socio-political region over periods from years to centuries” (Holling 2001, 392).

### **Attraction Basin**

“An attractor is a stable state of a system, an equilibrium state that does not change unless it is disturbed. The basin of attraction is all the stable states of the system that tend to change toward the attractor” (Walker and Salt 2006, 163).

“a region in state space in which the system tends to remain” (Walker et al. 2004, 3).

### **Sustainability**

“requires both change and persistence” (Holling 2001, 403).

“Sustainability is the capacity to create, test, and maintain adaptive capability. Development is the process of creating, testing, and maintaining opportunity. The phrase that combines the two, “sustainable development,” therefore refers to the goal of fostering adaptive capabilities while simultaneously creating opportunities. It is therefore not an oxymoron but a term that describes a logical partnership” (Holling 2001, 399).

### **Socio-ecological System**

“Linked systems of people and nature” (Walker and Salt 2006, 164).

1. A social-ecological system is one integrated system that spans matter, life, and human social and cultural phenomena (or mind).
2. A social-ecological system consists of relationships between elements at a number of scales and within nested systems.
3. SESs are systems that are complex and adaptive, with properties of self-organization and emergence
4. What differentiates SESs from other systems is the introduction of abstract thought and symbolic construction" (Du Plessis 2008, 3).

### **Resistance**

"the ease or difficulty of changing the system; how "resistant" it is to being changed"  
(Walker et al. 2004, 2).

### **Latitude**

"the maximum amount a system can be changed before losing its ability to recover (before crossing a threshold which, if breached, makes recovery difficult or impossible)"  
(Walker et al. 2004, 2).

### **Precariousness**

"how close the current state of the system is to a limit or 'threshold'" (Walker et al. 2004, 3).

### **Transformability**

"The capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable" (Walker et al. 2004, 3).

### **Redundancy**

"systems designed with multiple nodes to ensure that failure of one component does not cause the entire system to fail" (Fleischhauer 277).

### **Diversity**

"The different kinds of components that make up a system. In respect to resilience there are two types of diversity that are particularly important:

Functional Diversity: Refers to the range of functional groups that a system depends on. For an ecological system this might include groups of different kinds of species like trees, grasses, deer, wolves, and soil. Functional diversity underpins the performance of a system.

Response Diversity: Is the range of different response types existing within a functional group. Resilience is enhanced by increased response diversity within a functional group" (Walker and Salt 2006, 164).

### **Flows**

"energy, material goods, and non-material services that sustain human well-being

and urban quality of life (Folke et al 1997). These flows enter an urban system either actively through human effort (transport) or passively via natural processes such as solar radiation, precipitation and various other hydrological and meteorological means (Decker et al 2000)" (Prospectus 2007, 11).

### **Feedback**

"The secondary effects of a direct effect of one variable on another, they cause a change in the magnitude of that effect. A positive feedback enhances the effect; a negative feedback dampens it" (Walker and Salt 2006, 164).

### **Threshold**

The point at which a system crosses over into another attraction basin. "Once a threshold has been crossed it is usually difficult (in some cases impossible) to cross back" (Walker and Salt 2006, 63).

### **Disturbance**

"actual change (of a system) is triggered by agents of disturbance, such as wind, fire, disease, insect outbreak, and drought" (Holling 2001, 394). Within the urban environment, disturbances may be social, ecological, or economic and vary from changes in institutional management, floods, social fads, a housing crisis, to migration.

### **Variables**

Controlling variables: Variables in a system that determines the levels of other variables. In terms of the urban environment, these might be the street network, government institutions, or regional ecologies.

Fast and slow variables: Controlling variables tend to act either slowly or quickly. Slow variables tend to be ecological, institutional, or cultural, while fast variables might be social fads, economic shifts, or droughts (Walker and Salt 2006, 165).

### **Adaptability**

"the capacity of actors in a system to influence resilience" (Walker et al 2004, 3).



## APPENDIX B: SUPPLEMENTAL MATERIALS

# ARGUMENTATION

## ENTHYMEME

**CLAIM:** Resilience theory is a relevant addendum to current landscape architecture theory and can serve as a framework for urban design.

**REASON:** because resilience theory provides a holistic approach to design that adequately addresses the complexity and dynamic nature of the urban environment.

## GROUNDINGS

Evidence and arguments showing the benefit of using resilience theory as a theoretical basis for urban design.

- Resilience theory describes the cross-scale interactions between complex adaptive systems, especially in the urban environment.
- Resilience theory and its principles are found in much of the literature body of the landscape architecture profession
- Landscape architects allied with landscape urbanism and ecological urbanism are poised to embrace resilience theory because of their knowledge and theoretical perspective.

## POSSIBLE CONDITIONS OF REBUTTAL

- Argument that the field of landscape architecture is moving forward in a positive direction without resilience theory
- Argument that the SSI and LEED programs are achieving sustainable goals for our urban environments
- Argument that landscape architects should not be concerned with theory, that it is a money-making profession

## WARRANT

Resilience theory provides an understanding of the complexity of our urban environments that is currently missing.

## BACKING

Arguments showing the missing knowledge and how resilience theory acts as a bridge that spans several different groups of theory.

- Identify key relationships between bodies of literature in relation to resilience theory
- The theories of landscape urbanism and ecological urbanism are too abstract; the addition of resilience theory gives these perspectives a concrete basis
- Case study analysis of how resilience theory has been applied by ecologists as a basis for planning and management efforts
- Case study analysis of key landscape urbanism and ecological urbanism projects and how resilience theory could strengthen the design
- Current approaches to sustainability are inadequate and do not address the way that systems interact and change over time

## POSSIBLE CONDITIONS OF REBUTTAL

- The landscape urbanism and ecological urbanism theories are moving the profession forward without using resilience theory
- Landscape architecture already uses an ecological and systems based approach to design, we do not need resilience theory
- Is there proof that resilience theory is relevant to landscape architecture?

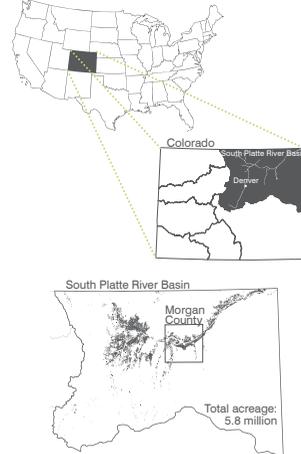
# Recalibrate SPRB: Resilient strategies for Colorado

## Abstract

The American West is facing a critical threshold in water use. As urban populations grow, municipal water demands are forcing the reallocation of agricultural water rights. It is estimated that by 2050 more than 70% of Denver's water needs will be met through the process of "buy and dry," leaving 40% of the state's total irrigated agricultural lands without water. The ramifications of this situation could result in the collapse of the South Platte River Basin's (SPRB) social, ecological, and economic systems. In order to mitigate a potential "dooms-day" scenario, the urban/rural water allocation threshold must be determined and the current irrigation strategies, water rights transfers, and agricultural practices must be recalibrated for the river basin to reach

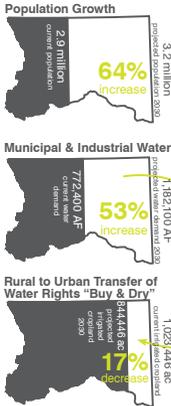
a resilient state. Guided by principles of resilience theory, this project seeks to balance the allocation of water use in the South Platte River Basin in order to support increasing urban demands, without compromising its agrarian vitality. A suitability model was generated to effectively manage the loss of irrigated agriculture for social, economic, and ecological adaptability and identify the water reallocation threshold. Through this modeling process, it is determined that the agrarian system cannot sustain resiliency beyond a 34% reallocation of its current water use. This threshold coupled with a recalibration of irrigation strategies, agricultural practices, and water rights transfers balances the gap between urban water demand and agricultural irrigation.

## Context

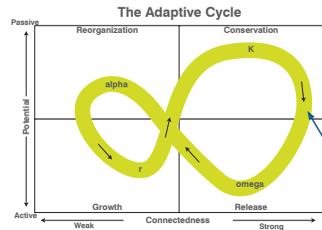


## Issues

### Projected Gaps by 2030



## Resilience Theory



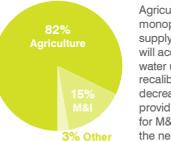
This project was viewed as an opportunity to explore the application of theory to design. The principles of resilience theory as developed by C.S. Holling were used to understand the cross-scale interactions of the systems central to the dilemma faced by the South Platte River Basin: social, economic, and ecological. From this theoretical base, the project goals were built with the intention to increase the resilience of this river basin. Resilience, as defined by Holling, is the ability for a system to withstand shocks without losing its basic identity, function and feedbacks. Currently the system is late in the conservation stage, where due to a variety of factors the system is prone to undergo a bifurcation, or an event where the system is undone completely.

