CLIMATE REFUGE:
Thermal Comfort in Urban Micro Climates

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By

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Abstract

This study addresses two major issues by responding to the significant decline in retail buildings including enclosed shopping malls and improving density, livability and human comfort in communities welcoming climate refugees. Future designs will become more responsive when involving suburban and urban infill landscape to enhance user experiences through thermal comfort.

Studies show that Earth’s temperatures are on the rise causing large populations to be displaced by rising sea levels and contributing to extreme weather patterns in the colder hemispheres. Specifically, in the Midwest United States, this means colder temperatures, more snow, and longer months of winter (Cohen 2018).

Analyzing microclimates to improve thermal comfort will give designers a better understanding of the link between human thermal comfort and their surrounding infill landscape. Because shopping malls have generalizable locations and footprints and a nearly identical hierarchy of ingress and egress locations, they are ideal for this type of microclimate analysis using climate data. These generalized footprints are becoming dead space in smaller cities leaving large unused parking lots which have the potential to positively serve these communities through various climate events, specifically polar vortexes. This study aims to mitigate extreme cold weather events through microclimate design by examining various site configurations with the use of data collection such as wind speed, temperature, and humidity. A Thermal Sensation Vote (TSV) was calculated to determine which configurations are best for thermal comfort (Wong 2015).

Keywords

Urban Microclimate, Polar Vortex, Climate Responsive Urban Design
Thermal Comfort, Microclimatology
Imagine it's January in the Midwest and news headliners read that work and school will be cancelled because of dangerously low temperatures. Travel is not advised, and families are stagnant in their homes powered by heaters to stay warm. They become stuck in their own homes because they previously thought the weather was too cold to be outside, and now they have to be indoors. Climate refugees could be more comfortable in higher density areas where microclimates are better controlled. How can people become more active outdoors in these cold weather communities?

After studying landscape architecture, I’ve learned that using data such as wind speed, temperature, and humidity can drive new designs, specifically for cold weather spaces that address human comfort and microclimatology. Examining this criterion will reveal configurative opportunities to manipulate the microclimates with intent to enhance the user experience. A variety of housing types can give options for refugees and when used for infill, creates more populated areas. Higher density results in more sustainable design practices and generates a more comfortable setting in the cold climate communities. The use of case studies and literature review will aid in understanding human comfort levels and best mitigation practices. Successful infill projects of regional shopping malls are changing the way people think about these spaces and will be used as a guideline for this project. The use of a multimeter will be critical in finding live data of these design scenarios and gives a numerical value to better evaluate the human comfort on each site. Being able to plug these numerical values into an equation can determine human comfort, thus driving designers to new solutions.

Growing up in rural Minnesota, I have experienced dangerously low temperatures. Activities such as skiing, snowmobiling, or even ice fishing becomes dangerous and forces people to stay indoors. The idea that weather can limit our outdoor activity can be upsetting and is the driving force in finding new solutions to keep the outdoors accessible, even when the climate makes it hard.

How can human comfort be enhanced through design? This is relevant to the discipline of Landscape Architecture as it directly involves user experiences in cold weather microclimates. New research is indicating that extreme events like polar vortexes - a low pressure system pushing polar temperatures south- are becoming more common. Learning more about what affects human comfort and how to manipulate landscapes to enhance microclimates.
Throughout the United States and commonly found in Denver, CO, retrofitting regional shopping malls is becoming a popular solution for suburban density. Large open spaces once used for parking are now being re-developed to house businesses and residences together. This typology maximizes land use through mixed-use buildings and civic spaces creating town centers and downtown districts for the growing suburbs. Depending on the size of each site, a variety of housing can solve density issues in these communities, and the once dead mall space can be rejuvenated to create a third-place that people can enjoy once again. To best address user experience, the typology looks for the best configuration of retrofitted infill to comply with the human comfort in the spaces proposed.
[RESEARCH METHODOLOGY]

Retrofitting regional malls has many benefits for the impacted communities. In the following precedent studies, previous projects show that there is a positive impact on the people that live, work, and shop in the re-developed landscape. The following projects were chosen for their close proximity to human comfort and the user experience.

