Climate Migration: Implications of Duluth as a "Climate-Proof City"

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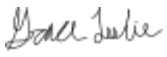

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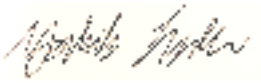

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Abstract

Climate change has created a plethora of disastrous challenges for people living in climate-vulnerable regions, including flooding due to rising sea levels, extreme heat waves, wildfires, and hurricanes. In many instances, these challenges have forced residents to relocate. As climate change persists into the future, these challenges will compound, and more residents living in vulnerable areas will have to relocate. Duluth, Minnesota is one proposed climate refuge for people fleeing disaster. In a 2019 conference at the University of Minnesota, Duluth, Harvard economist Jesse Keenan proposed Duluth market itself as a "climate-proof" city for "climate migrants," individuals seeking safer, more climate-resilient places to relocate. Through seeking to understand current Duluth residents' perceptions of climate migration to their city, this capstone project examines the efficacy of Keenan's proposed "climate-proof" marketing strategy. After surveying a sample of 207 Duluth residents, we found responses that varied in support for climate migration. Many residents expressed concerns regarding gentrification and potential resource strains, suggesting that Duluth is not as "climate-proof" as the term implies. Some opposed to climate migration mentioned wanting to preserve Duluth's unique culture and current population. Others, however, expressed support for migration to Duluth either because they believed a population increase would lead to economic growth or because they hoped to provide refuge for migrants. Ultimately, the results of our study suggest that policy-makers must consider the concerns and nuances of public opinion regarding "climate-proof" marketing strategies before deciding whether or not to implement them.

Introduction

Duluth, Minnesota, a small northern city that sits on the southwestern edge of Lake Superior, could become the ideal destination for those seeking a stable and comfortable life with minimally disruptive climate change impacts. As waters rise in Florida, hurricanes devastate Texas and Louisiana, and wildfires spread from California to Colorado, Duluth is projected to have little increase in precipitation, and few days with extreme heat each year. Its proximity to Lake Superior offers inhabitants a reliable and enduring source of fresh water. For these reasons, Duluth could be a "climate-proof city," poised to enjoy an increasing population and economic development, at least according to Harvard economist Jesse Keenan, who coined the term (Pierre-Louis, 2019). Keenan recommends that the city launch a campaign to reinvent itself and actively attract climate migrants fleeing more climate vulnerable regions.

The "climate-proof" label picked up local attention and national press after Keenan presented his vision at a March 2019 conference at the University of Minnesota, Duluth. Several stakeholders have expressed enthusiasm for the economic development that being "climate-proof" could bring, yet others express reluctance (Pierre-Louis, 2019). Some populations are more vulnerable than others when it comes to the higher population density, increased demand for housing, urban sprawl, and strains on natural resources that a growing population could bring. Karen Diver, a former leader of the Fond Du Lac Band of Lake Superior Chippewa, whose lands surround Duluth, has raised concerns over possible impacts to cultural and subsistence practices (2020). Economic theory points to the threat of gentrification, which would displace low- and middle-income residents from their homes. All of this occurs against the backdrop of physical climate-change impacts to which Duluth must adapt.

Currently, Mayor Emily Larson has no plans to market Duluth as a climate-proof city. "I find the notion of the reality that there would be climate refugees and climate-proof cities

unsettling and creepy… I have zero interest personally in marketing to climate refugees," Larson said recently in an interview. However, both Larson and the city's Sustainability Officer, Mindy Granley, have noted that Duluth is beginning to attract climate migrants regardless of any marketing scheme. "I regularly meet people...who move to Duluth for this very reason," Larson said (2020). Thus, whether or not Duluth markets itself as a "climate-proof city" in the future, outsiders may develop the notion anyway. As climate change heightens climate vulnerability in certain regions, climate migration across the nation and globe will occur more frequently, and will perhaps become necessary for certain populations. Some cities may welcome migrants while others may be more reluctant to let outsiders in. The purpose of this study is to acknowledge and explore current Duluth residents' concerns about climate migration. How do Duluth residents feel about climate migrants inhabiting their city, and why do certain residents oppose or support climate migrants? Understanding how current Duluth residents react to the notion of future climate migration provides a more comprehensive understanding of whether Duluth is truly fit to harbor a vast array of future climate migrants.

Literature Review and Theoretical Framework

We determined three primary factors influencing Duluth residents' perceptions of the costs and benefits of climate migration: cultural shifts that arise as a result of migration and rebranding, environmental pressures, and equity concerns.