Current position of the SPRB system; at a critical threshold before going into the release phase

### The worth of resources in the SPRB



### Water Use in Colorado



### Significance of resilience

The South Platte River Basin Account

## Design Goals: Recalibrating for System Resilience

|  | Social  | Economic  | Ecological   |
|--|---|---|--|
| <b>Water   Energy Nexus</b>            | <ul style="list-style-type: none"> <li>Decrease diesel consumption of water pumps by strategically limiting or eliminating irrigated agriculture</li> </ul>                         | <ul style="list-style-type: none"> <li>Shift economic focus away from energy intensive agricultural practices and diversify economy of the river basin</li> </ul> | <ul style="list-style-type: none"> <li>Decrease harmful emissions from farm implements and water pumps used for irrigation</li> </ul>                                |
| <b>Water Scarcity and Availability</b> | <ul style="list-style-type: none"> <li>Increase social awareness of the importance of water by increasing water bills to compensate farmers for transferred water rights</li> </ul> | <ul style="list-style-type: none"> <li>Develop strategies for making the transfer of water rights more economically viable for all parties involved</li> </ul>    | <ul style="list-style-type: none"> <li>Limit the use of water consumed by irrigated agriculture to recalibrate the ecological function of the river basin</li> </ul> |
| <b>Localized Resources</b>             | <ul style="list-style-type: none"> <li>Instill social value of local water and ecological resources to increase social memory and social adaptive capacity</li> </ul>               | <ul style="list-style-type: none"> <li>Decrease agricultural exports to create local importance for food and establish diversity in local resources</li> </ul>    | <ul style="list-style-type: none"> <li>Enlarge habitat networks and resources through recalibration of agricultural land to EcoReserve areas</li> </ul>              |
| <b>Social Equity</b>                   | <ul style="list-style-type: none"> <li>Mitigate the impacts of rural to urban migration and the aging farm population</li> </ul>  | <ul style="list-style-type: none"> <li>Develop strategies for keeping agriculture a viable practice in light of water shortages</li> </ul>                        | <ul style="list-style-type: none"> <li>Create social responsibility for the management of ecosystem services for both urban and rural populations</li> </ul>         |

## "Buy and Dry"

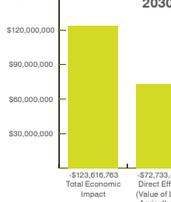
The current trend in the transfer of agricultural water rights to municipalities is the "buy and dry" effect. This occurs when a farmer sells his senior water rights to a municipality because it is more economically viable than to continue to practice agriculture. In this case, the agricultural land is not irrigated and unmaintained which has serious ecological implications. Topsoil erosion, soil degradation, rural to urban migration, food production loss, and even dust storms are all negative impacts of this buy and dry trend. If this current process continues across a large scale, the impacts will only continue to increase.

It is predicted that by 2030, the economic loss in the South Platte River Basin alone will be \$123,616,763 due to decrease in agricultural production and indirect effects on other economic sectors such as livestock and farm implement production.

### The Future Landscape of "Buy and Dry"



### Economic Impact 2030



## Historical Analysis



# Colorado's South Platte River Basin agrarian landscape

2030  
 3.2 million  
 1,182,100 AF  
 70%  
 1,023,444 ac

Water Demand  
 1,182,100 AF  
 70%  
 1,023,444 ac

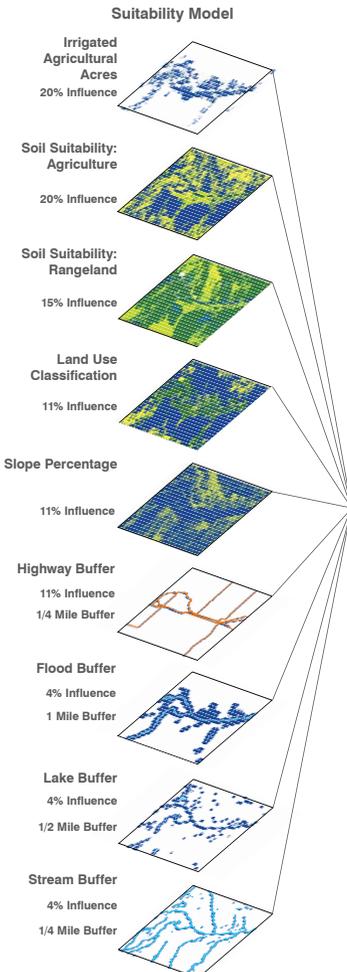
Water Demand (projected for 2050)  
 Agriculture has a dominant monopoly on Colorado's water supply. It is projected that agriculture will account for 82% of Colorado's water use by 2050. The proposed recalibration will significantly increase this percentage, thus providing a larger percent of water for M&I use and ultimately mitigating the need to sell water rights.

Water Demand (projected for 2050)  
 Accounts for:  
 98% Irrigated ag, 16% Municipal and Industrial (M&I), 40% Unirrigated ag

Impacts of "Buy and Dry" 2030 Projection  
 2,733,489 Net Effect (Loss of Production)  
 \$29,072,774 Indirect Effect  
 \$11,810,489 Induced Effect



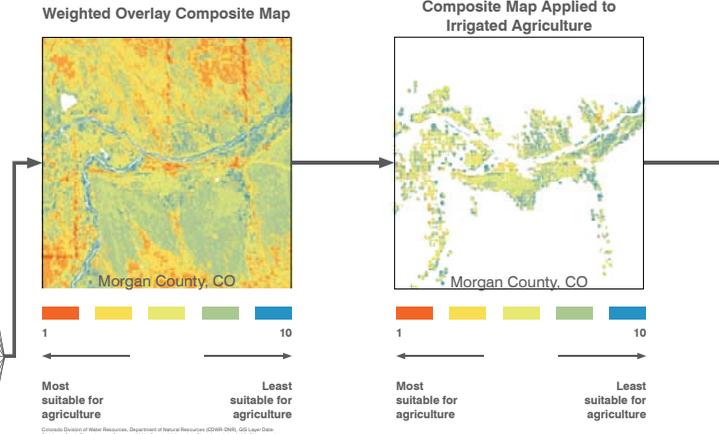
The South Platte River Basin is facing a situation where water-use in the basin now exceeds the already-limited supply. This threshold was reached at approximately the same time the devastating 2002 drought hit Colorado.



## Recalibrate Irrigated Agriculture

A suitability model was used at the county scale to prioritize areas that were more suitable as EcoReserve than for agriculture. The model utilized nine different factors that were overlaid to produce a composite map. After the composite map was created, it was clipped to the irrigated agriculture. The result shows which irrigated acres are suitable to be removed and converted to maintained EcoReserve. The three scenarios were then modeled

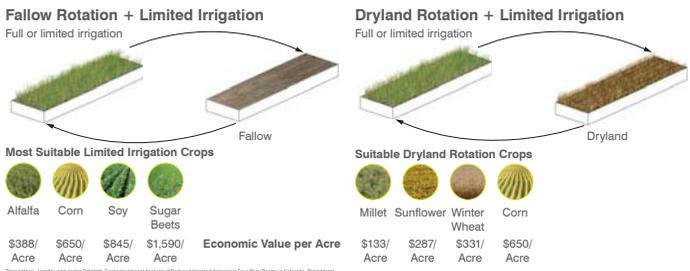
based upon this suitability, where irrigated acres that are least suitable for agricultural production are removed and the most suitable areas are converted to EcoReserve. The model is capable of being replicated for other counties, which is an appropriate scale based upon data availability. Morgan County was chosen because it included a diversity of land use including urban areas, significant hydrologic systems, and a large irrigated acreage.



## Recalibrate Agriculture Practices

Current agriculture practice in the South Platte River Basin relies heavily on center pivot and ditch irrigation. Both methods use large amounts of water, with center pivot also consuming mass amounts of diesel fuel (24 gallons per acre inch of irrigation). Alternative practices currently being investigated include rotational

strategies and limited irrigation. Both of these methods can reduce water consumption by 30-40%. Significant water savings can occur while seeing little decrease in farmer revenues of only -\$30 per acre. Large-scale implementation of these strategies would also increase resistance to drought and soil erosion.