CONSIDERATION FOR PRECEDENT STUDIES:

+ TYPEOLOGY
- Retrofitted Regional Malls
- Urban Parks/Open Space

+ PROTOLOGY
- Suburban
- Regional Shopping Center

+ PROGRAMMING
- Mixed-Use Buildings
- Civic Space
- Walkability

+ PROJECT LOCATION

+ CLIMATE TYPE
- All Seasons

CHosen STUDIES:

+ Belmar | Lakewood, CO
+ Cottonwood | Holladay, UT
+ Mary Bartelme Park | Chicago, IL
Typology: Mall Retrofit
Location: Lakewood, CO
Size: 104 acres
Designer: Elkus Manfredi Architects, Ltd. & Civitas, Inc.
Date Completed: 2012

SUMMARY

The 104-acre site hosted a 1.2 million sq. ft. regional mall called Villa Italia with accessibility only by car. The new design created a downtown district with nearly 3.3 million sq. ft. of new mixed-use construction while creating walkability and better access. The mixed use combines shopping, residences, and office and civic spaces on twenty-three urban scaled streets and blocks. The sustainable development and green building of this design received LEED certification. Site drainage, recycled demolition materials, reused buildings, and a wind farm are significant for the sustainable practices used in the development of Belmar. On this site, there is a variety of housing types that read as authentic to the history and climate of Denver. Rentals-over-retail, townhouses, loft condominiums, and zero-lot-line houses account for the 1,300 units. The primary retrofitting strategies include scraping and rebuilding of a dead mall greyfield superblock, blocks developed in phases, and a continuous network of streets and open spaces for a 'downtown' experience.
PROJECT TAKE-AWAYS

Belmar project was developed with a primary focus on private and public spaces. This retrofitted design includes residences, businesses, restaurants and cafes to create a new district. Belmar was successful with interconnecting streets and green spaces for civic uses. The building materials also brought a new level of success that made this project unique to the people of Denver. The retrofitted mall will act as a downtown for the large, sprawling suburb that never had one or at least easy access to one.
PROJECT TAKE-AWAYS

Cottonwood held mini-charette’s to determine the right mixed-uses for this 57 acre site. With the help of professionals, a configuration of successful spaces was determined to help push the project along. Their detail-oriented approach to this project is important in order to create a successful retrofit project and to designate this new space as a town center. The 650,000 sq. ft. of retail space mixed with 500 dwelling units maximized the land use and gave a unique setting for the people of Holladay to enjoy.
Typology: Mall Retrofit
Location: Holladay, UT
Size: 57 acres
Designer: Duany Plater-Zyberk & Company
Date Completed: Conceptual Stage

SUMMARY

Announced on July 5th, 2007 this 57 acre site was the topic of discussion for retrofitting a dying mall. The town of Holladay, Utah had a typical regional mall that was dying and in need of change. The process of redeveloping this site into a mixed-use town center included a market study and mini-charette to determine that this area would benefit from a successful mixed-use town center that includes retail, office, and residential space. Owned by one of the largest retail real estate investment trusts (REITs), this project became one of the first for them to mixing uses on their properties being it is a considerable risk for a Wall Street-traded firm with impatient investors.

The mini-charette to determine the mixed-uses of this space were held in Miami and Utah. A variety of stakeholders, designers, and expert consultants including author Ellen Dunham-Jones were able to walk around the successful retrofit project in Miami to help them visualize what worked and what didn’t. This ultimately gave direction for Cottonwood, and being in the early stages of development, gave caution to accepting one solution.
MARY BARTELMEL PARK

Typology: Urban Park
Location: Chicago, IL
Size: 2.3 acres
Designer: Site Design Group
Date Completed: 2010

SUMMARY

Located on a brownfield site in the heart of a revitalized warehouse district, Mary Bartelme Park attracts visitors using a sculptural misting fountain, accessible playground, dog park, grassy berms, and quiet contemplative areas. Among other features, the pedestrian walkways incorporate 10,826 sq. ft. of permeable pavers. The 64,500-gallon underground infiltration bed is designed to handle stormwater from a 100-year storm event. This project was faced with a challenge from the city implementing a new planting strategy that is designed for more native plants. Mary Bartelme Park was able to achieve this prairie style planting with a limited 9 native plants, which also helped to reduce maintenance.