1. **Historical and Future Cultural Changes in Duluth**

Cities are dynamic. They expand, shrink, prosper, and collapse. Cultural shifts are one of the many changes a city encounters throughout its lifetime. These shifts can be attributed to immigrants, migrants, and fluid economies. Rebranding itself as a climate-proof city and

encouraging migrants to move to Duluth will inevitably result in a cultural shift. We hope to understand what this cultural shift might entail, and how Duluth residents will react to such changes.

The city's past rebranding caused drastic cultural and behavioral changes. For most of the twentieth century, Duluth's economy relied heavily on steel mining, but a nationwide steel crisis in the 1970s prompted the city to close its largest steel plant, Duluth Works, in 1981 (Langston, 2020). Due to this steel crisis, the population had shrunk by 15,000 from 1970 to 1990 (Walljasper, 2016). In the thirty years since, Duluth has successfully rebranded itself as the outdoor capital of the Midwest. *Outside* magazine even named it "the Best Town in America" in 2014 (Pearson, 2014). While the success of the steel mining industry lay at the core of many residents' values before the 1970s, recreational activities in the outdoors such as canoeing, skiing, mountain biking, and fishing have taken the steel mining industry's place. Many people now move to Duluth specifically for its outdoor recreational resources (Louwagie, 2019). In effect, many Duluth residents have come to appreciate nature preservation.

Cultural values may shift along with behaviors if climate migrants move to Duluth. But what kinds of cultural values will change and what behaviors might arise from those changes? Part of this answer lies in how residents perceive migrants. Culture can either heighten hostilities towards migrants or diminish them. For example, some cultures foster fear towards migrants because they perceive them as threats. The "intergroup threat theory," developed by Walter and Cookie White Stephan of the University of Hawaii, distinguishes the different aspects of threat—connected to asylum-seekers and migrants—perceived by the receiving society (2017). According to this theory, members of the receiving society are concerned about migrants becoming competitors or challenging their values, beliefs, and identities (Stephan & Stephan,

2017). In allegiance with this theory, Duluth residents may fear climate migrant-induced cultural shifts. “We aren’t flashy,” Mayor Larson noted. “We aren’t splashy, we aren’t going to market climate refugees, that’s not the brand of what Duluth is, that’s not the personality of who Duluthians are.” However, Duluth residents might instead welcome incoming climate migrants because they see an economic benefit in population growth.

Rebranding Duluth as an “outdoor capital” created a cultural shift towards valuing the outdoors. In line with the intergroup threat theory, we predict that current Duluth residents who value their natural resources, outdoor spaces, and enjoy modest property values, may feel reluctant to share their resources with a population who might not necessarily share their values. Others, however, may welcome the migrants as an opportunity for economic growth.

2. Physical Impacts and Current Climate Challenges

Dr. Keenan encourages climate migration to Duluth because of forecasting that indicates a lack of extreme heat waves and access to freshwater in the future. City officials have also noted that the city’s street and sewer infrastructure was originally built for about double the current population (Pierre-Louis, 2019; Lovrien, 2019). These natural conditions and built environment conditions, along with social conditions in Duluth make up the Duluth “social-ecological system” (SES). The SES framework is useful for conceptualizing situations where social and environmental variables interact (Ostrom, 2009). Whether the Duluth SES can accommodate migrants will depend upon its resilience, vulnerability, and adaptive capacity. Systems are vulnerable to hazards when outside factors make them behave differently or collapse, while they are resilient if the system can maintain its structure when faced with a hazard; adaptive capacity refers specifically to the ability of a system to change its behavior while still maintaining its structure (Gallopin, 2006). Climate change is one possible source of hazards, which will interact

with social factors if migrants impact cultural or economic parts of the system. Individuals may base their opinions of migrants on their understanding of all parts of the Duluth SES, including the climate system.

Despite Keenan's optimistic outlook on the human impacts of climate change in Duluth, the region is still undergoing serious changes. Recent research suggests that climate change promotes invasive mussels and subsequently the growth of invasive toxic algae within Lake Superior, which has dominated shallower regions of the lake (Kraker, 2017). Due to the increased competition this invasive species provokes, along with decreased resource availability, many native fish and bird populations will likely decline. Scientists have noted that the world's largest lake, located along and within Duluth, has been an extremely sensitive indicator of climate change due to its shrinking winter ice coverage, warmer water temperatures, and increased wind speeds (Oakes, 2007).