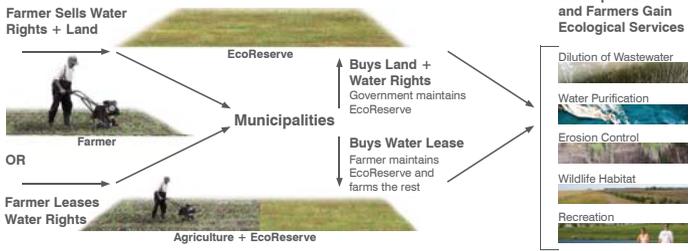


## Recalibrate Land Types



## Recalibrate Water Rights

An alternative to the current "buy and dry" method to transfer agricultural water rights is a leasing strategy. A majority of farmers in the SPRB expressed a willingness to lease part of their water rights rather than sell off completely, and preferred a compensation of \$300-500 per acre lost. Concurrently, municipal households are willing to pay a higher water bill (about \$300 annually) to compensate farmers for leasing their water rights and maintaining the resulting land for five ecosystem services: dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation opportunities. Coupled with alternative agriculture practices, significant water can be saved while also supplying the growing need of Denver and other urban areas in the SPRB.





## Current Scenario



2,485,800 Acre Feet of Water for Agricultural Irrigation

1,381,000 Irrigated Acres in the SPRB

59,659,200 Gallons of Diesel Fuel Used for Irrigation

### System Resilience

**Social:** Fails to meet water needs of urban population, lack of recreation opportunities, significant rural to urban migration, aging farmer population, lack of appreciation for place, high importance placed on agriculture



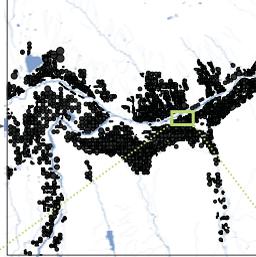
**Economic:** Agricultural land use monoculture along South Platte River, not resilient to economic shocks, drought has high economic effects on agriculture, economic productivity based upon water availability

### Economic

**Ecological:** Heavily dependent on water consumption, not resilient to drought, degraded riparian and stream habitat, lack of biodiversity, susceptible to invasive species

### Ecological

### County Scale Model



## 2030 Projection



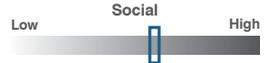
422,586 Acre Feet of Water Transferred

234,770 Agricultural Acres Converted to EcoReserve

10,142,064 Gallons of Diesel Fuel Saved

### System Resilience

**Social:** Urban water needs still not met, fails to adequately address aging farm population, some recreational opportunities are created, communities remain intact, importance of agriculture is maintained



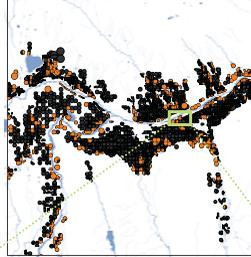
**Economic:** Land use monoculture remains, lacks diversity to increase resilience to shocks, drought remains an economic issue, not adequate emphasis on local production and resources

### Economic

**Ecological:** Fails to create an effective hydrologic buffer and ecosystem matrix, unprimed farmland is still being used, energy use begins to decrease

### Ecological

### County Scale Model



## Benefits of EcoReserves in the Agrarian Landscape

### Public Attitudes about Agriculture in CO

Colorado agriculture provides: a way of life and spirit that instills a sense of hard work and determination, a way of life and spirit that believes in being good stewards of the land, a way of life and spirit that believes in strong community and family bonds, farmers and ranchers provide a source of "rural ethos" for the entire state.

74% surveyed felt that agriculture is very important to the quality of life in Colorado

67% indicated that they would definitely buy more Colorado grown and produced products

83% felt it is very important to maintain land and water in agricultural production

87% agreed that public funds should be used to help farmers and ranchers improve wildlife habitat and conserve soil and water resources

73% felt that agriculture should be a top priority for water use in a dry year

Colorado Department of Agriculture and Colorado State University, June 2008

### Ecological Adaptive Capacity



### Phytoremediation & Nutrient Cycling

A diversity of native EcoReserve species allow better extraction of contaminants produced by agriculture than the crops themselves. A diversity also increases the availability of nutrients to cropland, thus making it more productive and reducing the need for supplemental (polluting) fertilizers.

### Groundwater Recharge

Native biodiversity reserves contribute to the factors (i.e. soil structure) that make infiltration of water possible. Thus providing some lateral subsurface irrigation while recharging the aquifers with filtered water.

### Water Quality

Filtration through native riparian buffers aids in removing agricultural runoff contaminants from entering the river.

## EcoRes

### Social Adaptive Capacity



Increase social memory

### Ecotourism

Providing linear open space for outdoor recreation opportunities.

### Agrarian Communities

Economic viability allows rural communities to sustain residency and maintain the agrarian landscape.

### Agritourism

Providing the urban population access to experience agrarian life and practices while recognizing the value of local food resources

Dryland continuing in the

### Vegetated Banks

Vegetation provides soil stabilization and reduces erosion and degradation and entr

### Lateral Stream M

Riparian buffers in the valley reduce the risk of bank erosion and deepening of the channel. This reduces the risk of bank erosion and deepening of the channel. This reduces the risk of bank erosion and deepening of the channel.

### South Platte River

Bedrock

Valley - river can occupy

## Resilient Scenario

## Non-Resilient Scenario



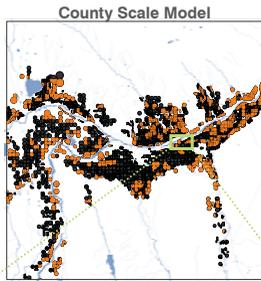
**845,172 Acre Feet of Water Transferred**

**469,540 Agricultural Acres Converted to EcoReserve**

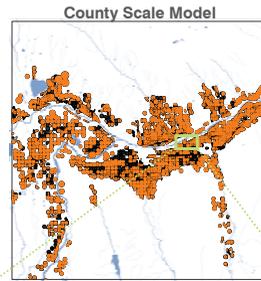


**2,112,930 Acre Feet of Water Transferred**

**1,173,850 Agricultural Acres Converted to EcoReserve**



**20,284,128 Gallons of Diesel Fuel Saved**



**50,710,320 Gallons of Diesel Fuel Saved**

### System Resilience

**Social:** Urban population gains significant water supply, rural communities become more diverse and viable, restores important sense of ecological place to the region, importance of agriculture is maintained in the basin



**Economic:** Economy becomes more diverse and resilient to shocks such as drought, agriculture remains viable where only the most suitable acres are farmed, increases agricultural efficiency



**Ecological:** Recovers critical habitat, hydrologic buffers are successfully created, resilient to drought, significantly reduces energy consumption



### System Resilience

**Social:** Stresses rural communities, too many farmers displaced, sense of place and identity is lost, importance of agriculture is lost, basic function and identity is undone, food productivity is minimal



**Economic:** Economy is not diverse and susceptible to shocks, significant loss in monetary and food source, effects other economic sectors such as livestock and machine industries, significant regional export is lost



**Ecological:** Transferred agriculture acreage is too much to effectively maintain, significant hydrologic buffers are created, energy use is significantly decreased



## EcoReserve Network in Morgan County

EcoReserve: 34% of previously irrigated agriculture is converted to high-functioning EcoReserve

Irrigated Agriculture: 66% remaining; using limited irrigation, crop rotation, dryland and fallow rotation practices

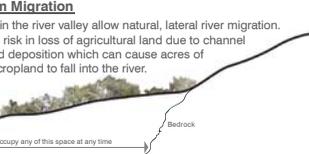
Ft. Morgan: growth and economic prosperity supported by economically viable surrounding agrarian rural communities

South Platte River EcoReserve Buffer: Portions of the 34% of irrigated acres converted to EcoReserve serve as the buffer for the South Platte River

dryland: existing dryland continues to be profitable in the basin



Bank migration: stream bank stabilization and reduces entrenchment causing destabilization.