The surrounding neighborhood has transitioned from deteriorating buildings into a successful area of high-tech industry, upscale residences, and trendy restaurants. Mary Bartelme Park is a destination for both locals and tourists as it has become a popular backdrop for graduation and wedding pictures, and has even made an appearance in a popular video game.
PROJECT TAKE-AWAYS

The surrounding area of high tech business, upscale residential space, and trendy eateries has created a scene for this complimentary park. The sustainable features of this site are clear for the success the site has received. The multi-function of the fountain as a sculpture and the stormwater management are key features in attracting locals and tourists into the open space. The features also gives a sense of place to the people visiting resulting in higher popularity, which gives the surrounding neighborhood a good reputation.
LESSONS LEARNED

+ SUSTAINABILITY

Sustainable materials help sites around the country perform to their best capabilities when used properly. It is important to understand and think about the performance criteria for a site when designing for the user experience in all scenarios. Using the SITEs guidelines, sustainable sites are becoming more important to the local communities. Rainwater run-off, plant pallette’s and local materials are just to

+ MIXED-USE SPACE

Breaking the old view of keeping private and public spaces separate, planner’s have been mixing the uses of buildings and civic space to maximize the land use. This idea has spread into multi-functional art, event space, and residential living. Mixed-Use can also be considered a sustainable practice as it increases density while decreasing carbon footprints.

+ SENSITIVE APPROACH FOR COMMUNITY NEEDS

Staying sensitive to what the public needs will result in a successful project. Community involvement gives people a sense of ownership when their ideas are heard and will likely give them a reason to use the new space. Careful consideration to the wants and needs is important to responding not only to the people, but the landscape as well.

+ SPATIAL EFFICIENCY

Through spatial efficiency, planning goals can be achieved such as walkability, accessibility, and civil interactions. Interconnecting streets with green space allows the re-developed area to become accessible by foot, bicycle, or motor vehicle. Considering the spatial layout is crucial in achieving thermal comfort.
[Major Project Elements]

Project Scope:

The scope of this project includes civic space, streetscapes, retail and residential planning, and placemaking. These are all elements that can enhance user experiences while being sensitive to the cooler climate and enhancing thermal comfort on site.

+ Civic Space
  - Plaza Space
  - Open Space

+ Placemaking
  - Public Art
  - Destination Nodes

+ Retail and Residential Planning
  - Mixed-Use Buildings
  - Restaurants and Cafes
  - Public v. Private

+ Streetscapes
  - Walkability
Figure 15 | Public Art Destination
Anticipated User Groups

In a city that fails to respond to the needs of the residents and with close proximity to high tourist areas, Fergus Falls is a prime location to address the issues of outdoor public space. Retrofitting retail centers will attract tourists, residents, and businesses. By addressing human comfort in these areas, the spaces will be attractive for year round attention and give a boost in economic and social growth for a city that needs it. Fergus Falls, MN is located on I-94 which is a direct route to cities such as Minneapolis, Saint Cloud, and Fargo making this city a great place to stop and visit. Businesses can move in and still be connected to customers, while residential space can bring new life to the city of Fergus Falls.

Economic Issues

Fergus Falls doesn’t pose many options for different shopping types. Shopping nodes such as Wal-Mart and Target have become one-stop shopping centers that people go to for their everyday essentials. Grocery and clothing in the same store. The issue is that the people of Fergus Falls may reject newly proposed shopping that takes business away from the big box stores. They may fail to see the economic benefit from shopping local, due to the slightly higher prices of products.

Peak Usage

The anticipated users of this site will have usage throughout the days. Depending on the programming elements of the infill project, peak usage can vary. Due to the proposed mixed-use in the retrofit plan, peak usage can be assumed to be after normal working hours when most people have the freedom to take time walking, shopping, and eating.
Site Description

Located in the midwestern state of Minnesota, Fergus Falls is a small city that can benefit through the growth of public greenspace. Westridge Mall, located in the shopping/business district is a good candidate for research in incorporating public green spaces, while also addressing other issues for retail and housing, because of the large unused area that is designated for parking. This site is located in a cold climate region that experiences various events throughout the winter months. This small specifically has been declining over the last 2 decades. A sporting goods store, dollar store, and a movie theater currently occupy less than half of the retail space, while the other half is unused.