In addition to the negative impacts Lake Superior may face as a result of exacerbated climate change issues, Duluth struggles financially to maintain its extensive roads and sewers (Lovrien, 2019). An increased population could raise expenses for infrastructure, exacerbating current maintenance issues Duluth faces. Though climate impacts in Duluth may not be as severe as rising sea levels or disastrous wildfires, significant and unexpected changes in the region will likely occur.

Because different populations have varying degrees of adaptive capacity, based on structural inequalities and oppression, the costs of climate hazards will not be borne equally within the Duluth SES. The Lake Superior Chippewa, who reside on the Fond du Lac Reservation, located roughly 30 miles outside of Duluth, have treaty rights to subsistence and cultural practices on lands throughout northern Minnesota. Subsistence practices which rely on

traditional management practices are disproportionately threatened by climate change (Dinero, 2013). The Native American population is not the only marginalized population vulnerable to climate change, and future planning needs to take that into account.

3. Social Equity and Distributional Impacts Due to Climate Migration

The demographic change caused by climate migration is likely to have effects on the distribution of benefits and costs among individuals with respect to their socioeconomic classes and identities, in addition to the unequal effects caused directly by climate change. Because of existing inequalities, people who are forced to migrate due to climate change will have varying abilities to do so. When migrants have little wealth or few resources, they are best thought of as refugees, and will be at risk of unjust treatment in their destination communities (Sherbinin et al., 2011). However, Keenan's assessment suggests that the people who move to Duluth will do so by choice and bring wealth with them into the community (Pierre-Louis, 2019). This type of voluntary migration raises a different set of equity questions, mainly based on fairness for existing residents.

"Climate gentrification" or, more broadly, "green gentrification" literature explains social inequality caused by voluntary migration. Green gentrification is defined as the process by which some people may be underserved, excluded from, or even displaced by "green" amenities, assuming that these amenities cause housing prices to increase and exclude poorer residents from the areas where they live (Anguelovski et al., 2019). A green amenity could be something like a park or hazardous materials cleanup project at the local scale, or it could be a favorable climate condition on a regional scale. In the case of Duluth, we consider natural resources, such as clean water, air, and natural spaces, to be green amenities. Several questions remain open in the scholarly field of gentrification, including detailed spatial analysis of how effects differ across

neighborhoods and regionally; whether the effects might be different in cities that are currently growing, declining, or stagnant like Duluth; and how financial institutions and property developers respond to green amenities in order to accelerate or oppose gentrification (Anguelovski et al., 2019). Because the term has only recently entered academic discourse, it is also unlikely that most individuals think about green gentrification in daily life, although they may experientially or intuitively understand that it occurs.

Buffalo, New York As a Case Study

Buffalo, New York is a present-day example of a city that has already received migrants. The Mayor of Buffalo declared the city to be a "climate refuge" in 2019 (News 4 WIVB Buffalo) but several community leaders observed that the city government was doing nothing to actually prepare for that eventuality (Deaton, 2019). Buffalo is nearly four times as large as Duluth, with a population of 255,284 (U.S. Census Bureau, 2019). However, it experiences a similar climate regime influenced by the Great Lakes (Deaton, 2019). Therefore, Keenan considers Buffalo and Duluth to be similarly situated.

Buffalo is also already experiencing climate migration – and what may be the beginnings of gentrification. Because this process is only in its beginning stages, we found no peer-reviewed work, nor rigorously tested causal connections; however, the case is still informative. About 10,000 of Buffalo's migrants are from Puerto Rico, and are best categorized as refugees, since they fled hurricanes and earthquakes, often with little preparation (Pierre-Louis, 2019; Deaton, 2019). Buffalo is a common destination city for Puerto Ricans because of its existing Puerto Rican community (Deaton, 2019). Duluth is nearly 90% white, and only 3% of the population is foreign born, compared to 47% and 10% for Buffalo (U.S. Census Bureau, 2019), so refugee migration due to existing immigrant communities is much less likely in Duluth. However,

Buffalo is also experiencing an influx of wealthier immigrants who move there by choice. At least some are partly influenced by climate (such as a business owner interviewed in CityLab who moved to escape lost productivity during the hurricane season), but many are merely attracted by lower housing prices relative to other cities (Deaton, 2019 and Teicher, 2015). At the same time, home prices have steadily increased at a greater rate than the national average since 2012 (Deaton, 2019), and some residents have complained of being forced to change neighborhoods due to rising rents (Fetouh and Terrell, 2017). At present, not all immigrants to Buffalo are climate migrants, and the time scale of gentrification does not line up with the time scale of being an official "climate refuge." However, the anecdotal evidence from Buffalo also suggests that migrants from southern locales are able and willing to live in northern cities, and that fears of gentrification among northern community leaders have intensified as immigration rates increase. Whether or not gentrification actually occurs, local perceptions have clear impacts on the politics of migration.