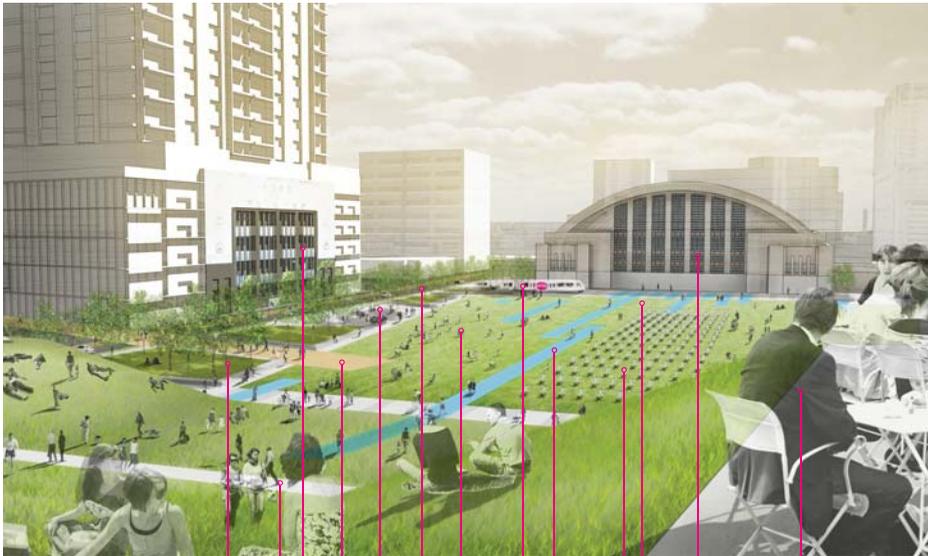
### Adaptive Economic Benefits

Even with the 34% decrease in cropland acreage due to growing the EcoReserves, the South Platte River Basin can support its own projected population of approximately 5.1 million people (1.6 million more than current).

A higher quality product increases the value of agriculture  
Less money is spent on insecticides and fertilizer  
Products from hunting, gathering, and fishing in the EcoReserves can also increase food revenue that benefits from the protection of natural capital



T125



**AN AFTERNOON AT THE ARMORY**

- Armory Biopark Library
- Connection to Skyway
- Preserved Star House facade
- Portland Avenue Light Rail
- Charles Schantz Water Park
- Portland Ave.
- Day Care noosa
- LCRT Line
- Skyway to parking ramp
- Taxi City on the lawn
- Freemasonic lawn
- The Armory
- Lands on the terrace



**CONCEPTUAL FRAMEWORK**

- Future Light Rail System
- Future Streetcar System
- Portland Avenue Transitway
- Armory District Threshold
- Armory Elementary School
- Riverside Park
- Densley Ethel Park



**VEHICULAR + TRANSIT CIRCULATION**

- Light Rail System
- Future Streetcar System
- One-way Street
- Proposed Parking Ramp
- Proposed Skyway
- Bus Stops



**FIGURE GROUND**

- Demolished Buildings
- Preserved Buildings
- New Construction
- Future Construction
- Mixed Use Residential
- Residential
- Retail
- Medical Office
- Hotel
- Parking Ramp

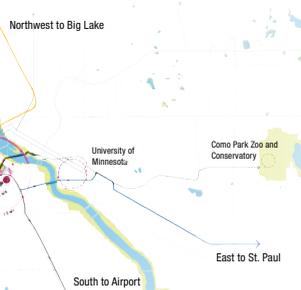
**VISION PLAN - AN ADAPTIVE FUTURE**



- EXISTING AND PLANNED TRANSIT SYSTEMS**
- Existing Norstair Light Rail
  - Existing Hawthalla Light Rail
  - Future Central Light Rail
  - Future Southwest Light Rail
  - Future Streetcar System
  - Transit Stops
  - Attractions
- PROPOSED STRATEGIES**
- Armory Flexible Use Market
  - Portland Avenue Bicycle Boulevard
  - Enhanced Bicycle Corridors

**REGIONAL CONNECTIVITY**

**PEDESTRIAN + BICYCLE CIRCULATION**



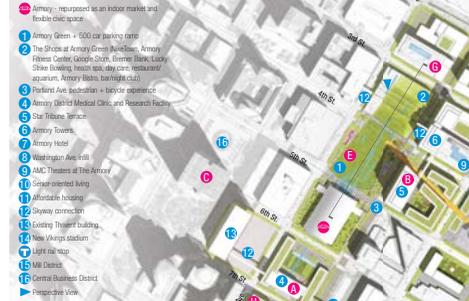
**LAND USE**



**PORTLAND AVENUE BICYCLE BOULEVARD**

# THE ARMORY

## A LANDMARK COMMUNITY FOR



- 1 Armory - reconverted to an indoor market and flexible civic space
- 2 Armory Green + 500 car parking ramp
- 3 The Shops at Armory Green Building, Armory Village Center, College Clinic, Streetcar Station, Skate Bowling, Insect Park, Day Care, Restaurant, Armory Market, Armory Plaza
- 4 Armory District Medical Clinic and Research Facility
- 5 The Tribune Terrace
- 6 Armory Towers
- 7 Armory Hotel
- 8 Washington Ave. Station
- 9 AMC Theaters at the Armory
- 10 Single-oriented living
- 11 Affordable housing
- 12 Skyway connection
- 13 Existing Theater building
- 14 Millie's vintage restaurant
- 15 Light tower
- 16 Mill District
- 17 Central Business District
- 18 Perspective View



**A Dusty**  
An avid cyclist and graduate student at the University of Minnesota, Dusty lives in Division and works at the Armory District Medical Clinic. He enjoys hiking, lunch at the Armory, the view of his daily commute, and promptly go to his favorite burger: the Clubhouse.

**B Bruce + Sara**  
Bruce and Sara recently purchased a condo at Armory Towers. They frequently buy a bottle of wine and watch the park from their balcony. Bruce is a director of technology at Target, while Sara is an active volunteer in the community.

**C Amon**  
A single mom, Amon has worked for years at City Hall. She commutes from the suburbs with her daughter, who attends nearby De La Salle High School. Amon often picks up a few things for dinner at the Armory on her way home.

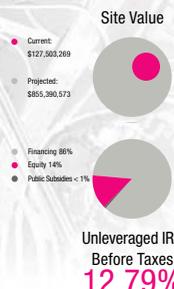
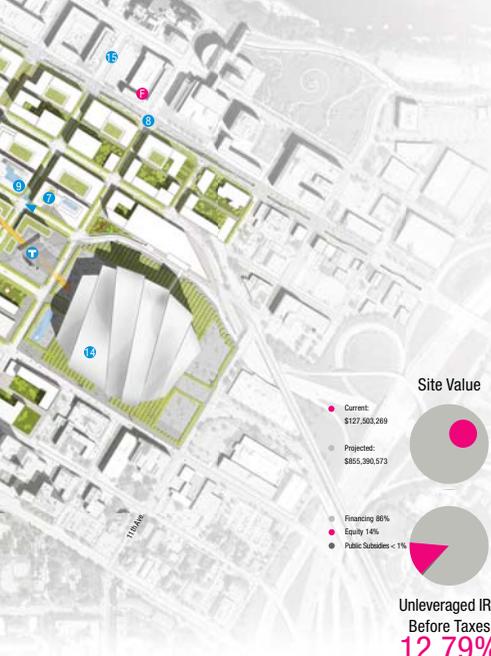
**D Don + Ashley**  
Don decided to move to independent living off of Portland Ave to be closer to his love for the performing and visual arts. This weekend he is going to St. Paul and is looking forward to seeing his granddaughters and attend her piano recital.



**VIKING VICTORY MARCH TO ARMORY GREEN**

# ARMORY

## FOR AN ADAPTIVE URBAN LIFESTYLE



### AN ICONIC GREEN FOR DOWNTOWN MINNEAPOLIS



PHASE ONE - 2015 Total: 1,729,849 SF



PHASE TWO - 2017 Total: 1,999,494 SF



PHASE THREE - 2021 Total: 714,793 SF

### Infill Strategies

- Internatalized Parking
- Pedestrian + Service Alleys
- Wind Relief
- Variable Facades
- Cellular Parcel Division

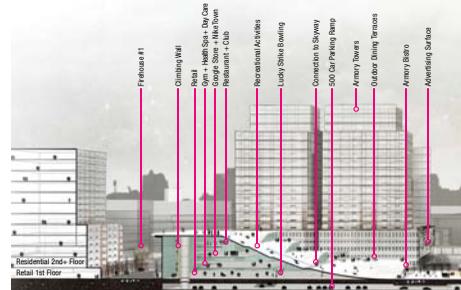


### Sustainable Strategies

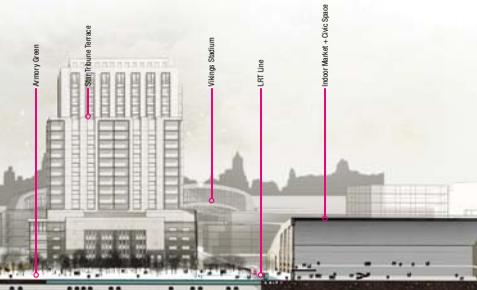
- Daylighting
- Green Roof Terraces
- Electric Car Charging Stations
- Grey Water Storage
- Solar Energy Collection



### WASHINGTON AVENUE INFILL STRATEGY



### MIXED-USE BUILDING TYPOLOGY



### WINTER ACTIVITIES AT ARMORY GREEN



**E Jason + Wendy**  
Jason and Wendy came into town for the Wings vs. Packers game. While waiting at Armory Green, Wendy was inspired by the variety of retail nearby she recognized Mike as an aspirational goal as a downtown developer.