The 3 access points on this site are used by vehicles and has essentially no walkable entrances due to the large roads and access that do not feature sidewalks or greenspace for pedestrians. On the site sits a 136,000 sq. ft. home improvement store which is next to the 240,000 sq. ft. mall. A general ratio of 4 parking spots for every 1,000 sq. ft. this site has 1,504 parking spots. There are only 8 active retail spaces, indicating there are hundreds of parking spots that are not in use. These parking spots and the access to them account for 20 acres of impervious surface.
Important Elements

There is an emphasis to enhance thermal comfort through the planning of retail and residential space and the civic space. Creating new connections to the site will improve land quality and accessibility for all.

+ Civic Space
  - Plaza Space
  - Open Space

+ Retail and Residential Planning
  - Mixed-Use Buildings
  - Restaurants and Cafes
  - Public v. Private
[Project Goals]

+ Theoretical
- Mitigate cold weather events through microclimate design.

+ Physical
- Reduce impervious surfaces by 50% - Increase housing density by 200%

+ Social
- Promote civic interaction by designing 100% of retail walkable (.25 miles) and a TSV of 0 - 50% of all units universally accessible.
Attacking the Theoretical

Achieving the theoretical is to understand climate elements and how people react to them. Although climate elements such as temperature or wind are inevitable, a microclimate design can change the way humans perceive them. Through calculated research this goal is achievable in the planning and design of redevelopment in the regional shopping mall site.

Attacking the Physical

The amount of impervious surfaces on the site is not ideal for a healthy and enjoyable user experience. Physically reducing this surface by implementing mixed-use buildings and softscapes will not only enhance the experience, but it will also enhance the site's performance. Another physical goal is to increase housing by 200%. Considering there is no current housing on the site, this can be achieved through a density study and reconsideration of the current zoning laws. A variety of housing options will increase density and promote diversity of incomes for the people living here.

Attacking the Social

Achieving civic interaction will happen by creating a 100% walkable retail site with interconnected streets and green space. Closely studying building configurations and accessibility standards will make the social aspect of this retrofit project achievable.
Shopping Malls

The introduction of shopping malls into the suburban landscape brought together communities and generated income resulting in a healthy economy. The extreme growth of these shopping centers brought with them large open buildings, parking lots, and civic spaces giving the communities a ‘Third Place’. These places were where families would spend their weekdays and weekends hanging out with friends while grabbing food or shopping for the next trendy outfit. When the economy dipped, the people could no longer afford the trips to the malls to just hang out and the large open buildings started to become empty. They would no longer generate the money needed to pay the utilities and this would result in the closing of the malls. Obviously, larger malls had more people that would visit whereas smaller malls could not stay open for the small group of people that would still go. Small market cities such as Fergus Falls, MN are the target for this study as malls are leaving behind large unused parking lots and retail centers. They are eyesores and negatively impact the environment. Historical records suggest a trend that stray from the big box stores normalized by these regional shopping centers. Socially, malls are great places to hang out with friends, but not when the thermal comfort levels are below what is perceived as comfortable. Physical aspects of these dead spaces are in fact harming the environment and taking away from the potential uses in these sites. This project is similar to other projects in the fact that it will primarily be infill that helps generate more thermally comfortable outdoor spaces. The research of thermal comfort is relatively new to the profession of Landscape Architecture and can greatly improve cold climate communities that are directly impacted by those cold weather months.

A brief history of the shopping mall indicates that the post-World War II period played the largest role in the development of these malls. The early designs sought to keep the Main Street feel by combining retail space with civic space such as post offices and government offices. Thanks to the suburban landscape offering large amounts of land, little regulations, and federal mortgage funding, developers planned communities of single-family housing and garden apartments. The suburbs growth sparked by the automobile allowed people to travel further distances. This dictated the earliest designs of the mall. Vehicular circulation and parking would be found on the peripherals while the pedestrian-friendly shopping is separated by being placed in the center. It wouldn’t be until the 1980’s that we would see a social shift in the malls going back to the streets.

More and more leisure time was being spent in the malls and less time was being spent on the local main street. The expansions of the shopping malls were killing the pure commerce of main streets, although, the suburban developments never really had them. The superregional malls like the Mall of America marked the beginning to the end as the souped-up entertainment theme parks were becoming the attraction rather than shopping. The 80’s marked a shift in the social context as the main street buildings would start to be renovated and leased such as the shopping malls were. These properties were cheap to turn over and resulted in the decline of the shopping malls.