Urban Containment

Urban containment, or the boundaries of development within a city, creates additional equity concerns. Urban containment as a legal policy is used in some U.S. and many European cities, preventing development beyond specified city limits, and is typically favored by both farmers and property developers (Pennington, 2000). Farmers favor urban containment because it prevents developers from buying out and fragmenting arable land, while developers benefit from a decreased supply of additional land on which to build housing, driving up housing prices (Pennington, 2000). In Duluth, the Fond Du Lac Band of Lake Superior Chippewa has treaty rights to perform subsistence and cultural activities on hundreds of square miles of land adjacent to Duluth and several surrounding cities (Fond Du Lac Band of Lake Superior Chippewa, 2021).

Their interests are roughly aligned with those of farmers in Pennington's urban containment model (2000) because these treaty rights require undeveloped land to be left as is. During our interview, Karen Diver, a former tribal Chairperson who has been vocal about the climate migration issue, expressed concerns many within her community harbor about climate migrants inducing a potential decline in moose populations (Diver, 2020). An increasing human population could lead to increased competition for moose meat and sport, resulting in a moose population decline. While non-indigenous hunters tend to hunt for recreation, moose hunting is a vital cultural and subsistence practice for the Ojibwe, founded in traditions that stretch back for millennia. "When others want to come here because they are looking for new homelands for themselves," Diver noted in a recent interview, "they are going to cause stressors on the way of life we are going to preserve" (Diver, 2020). Marketing Duluth as a climate-proof city and promoting migration could counter the Lake Superior Chippewa's goals for preserving their cultural and subsistence resources. This potentially places the politically marginalized Fond Du Lac Band of Lake Superior Chippewa in opposition to economically marginalized Duluth residents over the issue of urban containment.

As an additional concern, urban containment does not prevent residents of Duluth from moving to other communities in the region, which would also have an impact on tribal lands. This possibility for urban expansion throughout the Minnesota Arrowhead region is supported by a deep learning model of migration patterns (Robinson et al, 2020). Deep learning makes nonlinear predictions by feeding data through a series of simulated neurons which perform random operations on the data and pass their results to the next set of neurons. The model is trained, or learns, by comparing the generated results to real-world data. The random operation steps can be adjusted according to optimization functions until the model makes very accurate

predictions, and these predictions are highly nonlinear and tailored to the type of data the model was trained on. The model by Robinson et al. (2020) was trained on historical migration data and climate conditions, and predicts some population increase in Duluth and more modest population increases in the counties surrounding Duluth. Without policy intervention, it is possible that gentrification and urban expansion could both occur simultaneously, as gentrification pushes people to move out of the urban core. This scenario would both displace poor Duluth residents and have a negative impact on tribal land rights.

Methods and Procedures

We conducted a survey of residents of Duluth and surrounding areas in December 2020, incorporating both open-response and closed-response questions. We then applied qualitative and quantitative analysis tools to create a narrative of opinions on climate migration and determine statistical connections between theoretically important demographic and opinion factors.

Survey

Our survey incorporates demographic information, direct questions about the perceptions of migrants, and questions about cultural, environmental, and economic values and perceptions. Demographic and economic questions relate to gentrification theory, while cultural and environmental questions relate to our culture and intergroup threat theoretical frameworks. Including questions with both social and ecological components connects survey responses to our understanding of Duluth as a social-ecological system. We presented opinion questions as statements or scenarios with a 5-point Likert scale ranging from “Strongly Agree” to “Strongly Disagree” or from “Strongly Support” to “Strongly Oppose.” When relevant, we included

short-answer open-response questions for qualitative analysis. We additionally asked for sociopolitical and demographic information by asking participants to self-select categories for: location in or outside the city of Duluth, length of residence in the region, age, gender, household income, race, education level, and housing type. Where applicable, we used the same categories as the United States Census, with minor modifications to better encapsulate necessary information.

We distributed our survey through social media posts in December 2020, and individuals completed the survey on a voluntary basis. We used this distribution method primarily out of convenience, with the hope of achieving a larger sample than would be feasible with other methods. The sample is not random in a statistically valid sense or representative of the entire population of the Duluth region, so all statistical analysis should be treated as a pilot study of a subset of the region's population. We posted our survey into two Facebook groups: "Real Life in Duluth, MN and Superior, WI" and "Duluth Nature Notes." From these groups, people shared the survey in other social media groups for Duluth, increasing the breadth of the overall population reached. Overall, we received a total of 207 responses.