**F Dave + Michael**  
Dave works via Skyway to his job at a marketing firm downtown and Michael commutes by light rail to a law firm in Edina. They are Minneapolis residents. They enjoy proximity to Armory Green and frequenting their favorite restaurants.

**G Cai**  
Cai lives in a studio apartment in the Armory District where she works nearby as a bartender and is finding her degree at Minneapolis Community College. Most weekends she visits her friends at the Armory Market to enjoy a heart-to-heart and coffee.

**H Elijah**  
Elijah is a recent graduate from culinary training courses at the nearby Catholic Charities Center after looking for a way out of homelessness. He now works at an Armory District restaurant that specializes in using local food sources.



# THE ARMORY

## Design and Development Strategy

The Armory is an iconic urban development that will create a strong identity for Minneapolitans in the 21st Century. Currently, Minneapolis looks to establish itself as a world-class cosmopolitan community. The city is approaching a threshold of becoming a model for how a mid-size urban region can function in response to dynamic change. The Armory is a development that provides the means to absorb predicted growth in density through an iconic approach.

The Armory is a vision for a district that effectively connects the components that make Minneapolis a successful city: parks, bicycling, a unique architectural vernacular, culture, and a strong work ethic. Portland Avenue serves as the spine for this connection, linking pedestrians to local and regional destinations via: the LRT network, a future downtown street car loop, skyways, and the first livable, pedestrian-oriented district in the Downtown area. The existing Armory building will be repurposed as a flexible civic meeting space and an indoor market. The Armory reinforces the rich history of the city's past, becoming a dynamic focal point for a new district.

Armory Green, the adjacent urban park and retail destination, rises in response to the Armory façade in a gestural embrace towards the River. Armory Green serves as a socio-economic crucible for the District and the downtown area. Visitors, commuters, and residents come to the Green to meet, shop, and relax in the City's first iconic urban open space. In wintertime, the Skyway connection activates the interior of the Green, where people shop in a unique open setting. In summer the interior opens up onto the slope, accommodating both daily activity and special events such as concerts and festivals. This spatial flexibility lends itself to the character of adaptable urbanism that embodies The Armory.

The downtown core is poised to experience increased urban density in the near term. The Armory responds to this predicted growth in both the scale and scope of development. Current and future planned construction projects consisting of office, retail, hotel and for-sale residential are not enough to meet forecasted absorption.<sup>1</sup> Moreover, Phase I construction will be completed during the expansion phase of the real estate cycle for each sector except multi-family.<sup>2</sup> Additionally, this development can be expected to spur demand from the Downtown commuting population of 133,000.

The Armory is one component of a greater vision for Minneapolis. It is a community that functions as a node of dynamic change, serving the Minneapolis-St. Paul region, the University of Minnesota, adjacent neighborhoods, and the business district. This development and its greater vision incorporate a community-centric design that will endure and be loved by future generations.

## Equity and Financing

Development of The Armory begins with the formation of a real estate development partnership capitalized by the owners' parcel contributions. The owner's initial capital contribution of land to the partnership along with a complete financial pro forma, detailed design, and appropriate bonding and insurance provide the security needed to obtain financing. This financing will come in the form of a construction loan followed by a take-out permanent loan for all three phases of construction. Public incentives provide additional capital as well as foster mutual interest for a successful development. These incentives give the owners the ability to create a downtown urban park from two valuable parcels. This increases value for both Minneapolis and the owners by creating an iconic landmark to serve the community.

The percentage ownership of the development partnership corresponds to the value of each owner's parcel contribution. These parcels form the equity basis of the construction and permanent loans. The lender assesses development feasibility, financial strength, borrower character, repayment ability, and security in the form of appropriate liens, possible individual guarantees, insurance, and bonding. The attached pro forma indicates that the development has a large return on capital, healthy debt coverage and an appropriate loan to value.

The construction loan is calculated on a term of one year at a rate of 200bp over Prime and one point fee. The loan balance increases as construction draws are presented to the lender.<sup>3</sup> Upon Phase I completion, the lender refinances the balance into a nine year balloon loan with a 30 year amortization.<sup>4</sup> The Phase I initial debt service payment and fee is paid from income generated in 2013 and 2014. Thereafter, the development's revenues provide robust debt coverage. At the maximum, LTV comes in around 73%. Each of the following phases use the same method of construction loan to permanent loan financing with increasing strength in coverage and collateral. Additionally, the permanent financing of all phases has a balloon payment scheduled in year 2024 for valuation purposes.

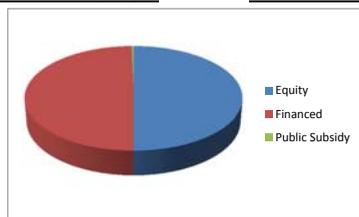
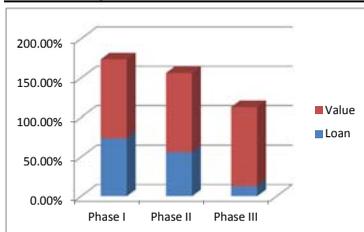
Minneapolis has committed public funds to building a 500 space parking ramp in Phase I. The city then operates the ramp for a ten year period, collecting revenue from 400 spaces and lease revenue for 100 spaces from the development entity. In year 10, title to the parking ramp reverts to the development entity. An assumption was made that federal funds would be generated through the Federal Historic Preservation Tax Incentive Program and the Low Income Housing Tax Credit Program.<sup>5</sup> A TIF PAYGO note is possible. However, based on the pro forma's strong expected return for the owners, the "but for" condition is unlikely to be met.<sup>6</sup>