This decline would leave behind large spaces that were not economically pleasing to just tear down. Developers wouldn’t want to spend their money on a property that they believe is expended. The asphalt parking lots showcase poor drainage compared to what that space could do. The large buildings are potentially in the way of new buildings that can re-enact a main city street or new forms of generating income. Ultimately, the physical context of these abandoned sites is poor.
Westridge Mall in Fergus Falls is a prime location for showing the decline of regional mall spaces. Emphasizing the site characteristics will spark the need for intervention, and will give the design some guidelines. The climate analysis is the most important to this site as the design looks to improve the microclimates. This data will drive the design and lead to more thermally comfortable spaces to retain climate migrants. Other existing analysis will be necessary in understanding the failed mall space, while staying sensitive to the original intent of the site. Images were taken in a time that the focus was on the failed site conditions.

Understanding the wind rose for prevailing winds will be necessary for climate intervention. Knowing now that the prevailing winter winds are most frequently out of the North West at higher rates of speed, the final design will need to address this issue in the North West of the site in order to prevent those high speed winds from going through the site. The sun pattern is also an important piece in knowing where the sun will rise and set in the winter months as this will affect shadows. Shadows have a direct correlation to microclimate temperatures and will possibly need extra intervention depending on where the outdoor spaces are located on the site. These climate factors will greatly reduce the comfortability of the site in the winter months as they play a cooling effect.

The existing site is also important to understand. The history of the mall, the stores that were there, and the stores that surround the property will help aim the design in the direction for better use. Knowing what once was the lifeline of the mall is the first step in developing longer lasting spaces that are more efficient and sustainable. Dunham’s sporting goods and Westridge Theater anchor this site as two destinations while surrounding stores such as Home Depot and Dollar Tree keep people coming through the site. All of these stores work to keep this site in use, but a clear intervention is needed to make this site accessible and walkable. There is currently no reason to visit this site unless you need new sporting gear, home renovation supplies, or want to enjoy a new film. The proposed design will add retail space, residential space, and outdoor civic space to accommodate even more visitors.

In conclusion, the site analysis screams for intervention. The lack of consistent users and retail options has lead this site to the dumps that it presents today. The existing site, being in the colder midwest, will be the perfect fit for the thermal comfort design that will create housing for climate migrants, while generating retail sales.
Fergus Falls is located in what locals call Lakes Country. These lakes were formed thousands of years ago by the great glaciers and through their process have exposed sandstone that can be used in the building materials.

In 1908, Fergus Falls began harvesting power from the Ottertail River permanently bringing settlers to the area. In 1978, Westridge Mall was introduced. This is the site for my design as I grew up in the area, I have experienced this property decline rapidly. In fact, in Fall of 2019 the property was auctioned off to new owners.

The site is 128 acres and is split in two by West Lincoln Avenue, which connects the site to I-94 as well as downtown Fergus Falls. It is currently 4 lanes with additional turn lanes, making the street excessively wide, reaching 120 feet. The 45 MPH road moves traffic through the site quickly, not allowing pedestrians to cross at the intersections.

The North-South connection is broken within the site resulting in the existing sidewalk being underutilized and does not promote active transportation. Here we see 1600 ft of sidewalk ending in the middle of the site.

Home Depot and Fleet Farm anchor this area and attract the most customers, while Dunham’s sporting goods has a healthy business through seasonal sporting equipment sales. Westridge Mall, the placemaker, is virtually empty only hosting a few businesses including the movie theater.

Some restaurants including a local chinese buffet and sports bar bring people onto the site for lunch and dinner. In the North West corner, a McDonald’s attracts travellers from the interstate and allows their customers to eat on the go.

Relatively new to the area is a grocery store that offers competitive prices compared to the larger stores, attracting customers from all around the county. Along with the grocery store there is a centrally located gas station..