Qualitative Analysis

We used qualitative analysis of the survey results to inform statistical analysis, highlight reasoning behind opinions, and compare and contrast the opinions of residents to authority figures such as Keenan and Mayor Larson. We identified common themes between responses and used these ideas to create a narrative of opinions on climate migration, using direct quotations as examples of reasoning. We then used our quantitative analysis to test whether the factors identified as important by the most opinionated respondents in open responses match the data obtained from closed-response questions.

Quantitative Analysis

The quantitative analysis consists of two separate methods. We first attempted an ordinal logistic regression to predict an individual's perception of climate migrants based on demographic and opinion factors. However, this model had very little predictive capacity, was poorly related to theory, and was not well-suited for our data. We then used a Chi Squared test to understand the level of difference between demographic groups on multiple-opinion questions.

Ordinal Logistic Regression

We attempted to quantify relationships between demographic and opinion variables and the perception of climate migrants using ordered logistic regression (UCLA Statistical Counseling). Ordered logistic regression allows us to predict the probability that a change in an explanatory variable will cause a change from one group to another with an ordered response variable. We used a sample of n = 148 cases in the regression after dropping NA responses for variables of interest. We defined our response variable based on the survey question:

> "Climate migrants" are people who move from places facing high-intensity climate-change impacts like rising sea level and wildfires to areas where climate change impacts are less severe. Most climate migrants can pay for their move on their own because there are not currently any government programs to support them. Would you favor or oppose climate migrants moving to Duluth?

The question accepted responses on a 5-point Likert scale from 1 = strongly oppose to 5 = strongly favor. Visual inspection indicated that using the 5-category response violates the proportional odds assumption – that is, ordered logistic regression requires that the difference between the categories of response is roughly equal, but we cannot assume that a respondent interpreted the answer scale this way. In order to improve conformity with this assumption, we

recoded our response variable to three categories where 1 = oppose, 2 = neutral, and 3 = favor. This improved the model's statistical validity, but not enough to justify drawing firm conclusions.

Chi-squared Tests. We then changed our method of analysis to use a series of Pearson's Chi-squared tests. The chi-squared test accepts a bivariate table containing counts of a categorical explanatory variable against a categorical response variable. The null hypothesis for the test is that there is no relationship between the variables, or that the observed data is equal to the expected data if there were no relationship. The alternative hypothesis is that the observed data is not equal to the expected data. The magnitude of the difference between observed and expected data is used to generate a p-value, which describes the probability that any difference could be due to random chance.

χ^2 *test*:

$H_0 = p_1 = p_2$

$H_a : p_1 \neq p_2$

We first considered our sample's perception of climate migrants, using the same response variable as for the ordinal regression. We compared all of the sociopolitical and demographic groups of respondents on their opinion of migrants. We then compared specific relationships that seemed to be relevant in qualitative analysis of open responses. As a final step, we used visual inspection of boxplots and proportional stacked bar-charts to determine which groups were responsible for deviating from other groups and the direction of the effect.

Results

Survey Sample Summary

Our survey had a total of 207 respondents. Their demographics are as follows:

- 69% live in Duluth, 31% live in another township or city within 50 miles of Duluth
- 63% have lived in Duluth for 20 or more years
- 76% are females, 21% are males, and 3% identify as other or preferred not to say
- 87% are white, 2% are American Indian 1% are Black or African American, 1% Other, and 9% prefer not to say
- 69% have either a Bachelor's or Master's degree

Out of the respondents, 48% were not aware that Duluth has been called a climate-proof city, while the other 52% were. 80% of respondents agreed that Duluth has a unique culture that is important to their experience of living in the area. A majority agreed or strongly agreed that culture should be preserved to keep things the way they are now, and that some types of people are better suited to living in northern Minnesota than others. In regard to economics, 89% of respondents felt that it is more important to ensure that everyone in their community has their basic needs met than to let the free-market reward successful individuals; and 80% felt that people in charge should prioritize taking care of the natural environment and disadvantaged people, even if it costs a great deal instead of prioritizing economic growth. These results indicate that our sample was very liberal across demographics. A clear majority also agreed or strongly agreed to the premise that climate change would cause serious problems in Duluth. However, when directly asked about gentrification, results were more split. Fifty-one percent of respondents said that they believe new people moving into their neighborhood would be more likely to revitalize the area and make life better, as opposed to the other 49% that felt new people would be more likely to drive up housing prices and make life more difficult. A clear majority responded that paying more for rent or mortgage would cause hardship, but the most common

response for whether the respondent would benefit from property value increase was neutral. Overall, gentrification was a salient concern for about half the sample, but this was not well connected to the theoretically related variables on housing prices.