| 1. Summary Pro Forma              |                              |                  |                  |                |                                       |                 |                 |                 |                  |                 | Team: 1155       |                |
|-----------------------------------|------------------------------|------------------|------------------|----------------|---------------------------------------|-----------------|-----------------|-----------------|------------------|-----------------|------------------|----------------|
|                                   | Year 0                       | Phase I          |                  | Phase II       |                                       |                 | Phase III       |                 |                  |                 |                  |                |
|                                   | 2013-2014                    | 2015             | 2016             | 2017           | 2018                                  | 2019            | 2020            | 2021            | 2022             | 2023            | 2024             |                |
| <b>Net Operating Income</b>       |                              |                  |                  |                |                                       |                 |                 |                 |                  |                 |                  |                |
| Market-rate                       | Rental Housing               | \$ -             | \$ 682,939       | \$ 844,113     | \$ 3,546,023                          | \$ 3,277,798    | \$ 3,569,054    | \$ 3,902,654    | \$ 6,852,628     | \$ 7,058,207    | \$ 7,269,953     |                |
|                                   | For-Sale Housing             | \$ -             | \$ 31,575,589    | \$ 38,592,386  | \$ 76,840,981                         | \$ 138,313,765  | \$ 92,209,177   | \$ -            | \$ 22,601,357    | \$ 27,623,881   | \$ -             |                |
| Affordable                        | Rental Housing               | \$ -             | \$ 682,939       | \$ 844,113     | \$ 3,546,023                          | \$ 3,277,798    | \$ 3,569,054    | \$ 3,902,654    | \$ 6,852,628     | \$ 7,058,207    | \$ 7,269,953     |                |
|                                   | Office/Commercial            | \$ 13,032,560    | \$ 6,516,280     | \$ 6,516,280   | \$ 3,750,543                          | \$ 3,750,543    | \$ 3,750,543    | \$ 3,750,543    | \$ 3,750,543     | \$ 3,750,543    | \$ 3,750,543     |                |
|                                   | Medical Office               | \$ -             | \$ 4,839,440     | \$ 5,032,144   | \$ 5,224,848                          | \$ 5,417,552    | \$ 5,610,257    | \$ 5,802,961    | \$ 5,995,665     | \$ 6,188,369    | \$ 6,381,074     |                |
|                                   | Market-rate Retail           | \$ -             | \$ 6,547,329     | \$ 6,779,392   | \$ 12,468,578                         | \$ 12,905,259   | \$ 13,354,668   | \$ 13,817,179   | \$ 14,990,142    | \$ 15,903,897   | \$ 16,032,628    |                |
|                                   | Hotel                        | \$ -             | \$ 17,795,828    | \$ 15,187,129  | \$ 15,642,743                         | \$ 16,112,025   | \$ 16,995,386   | \$ 17,095,248   | \$ 17,606,045    | \$ 18,134,226   | \$ 18,678,253    |                |
|                                   | Structured Parking           | \$ -             | \$ 2,967,805     | \$ 3,065,634   | \$ 6,298,638                          | \$ 6,496,591    | \$ 6,700,495    | \$ 6,910,510    | \$ 8,882,965     | \$ 8,992,454    | \$ 9,230,021     |                |
|                                   | Surface Parking              | \$ 720,479       | \$ 1,553,006     | \$ 1,553,006   | \$ 988,674                            | \$ 988,674      | \$ 988,674      | \$ 988,674      | \$ 177,642       | \$ 177,642      | \$ 177,642       |                |
|                                   | Other                        | \$ -             | \$ -             | \$ -           | \$ -                                  | \$ -            | \$ -            | \$ -            | \$ -             | \$ -            | \$ -             |                |
| <b>Total Net Operating Income</b> |                              | \$ 13,753,039    | \$ 8,069,286     | \$ 67,160,956  | \$ 75,084,128                         | \$ 128,307,050  | \$ 190,540,011  | \$ 146,347,307  | \$ 55,357,390    | \$ 87,509,615   | \$ 94,447,426    | \$ 68,790,073  |
| <b>Development Costs</b>          |                              |                  |                  |                |                                       |                 |                 |                 |                  |                 |                  |                |
| Market-rate                       | Rental Housing               | \$ -             | \$ 10,623,785    | \$ -           | \$ 29,372,612.00                      | \$ -            | \$ -            | \$ -            | \$ 28,187,329.00 | \$ -            | \$ -             | \$ -           |
|                                   | For-Sale Housing             | \$ -             | \$ 61,279,558    | \$ -           | \$ 241,586,177.00                     | \$ -            | \$ -            | \$ -            | \$ 52,284,738.50 | \$ -            | \$ -             | \$ -           |
| Affordable                        | Rental Housing               | \$ -             | \$ 14,947,935    | \$ -           | \$ -                                  | \$ -            | \$ -            | \$ -            | \$ -             | \$ -            | \$ -             | \$ -           |
|                                   | Office/Commercial            | \$ -             | \$ -             | \$ -           | \$ -                                  | \$ -            | \$ -            | \$ -            | \$ -             | \$ -            | \$ -             | \$ -           |
|                                   | Medical Office               | \$ -             | \$ 41,304,596    | \$ -           | \$ -                                  | \$ -            | \$ -            | \$ -            | \$ -             | \$ -            | \$ -             | \$ -           |
|                                   | Retail                       | \$ -             | \$ 55,452,205    | \$ -           | \$ 43,064,164                         | \$ -            | \$ -            | \$ -            | \$ 4,803,906     | \$ -            | \$ -             | \$ -           |
|                                   | Hotel                        | \$ -             | \$ 62,531,840    | \$ -           | \$ -                                  | \$ -            | \$ -            | \$ -            | \$ -             | \$ -            | \$ -             | \$ -           |
|                                   | Structured Parking           | \$ -             | \$ 26,208,000    | \$ -           | \$ 16,161,600                         | \$ -            | \$ -            | \$ -            | \$ 7,134,400     | \$ -            | \$ -             | \$ -           |
|                                   | Surface Parking              | \$ -             | \$ -             | \$ -           | \$ -                                  | \$ -            | \$ -            | \$ -            | \$ -             | \$ -            | \$ -             | \$ -           |
|                                   | Demo & Remediation           | \$ -             | \$ 1,173,401     | \$ -           | \$ 520,077                            | \$ -            | \$ -            | \$ -            | \$ 240,869       | \$ -            | \$ -             | \$ -           |
|                                   | Land Acquisition             | \$ -             | \$ 23,853,420    | \$ -           | \$ -                                  | \$ -            | \$ -            | \$ -            | \$ -             | \$ -            | \$ -             | \$ -           |
|                                   | Total Infrastructure         | \$ -             | \$ 12,365,711    | \$ (300,000)   | \$ 10,339,437                         | \$ -            | \$ -            | \$ -            | \$ 3,874,636     | \$ -            | \$ -             | \$ -           |
|                                   | Developer Fees               | 5%               | \$ 15,487,023    | \$ (15,000)    | \$ 17,052,203                         | \$ -            | \$ -            | \$ -            | \$ 4,826,294     | \$ -            | \$ -             | \$ -           |
| <b>Total Development Costs</b>    |                              | \$ -             | \$ 325,227,474   | \$ (315,000)   | \$ 358,096,271                        | \$ -            | \$ -            | \$ -            | \$ 101,352,172   | \$ -            | \$ -             | \$ -           |
| <b>Annual Cash Flow</b>           |                              |                  |                  |                |                                       |                 |                 |                 |                  |                 |                  |                |
|                                   | Net Operating Income         | \$ 13,753,039    | \$ 8,069,286     | \$ 67,160,956  | \$ 75,084,128                         | \$ 128,307,050  | \$ 190,540,011  | \$ 146,347,307  | \$ 55,357,390    | \$ 87,509,615   | \$ 94,447,426    | \$ 68,790,073  |
|                                   | Total Asset Value            | \$ -             | \$ 83,542,050    | \$ 441,559,111 | \$ 452,750,411                        | \$ 637,775,369  | \$ 649,335,726  | \$ 672,241,147  | \$ 696,341,005   | \$ 794,619,501  | \$ 817,854,178   | \$ 855,390,573 |
|                                   | Total Costs of Sale          | \$ -             | \$ 325,227,474   | \$ (315,000)   | \$ 358,096,271                        | \$ -            | \$ -            | \$ -            | \$ 101,352,172   | \$ -            | \$ -             | \$ -           |
|                                   | Net Cash Flow                | \$ (113,750,230) | \$ (317,158,188) | \$ 67,475,956  | \$ (283,012,143)                      | \$ 128,307,050  | \$ 190,540,011  | \$ 146,347,307  | \$ (45,994,783)  | \$ 87,509,615   | \$ 94,447,426    | \$ 795,460,115 |
| <b>Value of Initial Land</b>      |                              |                  |                  |                |                                       |                 |                 |                 |                  |                 |                  |                |
|                                   | Contribution                 | \$ (127,503,269) |                  |                |                                       |                 |                 |                 |                  |                 |                  |                |
| <b>Debt Service</b>               |                              |                  |                  |                |                                       |                 |                 |                 |                  |                 |                  |                |
|                                   | Total Const. Loan Pmts       | \$ -             | \$ (20,326,717)  | \$ -           | \$ (22,604,827)                       | \$ -            | \$ -            | \$ -            | \$ (6,397,856)   | \$ -            | \$ -             | \$ -           |
|                                   | Permanent Loan Pmts          | \$ -             | \$ (20,358,485)  | \$ -           | \$ (20,358,485)                       | \$ (42,998,641) | \$ (42,998,641) | \$ (42,998,641) | \$ (49,406,496)  | \$ (49,406,496) | \$ (733,457,520) |                |
|                                   | Loan Proceeds                | \$ -             | \$ 325,227,474   | \$ -           | \$ 361,677,234                        | \$ -            | \$ -            | \$ -            | \$ 102,365,694   | \$ -            | \$ -             | \$ -           |
|                                   | Leveraged Net Cash Flow      | \$ (113,750,230) | \$ (12,257,431)  | \$ 47,117,471  | \$ 35,701,778                         | \$ 85,308,409   | \$ 147,541,370  | \$ 103,348,666  | \$ 6,974,414     | \$ 38,103,119   | \$ 45,404,930    | \$ 62,002,595  |
|                                   | Net Present Value            | \$ -             | \$ 23,938,311    | \$ -           | \$ -                                  | \$ -            | \$ -            | \$ -            | \$ -             | \$ -            | \$ -             | \$ -           |
|                                   | Leveraged Net Present Value  | \$ -             | \$ 445,131,091   | \$ -           | \$ -                                  | \$ -            | \$ -            | \$ -            | \$ -             | \$ -            | \$ -             | \$ -           |
|                                   | Loan to Value Ratio (LVR)    |                  | 73.65%           | 0              | 56.15%                                | 0               | 0               | 12.75%          | 0                | 0               | 0                | 79.97%         |
|                                   | Unleveraged IRR Before Taxes |                  | 12.79%           |                | Current Site Value (start of Year 0)  | \$ 127,503,269  |                 |                 |                  |                 |                  |                |
|                                   | Leveraged IRR Before Taxes   |                  | 35.9%            |                | Projected Site Value (end of Year 10) | \$ 855,390,573  |                 |                 |                  |                 |                  |                |
|                                   | Debt Coverage                |                  | 1.07             | 3.30           | 1.75                                  | 2.98            | 4.43            | 3.40            | 1.12             | 1.77            | 1.91             | 1.39           |