This vehicle centric design is apparent with the lack of walkability and large parking areas throughout. The existing stores are widespread and do not attract enough customers to justify these large spaces. This site is surrounded with businesses and residences, but still lacks in pedestrian experience.
Performance Applications

Performances are judged on a variety of levels to determine a landscapes success. The criteria previously listed will be measured specifically for this project and will give the client a sense of what can be achieved. The goals of the project aided in driving this criteria as the project looks to achieve those as an end result. These six performance measurements will aid us in deciding if the project has failed to meet, met, or exceeded the goals. The physical goals of this project aim to reduce impervious surfaces by 50% while increasing housing density from 0 to 20 units per acre. Through the space allocation, environmental impact, and code compliance I will be able to determine the success of this goal. The social goal is to promote public interactions by creating 100% walkable retail space with at least 50% of that being universally accessible can be determined through the criteria of environmental performance, behavioral performance, and psychological impact. The anticipated performance will help guide the rest of the project by understanding spatial relationships, material choices, and the environmental impacts.

Space allocation, environmental impact, and code compliance are factors in the physical goals to reduce impervious surfaces and increase housing density. This site is zoned for retail, so already the goal to develop housing will be difficult to increase. This project will need to exceed all other requirements to make a strong case to develop residential space in this zone. Through space allocation and the justifiable environmental impact should hold power in changing the zoning code. While looking back to the case studies, the space allocation will be in ratio to the overall site size.

Environmental performance, behavioral performance, and the psychological impact will aid in the success for creating walkable and accessible retail. By developing a thermally comfortable environment users will be able to use the outdoor spaces more often creating a more comfortable walking environment. This, along with comfortable walking distances, will ensure the retail space is in fact walkable. The study of behavioral performance will give the site the best routes in creating space for vehicle and pedestrian travel creating a more accessible and walkable environment. The psychological impact of the site will play a role in how well the site is perceived as thermally comfortable. The longer somebody stays outdoors, the more thermally comfortable that space will need to be. The time spent in the outdoor spaces will be in direct correlation with the thermal sensation and in turn how walkable retail and residential spaces will be.

Applying the thermal comfort research to this site happened using a program called AutoDesk Flow. This program allowed me to run simulations on various layout plans to determine the best layout for human thermal comfort. This program was limited in the fact that the variables were wind direction and speed. I was only able to test the wind from one direction at a time, so to limit any inconsistencies, I tested the prevailing winter winds from the North West. The results were directly correlated to the research that ‘L’ shaped buildings are more thermally comfortable in the South East spaces.
Climate Migration Mitigation

Climate migration research has lead me to believe there will become a trend for the people in cold-weather regions to move into more temperate climates. In one article, thresholds have been illustrated that describe the reasoning to the migration patterns cause by climate change. The threshold that I am referring to is a situation when the nature of the human-environment relationship undergoes extreme change. This threshold is reached when adaptation is no longer a beneficial option. This research can be used to justify the historical, social, and cultural need for intervention in the region.

For example, when the temperatures in the winter months drop to dangerously low negatives, heating costs will rise to extreme highs in order to keep living spaces comfortable. When that heating cost becomes economically harmful to an individual, they may look to move where the environment will not increase their bills. This form of migration is a potential factor in the Midwest region as the winter months are seemingly colder for longer periods.

Historically, there is no data to prove that midwesterners are migrating away from the dangerously low temperatures. This trend that people are leaving the wintery Midwest is only a prediction and the intervention of this project aims to keep residences comfortable where they are. We are just now experiencing the extreme events caused by climate change that has been in effect for the last few decades. Usually, when somebody from the midwest looks to move South, they are in search of better work opportunities or schooling. The more temperate climate may play a role in their decision, but there is no evidence that it is the main reason.

Climate refugees, as a social prediction, are migrating for the lack of activity in the harsh winters. Canada is a great example of how their people embrace the winter and host festivals and other activities to stay active. In Fergus Falls, MN specifically, there are not a lot of activities that people justify freezing over. The programming elements of this project will need to be compelling enough for people to want to embrace the cold.

Climate refugees are creating a culture to leave behind their homes, and this project will allow them to embrace the climate change. The idea to create more thermally comfortable landscapes can greatly enhance one’s experience and may give them a reason to stay in the region, rather than leaving. Again, Canada’s embrace of their climate is remarkable as they celebrate something that has such a negative connotation. Ice fishing and snowmobiling are impactful for the Fergus Falls area as we see people travel to engage in these activities. What are the activities for people who cannot afford a snowmobile or the people that do not enjoy ice fishing? The culture needs to be spread to the various groups of users to allow for a better experience and a larger impact on the communities.
Space Allocation

Space allocation can be measured in area (sq. ft.) in the residential, retail, parking, and park spaces. The size of these spaces will be in direct correlation to the ratio of spaces in successful infill projects and will be easily attainable through maps and drawings. This numeric value will be used in comparison to the case studies to determine success. If the size of the space in comparison to the site as a whole is within the same ratio as the case studies, this project can be deemed successful.