Quantitative Results

Ordered Logistic Regression Results

The results of ordered logistic regression are presented in Table 1. Model (1) is over-specified with all demographic and opinion questions from the survey included. Model (2) includes only demographic variables, as we are interested in these variables to answer our research question about socio-economic vulnerability. However, Model (2) performs very poorly. None of the variables are significant, as standard error is greater than the estimated coefficient in many cases, and residual deviance and AIC, measures of overall fit, are very poor. Model (3) eliminates most insignificant parameters, but retains the most theoretically important demographic predictors of race and housing type. Model (4) drops all insignificant predictors.

The regressions all perform poorly and may be subject to significant error because our data has poor compliance with the assumptions necessary for ordered logistic regression. With that caveat, the best fit model based on AIC and residual deviance, Model (3), implies that socio-economic factors are less important in our sample than opinion factors on related issues to migration. The population is less likely to support climate migrants if they are aware of Duluth's identity as "climate-proof," if they believe gentrification is an issue, and if they believe that population increase harms the environment. They are more likely to support migrants if they believe that property value increases will be beneficial. In Model (3), belief in maintaining Duluth's culture is also significant, but with an unclear effect. Overall, the results relating to property values and gentrification are consistent with gentrification theory, while the relationship

between concerns about population pressure on the environment and migrant opposition is unsurprising.

Chi-squared Test Results

The chi-squared tests indicated that some relevant socio-economic factors are related to the perception of climate migrants. Although the chi-squared test is more appropriate for our data type than ordered logistic regression, it cannot control for the multiple possible factors that influence opinion, so we performed the test for each demographic variable. Of these tests, we reject the null hypothesis that there is no association for only age ($p = 0.011$) and education ($p = .073$). We are confident that age plays a significant role in perception of climate migrants, with older respondents more likely to favor migrants than younger ones. We are slightly confident that education influences the perception of climate migrants, although there is no clear directional relationship between level of education and level of support. Those with a Bachelor's degree were least likely to support migrants, while both high school graduates and those with a Master's degree leaned towards supporting migrants. Respondents who had completed trade school or a higher degree were more evenly divided on the question.

For all other socio-economic groups, we did not find an association with level of support for migrants. For race, this may be due to our relatively homogenous sample – visual inspection indicated clear differences between groups, but Blacks and Native Americans were represented by fewer than 5 observations each and can't be taken as representative. Renters also appeared to favor migrants more than any of the four other housing categories on our survey, but the chi-squared test on living arrangement indicated a highly insignificant relationship ($p = 0.64$). This insignificant finding was robust to collapsing all non-renters into one category and comparing renters against non-renters ($p = 0.32$).

1. Residents' Attachment to Duluth's Size and Culture

An unsurprising result of our chi-square tests showed that more educated respondents of our survey were more likely to know about Duluth being labelled "climate-proof" ($p < 0.001$). When we asked Mayor Larson about residents' reactions to the news she responded saying: "There were two reactions from Duluth residents. One is 'oh, that's kinda neat'... there is a little bit of Duluth pride because we care about our environment, we're deeply connected to the water, to the greenspace, to all of that and so you do feel a little pride… There is also this collective 'eyew'... because we aren't flashy, we aren't splashy, we aren't going to market 'climate refuge.' That's not the brand of who Duluth is, that isn't the personality of [Duluthians]." However, "it is true. I regularly meet people… who move to Duluth for this very reason… so I also think that it's true" (Larson, 2020).

Mayor Larson and Duluth's Sustainability Officer, Mindy Granley, spoke to Duluth residents' strong sense of attachment to their city's culture and population size, which was also apparent in the open responses of our survey. Several respondents claimed to like Duluth due to its relatively smaller population compared to other cities and metropolitan areas, such as Minneapolis and St. Paul, and opposed climate migration for fear of a drastic increase in population. Respondents also feared that a population increase, especially one prompted by people moving to Duluth specifically to avoid climate-change threats, would alter the unique "flavor" of the city. One respondent replied, "Duluth has a unique draw for people who want to live a lifestyle that includes being close to nature and participating in outdoor activities. Too many people moving here from other areas (especially more urban areas) would cause more gentrification and change the 'flavor' of Duluth." 80% of our respondents agreed that Duluth has a distinctive culture, and many hope to preserve what they perceive as the outdoorsy, friendly,

and artistic nature of Duluth. Climate migrants, in their view, could rupture Duluth's unique identity. Indeed, the relationship between culture and the perception of migrants is highly significant in a chi-squared test ($p < 0.01$). However, this was not closely related to socio-economic variables.