| 2. Multiyear Development Program             |                                   |                                    |         |           |           |           |           |           |           |           |           |           |
|--|-----------------------------------|------------------------------------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|  | Total Buildout                    | Year-by-Year Cumulative Absorption |         |           |           |           |           |           |           |           |           |           |
|  |                                   | 2014                               | 2015    | 2016      | 2017      | 2018      | 2019      | 2020      | 2021      | 2022      | 2023      |           |
| <b>Project Buildout by Development Units</b> |                                   |                                    |         |           |           |           |           |           |           |           |           |           |
| Market-rate                                  | Rental Housing (units)            |                                    |         | 55        | 55        | 206       | 206       | 206       | 206       | 206       | 351       | 351       |
|  | For-Sale Housing (units)          |                                    |         | 234       | 234       | 1,257     | 1,257     | 1,257     | 1,257     | 1,257     | 1,456     | 1,456     |
| Affordable                                   | Rental Housing (units)            |                                    |         | 110       | 110       | 110       | 110       | 110       | 110       | 110       | 110       | 110       |
|  | Senior Independent Living (units) |                                    |         |           |           |           |           |           |           |           |           |           |
|  | Hotel (rooms)                     |                                    |         | 575       | 719       | 719       | 719       | 719       | 719       | 719       | 719       | 719       |
|  | Structured Parking (spaces)       |                                    |         | 860       | 860       | 1,637     | 1,637     | 1,637     | 1,637     | 1,637     | 1,980     | 1,980     |
|  | Other                             |                                    |         |           |           |           |           |           |           |           |           |           |
| <b>Project Buildout by Area</b>              |                                   |                                    |         |           |           |           |           |           |           |           |           |           |
| Market-rate                                  | Rental Housing (s.f.)             |                                    |         | 54,621    | 54,621    | 205,637   | 205,637   | 205,637   | 205,637   | 205,637   | 350,559   | 350,559   |
|  | For-Sale Housing (s.f.)           |                                    |         | 280,313   | 280,313   | 1,508,197 | 1,508,197 | 1,508,197 | 1,508,197 | 1,508,197 | 1,747,365 | 1,747,365 |
| Affordable                                   | Rental Housing (s.f.)             |                                    |         | 98,090    | 98,090    | 98,090    | 98,090    | 98,090    | 98,090    | 98,090    | 98,090    | 98,090    |
|  | Office/Commercial (s.f.)          | 762,138                            | 762,138 | 762,138   | 438,660   | 438,660   | 438,660   | 438,660   | 438,660   | 438,660   | 438,660   | 438,660   |
|  | Medical Office (s.f.)             |                                    |         | 240,143   | 240,143   | 240,143   | 240,143   | 240,143   | 240,143   | 240,143   | 240,143   | 240,143   |
| Market-rate Retail                           | (s.f.)                            |                                    |         | 392,721   | 392,721   | 697,708   | 697,708   | 697,708   | 697,708   | 697,708   | 731,730   | 731,730   |
|  | Hotel (s.f.)                      |                                    |         | 255,232   | 255,232   | 255,232   | 255,232   | 255,232   | 255,232   | 255,232   | 255,232   | 255,232   |
|  | Structured Parking (s.f.)         |                                    |         | 403,200   | 403,200   | 651,840   | 651,840   | 651,840   | 651,840   | 651,840   | 761,600   | 761,600   |
|  | <b>Total (s.f.)</b>               | 762,138                            | 762,138 | 2,486,458 | 2,162,980 | 4,095,507 | 4,095,507 | 4,095,507 | 4,095,507 | 4,095,507 | 4,623,379 | 4,623,379 |

| 3. Unit Development and Infrastructure Costs |                                   |                          |
|--|-----------------------------------|--------------------------|
| Development Costs                            | Unit Cost                         | Total Cost               |
| Market-rate                                  | Rental Housing (\$ per unit)      | \$ 170,550               |
|  | For-Sale Housing (\$ per unit)    | \$ 290,100               |
| Senior Independent Living                    | (\$ per unit)                     | \$ 170,550               |
| Affordable                                   | Rental Housing (\$ per unit)      | \$ 117,912               |
|  | Medical Office (\$ per s.f.)      | \$ 167                   |
|  | Retail (\$ per s.f.)              | \$ 136                   |
|  | Hotel (\$ per room)               | \$ 88,750                |
|  | Structured Parking (\$ per space) | \$ 19,200                |
|  |                                   | <b>\$ 718,350,076.35</b> |
| <b>Infrastructure Costs</b>                  |                                   |                          |
|  | Public                            | Private                  |
| Minneapolis Infrastructure Subsidy           | \$ 600,000                        |                          |
|  | Skywalks                          | \$ 2,007,706             |
|  | Park/Landscaping/Sod              | \$ 3,652,173             |
|  | Trees                             | \$ 7,710                 |
|  | <b>Total Infrastructure Costs</b> | \$ 5,067,589             |
|  | Demo, Acquisition, Fees           | \$ 63,138,287            |
|  | <b>Total Development Costs</b>    | \$ 786,555,953           |

| 4. Equity and Financing Sources         |   |                               |                      |                  |
|---|---|-------------------------------|----------------------|------------------|
| Initial Equity Sources (total)          |   | Amount                        |                      | Percent of Total |
|   |   | Initial                       | End                  |                  |
|   | 49% Equity - Owner 1                                | \$ 61,903,630                 | \$ 389,775,456       | 24.51%           |
|   | 51% Equity - Owner 2                                | \$ 65,599,639                 | \$ 405,684,659       | 25.51%           |
|   | <b>Total Equity</b>                                 | \$ 127,503,269                | \$ 795,460,115       | 50.0%            |
| <b>Financing Sources (total)</b>        |   |                               |                      |                  |
|   | Phase I: Construction Loan                          | \$ -                          | \$ 325,227,474       |                  |
|   | Phase I: Long Term Financing                        | \$ -                          | \$ 325,227,474       | 20.45%           |
|   | Phase II: Construction Loan                         | \$ -                          | \$ 361,677,234       |                  |
|   | Phase II: Long Term Financing                       | \$ -                          | \$ 361,677,234       | 22.74%           |
|   | Phase III: Construction Loan                        | \$ -                          | \$ 102,365,694       |                  |
|   | Phase III: Long Term Financing                      | \$ -                          | \$ 102,365,694       | 6.44%            |
|   | <b>Total Financing</b>                              | \$ -                          | \$ 789,270,402       | 49.63%           |
| <b>Public Subsidies</b>                 |   |                               |                      |                  |
|   | Minneapolis Infrastructure Subsidy                  | \$ -                          | \$ 600,000           | 0.04%            |
| <b>Possible Subsidies (Tax Credits)</b> |   |                               |                      |                  |
|   | LIHTC   | \$ -                          | \$ 1,229,117         | 0.08%            |
|   | Federal Historic Preservation Tax Incentive Program | \$ -                          | \$ 3,591,536         | 0.23%            |
|   | Minneapolis "PAYGO" TIF                             | Unlikely based on projections |                      |                  |
|   | <b>Phase I LTV</b>                                  | <b>Phase II LTV</b>           | <b>Phase III LTV</b> |                  |
|   | 73.65%  | 56.15%                        | 12.75%               |                  |