Environmental Performance

Environmental performance is the key to my research. Developing thermal environments can be measured by using climate data to determine comfort levels. In order to measure the environmental performance, climate data will be collected and calculated through an equation that determines a thermal sensation value. This data can be measured through on-site evaluations and computer simulations to show the areas of higher thermal comfort. To the limitations of the computer simulations, thermal comfort can be analyzed from wind speed and temperature. Thermal comfort differs for each person so to determine success, the final TSV should land in a range that is perceived as thermally comfortable by many.

Code Compliance

Code compliance will be measured to determine the validity of the city code. These may dispute existing codes to gain the best building practices for thermal comfort. A compilation of the other measurements with the map measurements for building codes will determine the validity. This analysis will be a comparison to determine the best practices. Typically code compliance will be successful if it is within the rules and regulations of the city code. This project may still be considered successful if those codes are broken, as long as the rest of the categories do not harm the people or the environment throughout the lifetime of the landscape.
**Psychological Impact**

Similar to the environmental performance, the perception of warmer microclimates can be calculated. This calculation will be its own unit of measure called a Thermal Sensation Vote (TSV). In order to measure the environmental performance, climate data will be collected and calculated through an equation that determines a thermal sensation value. This data can be measured through on-site evaluations and computer simulations to show the areas of higher thermal comfort. This analysis will be done through a calculation that will produce a Thermal Sensation Vote (TSV).

**Behavioral Performance**

Usage patterns can be measured in path distances for both pedestrian and vehicle circulation. This measurement will be in miles to better grasp how far one may travel on-site. Drawings and maps will be used in order to accurately measure distances through the proposed space. This numerical value can be used to compare distances to the daily average in similar spaces. Success in this category will be determined by the goal of 100% walkable and at least 50% universally accessible.

**Environmental Impact**

The environmental impact can be measured by converting asphalt space into green space. The addition of residential and retail space will impact the environment through wastewater management, energy consumption, and everyday usage. The measurement of the environmental impact will be best done by computer simulations. The materials used and their thermal reflections work simultaneously and would be very difficult to calculate through any other medium. The computer simulators will be able to analyze the reflective properties of the materials and will tell us how each material impacts the environment. To be considered successful for environmental impact, the materials used should not negatively impact the TSV or the goals of the site.
Pioneers shaped our country and introduced new ideas and opportunities that would shape how we live our lives today. They settled the wilderness and brought order to chaos. George Wright and R.J. Mendenhall saw the potential of the river as a source of power, sparking the growth of Fergus Falls and built a city by offering free business lots to those who wanted to build. This would later route the railroad through town marking this as a trading hub. The vision of Wright and Mendenhall introduced new technology into the region that would bring new opportunities with it, inspiring to those who chose to pioneer a new future.

Figures can be seen in appendix “Process Drawings”
Through the schematic and design development phase, I really focused on maintaining my density goals while creating models for AutoDesk Flow. These two phases worked together to shape how the thermally comfortable landscape will look and gave the design the maximum amount of space for both the infill goals and the thermal comfort goals. Please review the appendix to see how those simulations shaped the project all together.

Figure can be seen in appendix “Presentation 2”
One solution to this is to infill with residential and business space to develop a new neighborhood. My goals include increasing density and accessibility while improving thermal comfort and walkability. In order to achieve this, I applied the results from my research and created infill layouts that I could test for thermal comfort suitability. Using AutoDesk Flow, I was able to identify and maximize thermal comfort pockets for landscape design.

The 3rd layout maximizes the amount of thermally comfortable space while maintaining a thermal connection. This layout introduces 7 new areas that can be developed into parks and plazas for public use. The 7 spaces amount to nearly 16 acres and connect into a 1.4 mile loop, excellent for active transportation. In the proposed plan, these existing stores will remain and be repurposed to better serve the new community.