2. Residents' Perceptions of Climate Change and Environmental Impacts in Duluth

We also asked local residents in our survey how they felt about climate change and the environment in Duluth and compared this to how much they approved or disapproved of climate migrants coming to Duluth. People who were most worried about climate impacts in Duluth were least approving of migrants, and the relationship is extremely significant ($p = 0.004$). There was also an obvious relationship between the opinion that a higher population harms natural lands and the environment and opposing migrants ($p < 1 \times 10^{-15}$), robust to the ordered logistic regression results.

Duluth's Mayor, Emily Larson (2020), expressed concern more for migrants and the global environment than the local environment. She said that she found the idea of people having to strategically move to climate resilient places "creepy." She further added that she was "uncomfortable with it [and] didn't like it" (Larson, 2020). She applauds Keenan for his brilliance and interesting idea, but ultimately she "find[s] the notion of the reality that there would be climate refugees and climate-proof cities... just unsettling and creepy" (Larson, 2020). She further states that "the reality is not incorrect, I don't think, I just don't find it emotionally comfortable and I find the notion of people having the liberty to move wherever they need and want really wonderful. I [also] see immediately the risk of that and have zero interest personally in marketing to climate refugees" (Larson, 2020).

3. Residents' Perceptions of the Duluth Housing Market

One concern mentioned frequently in our survey was the potential gentrifying effects climate migration could induce. As one respondent put it, "There has been a lot of gentrification in my mainly low-income neighborhood led by new Duluthians and which has driven up housing costs even further. Our numbers of unsheltered persons [have] increased to unprecedented figures. Duluth does not have the housing available to accommodate climate or any other types of incomers at this time and city leaders do not seem to understand how to remedy this situation. Nor is the money there to do it." According to the chi-squared tests, there is an extremely significant link between the belief that new people moving into an area will increase housing costs and opposing migrants ($p < 1 \times 10^{-13}$), a relationship which matches the result of the ordered logistic regression. Both people who thought they would benefit from increased property values in their neighborhood ($p < 1 \times 10^{-5}$) and those who were less worried about increasing housing costs ($p = 0.12$) were more likely to support migrants. However, these opinions did not relate closely to the actual housing situation the respondent reported. A person's housing situation was not significantly related to a level of support for migrants or to whether or not the respondent thought they would benefit from property value increases in their neighborhood. However, housing was related to whether or not the respondent expressed concern about increasing housing costs ($p = 0.02$). People who owned a home were less worried about housing costs while other groups expressed relative concern, on average marking a 4 out of 5 on the scale for level of concern. This suggests a disconnect between the perception of property values and housing costs.

4. Residents' Perceptions of Migrants' Influence on Business and Revenue

Although Mayor Larson doesn't necessarily support every facet of Keenan's proposal, she does recognize the potential business benefits climate migrants would bring. Our findings

suggested that residents held conflicting views of migrants' influence on business and revenue. 49% of our respondents agreed that climate migrants were most likely to help Duluth's economy grow, while several respondents thought that the costs climate migrants would impose upon the city's established residents, such as gentrification, would ultimately outweigh the benefits of economic and business growth. One respondent, while recognizing the potential for the economic growth migrants would bring, mentioned a concern for those who might face housing issues as a result. "It would be great for our local economy, but the housing market is already really tough in the area currently, so a rush of new people would drive prices up even more," they responded.

Limitations to Our Study

Many of our limitations involve sampling errors. Because our target population, all current residents of Duluth and surrounding areas, was relatively large, acquiring a sample representative of the population became a difficult task. For best representation, we initially proposed using a systematic random sampling method that involved generating a complete numbered list of Duluth and surrounding areas, using a random number generator to pick a random starting number, then sampling every tenth address. Unfortunately, we could not obtain access to data on addresses, which eliminated any form of randomized sampling. As a result, our sample was not random, but relatively selective.

We also did not sample a population that is theoretically important and has a demonstrated real-world stake in the issue – the Fond du Lac community. The lack of this perspective does not invalidate the data we have gathered on people who live in Duluth, but it does mean that our research is not able to consider all of the relevant data. It would be a mistake to treat our sample as representative of the breadth of opinion and experience in the region.