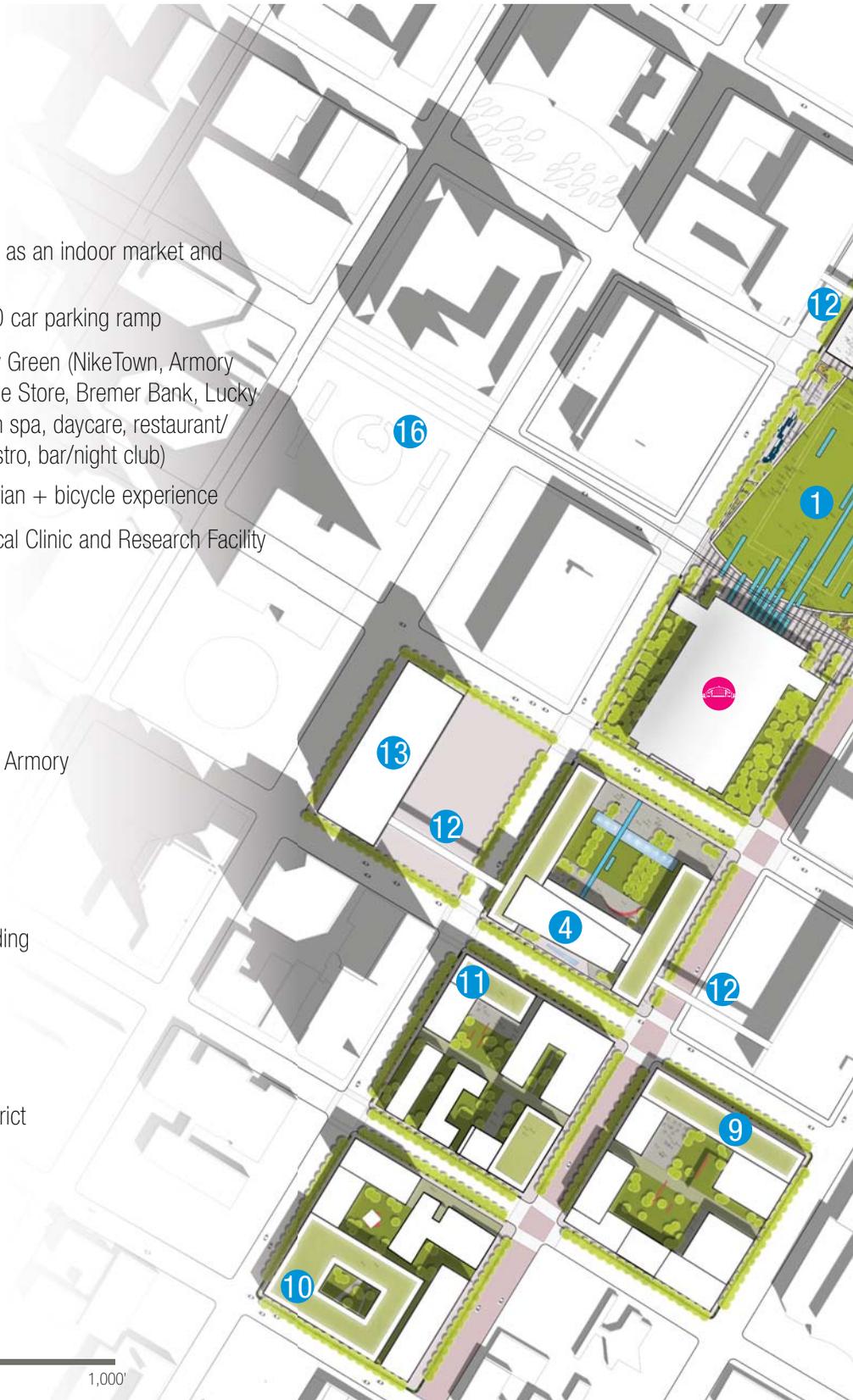
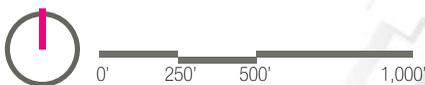
| Phase     | Loan   | Value |
|-----------|--------|-------|
| Phase I   | 73.65% | 100%  |
| Phase II  | 56.15% | 100%  |
| Phase III | 12.75% | 100%  |

| Category       | Amount        |
|----------------|---------------|
| Equity         | 795,460,114.9 |
| Financed       | 789,270,402   |
| Public Subsidy | 542,065.407   |

| Owner   | Initial Asset Value | Final Asset Value |
|---------|---------------------|-------------------|
| Owner 1 | \$ 61,903,630       | \$ 389,775,456    |
| Owner 2 | \$ 65,599,639       | \$ 405,684,659    |

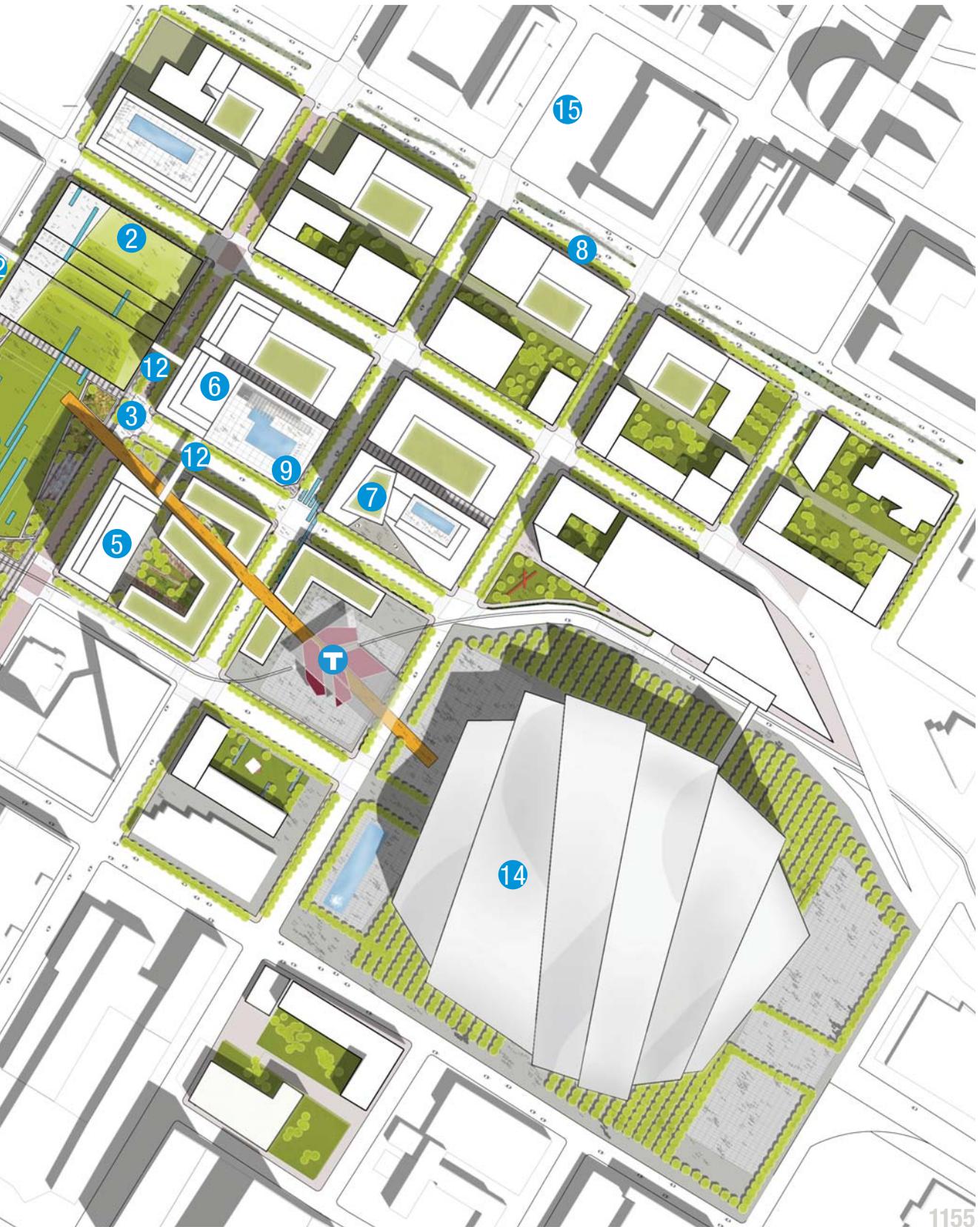


-  Armory - repurposed as an indoor market and flexible civic space
- 1** Armory Green + 500 car parking ramp
- 2** The Shops at Armory Green (NikeTown, Armory Fitness Center, Google Store, Bremer Bank, Lucky Strike Bowling, health spa, daycare, restaurant/aquarium, Armory Bistro, bar/night club)
- 3** Portland Ave. pedestrian + bicycle experience
- 4** Armory District Medical Clinic and Research Facility
- 5** Star Tribune Terrace
- 6** Armory Towers
- 7** Armory Hotel
- 8** Washington Ave. infill
- 9** AMC Theaters at The Armory
- 10** Senior-oriented living
- 11** Affordable housing
- 12** Skyway connection
- 13** Existing Thrivent building
- 14** New Vikings stadium
- T** Light rail stop
- 15** Mill District
- 16** Central Business District



## 8.7

### ULI/Hines Site Plan



1155