A new shopping street will connect through West Lincoln Avenue adding mixed-use buildings allowing for both retail and residential space. This proposed street is centrally located to increase accessibility by creating a connection from the existing residences to the existing businesses. These buildings reach heights of 30 feet and feature Fergus Falls code compliant units at 1,000 sf. Multi-Family complexes were strategically planned to protect vulnerable areas from the prevailing winter winds creating the most thermally comfortable site. These buildings reach heights of 40-50 feet and feature Fergus Falls code compliant units at 1,000 sf. Mixed Use, multi-family, and single family units were planned out to meet the cities minimum code requirements allowing for maximum density. These lots are protected in the winter months and gives a variety of housing options to the new americans.
[Design Details]

+ Paver Detail

+ Sandstone Wall Detail
[Conclusion]

At 5.5 acres, Lincoln West Central Park includes cultural gardens, active lawns, and social gathering spaces. The Lincoln West Promenade curves through the site and serves as a strong connection through the design. Featured in the promenade is ground lighting with a pine and steel bench the sugar maple canopy offers great fall quality. The dual functioning court acts as a viewing court for stage performances, a basketball court, and a cultural design which makes it a great location to host any event. In the cultural gardens, bright plantings surround the self reflection circle and connect new americans to their original cultures. The sandstone pavers connect to the location, while the reflection monument recognizes the cultures that are present. Lincoln Plaza is the connection between public and private, hosting the sandstone terrace and the glacial mounds. Large gatherings can happen in the lawn while smaller groups can convene in the glacial mounds. This section reveals a 31 foot street with parallel parking and a bike lane. The large sidewalks feature an egg shaped tree grate that is used throughout the site to create a placemaker. In the sandstone terrace, a pine pergola is designed for summer shade while allowing sun to come through in the winter. Sandstone block builds up the retaining wall, and an interactive water feature pumps through to create a white noise, giving the terrace a more private setting.

Throughout this process of research and design, I have learned many new ways to approach urban design. This research project stemmed from a small idea of wanting to combat harsh winter conditions and grew into a design that can be implemented for human thermal comfort, ultimately enhancing a user’s experience throughout the year. Starting with my research on how to measure and collect data, I was able to determine how I can design for thermal comfort through infill layouts. Using the simulations, the design began shaping itself into a new community for new Americans that are affected on the global level. The final park design acts as a template for future parks and what they should include. Creating spaces to perform through all seasons is an incredible challenge, and I hope that through my research I have been able to teach you a little about the effects that climate change plays in our daily
Lincoln West Central Park

Figure 24 | Final Design
Sources


[Design Appendices]

+ Design

+ Process Drawings  45-46
+ Presentation 1  47-50
+ Presentation 2  51-56
+ Final Presentation  57-64

Figure 18 | Existing Mall Entrance
[Research Question]
How can infill layouts improve thermal comfort indexes in the cold-weather regions of the Upper Midwest?

[Location]
Westridge Mall
Fergus Falls, Minnesota

[Size]
124 acres

Configuration 1
Study 1
Study 2
200'
200'
500'

+130%
200'

Configuration 2

+130%
Configuration 3
**Density**
- Single Family: 104 Units
- Multi-Family: 1,996 Units
- Mixed-Use: 380 Units

**Thermal Comfort**
- Park System: 15.5 Acres
Pioneers shaped our country and introduced new ideas and opportunities that would shape how we live our lives today. George Wright and R.J. Mendenhall saw the potential of the river as a source of power, sparking the growth of Fergus Falls and the railroad through town, marking this as a trading hub. The vision of Wright and Mendenhall introduced new technology into the region that would bring new opportunities with it, inspiring those who chose to pioneer a new future.

Inspired by the vision, the design of the site is informed by past with a modern touch. The winding river and the order of the city create a dependable solution. The foundation for a brighter future is in place to prepare for growth and inspiration.
THERMAL COMFORT IN URBAN MICROCLIMATES

Nathaniel Horvath
Inventory & Analysis

Project Goals

- Increase Density to 20 units/acre
- Increase Thermal Comfort
- Increase Walkability and Accessibility
Thermal Comfort Study

Diagrammatic Master Plan

- MU (380 units)
- MF (1,996 units)
- SF (104 units)
  - Density (20 units/acre)
- Parks & Plaza’s (15.5 acres)
Contemplation Circle

Lincoln Plaza