We administered surveys through social media, posting on various Duluth-based Facebook groups, and received 207 responses. Given that the respondents were self-selecting individuals who had access to social media, rather than randomly selected individuals, we recognize our sample is not an ideal representation of our target population. The accuracy of representation is unknown from this group. 76% of the respondents were females, 87% were white and an additional 8% did not specify a race, and 69% have bachelor's degrees or higher. In comparison, 88.3% of Duluth's residents are non-Hispanic white, 51.3% are females, and 37.9% have bachelor's degrees or higher (U.S. Census Bureau, 2019). Thus, our respondents were both more educated and consisted of more females than the general Duluth population. We were also unable to draw conclusions based on race due to the very low number of respondents identifying as a race other than white. Furthermore, our survey circulated through several outdoor-based groups, which could have led to a biased set of responses. For example, we believe that respondents willing to take the survey generally harbored a strong sense of pride for Duluth, and thus may have placed more value on cultural importance than the general Duluth population. Furthermore, we expect that if the respondents enjoy outdoor recreation, they may think of climate change as a larger threat than the average Duluth resident.

Discussion

The topic of our research was initially inspired by a "Harvard climate adaptation expert," Jesse Keenan, who asserted in a *New York Times* article that Duluth was a "climate-proof city." He even went so far as to create a marketing and development plan for the city, in which he argued that Duluth should take this opportunity to market itself to climate migrants. Our research, however, does not support this plan; neither government officials nor locals seem to

prefer this marketing approach and many even seem skeptical about Keenan's optimistic description of Duluth's climate resiliency. Nearly half were not aware of their designation as climate-proof. Culture, intergroup threat, and gentrification were all at least partially accurate lenses through which to view opinions in our sample. While we did not find support for the idea that the most vulnerable populations perceive the most risk from climate change or climate migration, we did find a widespread belief that risks to vulnerable populations exist. At the very least, further research should determine the probability and magnitude of impacts to vulnerable populations and the Duluth SES so that residents can develop informed opinions about climate migrants.

Mayor Larson provided two conflicting judgments on her reaction to Keenan's "climate-proof Duluth" proposal. The first is that Keenan's idea that certain communities can and even should profit off of others' climate disasters is unsettling. The second is that there may be some truth to Keenan's argument, in that climate change has the ability to put relatively climate- resilient communities in difficult positions vis-a-vis how they want to market or accept migrants. As climate change accelerates and natural disasters put more coastal communities at risk, other climate-resilient communities will likely be forced to decide if they want an increased population from climate migrants and should start planning how they will or will not market themselves. In Duluth's case, the city officials show no intention of marketing Duluth as a climate-proof city, but there are still important environmental effects that must be taken into account to better understand if Duluth has the capacity to take in more migrants.

The number of climate migrants that more resilient cities, like Duluth, can support is unknown and will inherently put these communities under further environmental stress. Further research on Duluth's SES and its capacity to take in more people and ultimately more stress is

needed to truly know if Duluth would make an ideal destination for climate migrants. The "Risk and Uncertainty Bearing Theory of Profit" states that profits arise as a result of uncertainty about the future (Zhiguo He et al., 2014). As Keenan argues, the uncertainty about future climate events is currently providing Duluth an opportunity to make profit. However, the mayor's own conflicting judgments about the idea of climate migration leads her to stray from the marketing plan, despite its potential economic benefits. In addition, the lack of information surrounding Duluth's SES puts Duluth at risk of further environmental degradation if migrants are encouraged to immigrate. Mayor Larson also alludes to seeing an immediate risk, which we assume to be overcrowding and subsequent gentrification.

In addition, the label "climate-proof" implies that Duluth will not be affected by climate change. However, this is not true and even Keenan acknowledges that Duluth will still see impacts, although not as extreme as wildfires and hurricanes. Various studies point to concerning changes in Duluth's ecosystem already. One study found that "Climate-induced changes in northern lakes include longer ice-free season, stronger stratification, browning, shifts in algae, and more cyanobacterial blooms" (Edlund et al., 2017, p.678). Another study found that "Climate change is expected to profoundly affect the Great Lakes region of North America. An increase in intensity and frequency of rain events is anticipated to deliver more runoff and to increase riverine inputs to Lake Superior's ecosystem" (Cooney et al., 2018, p.1719). While the threats might not be as severe as those in coastal regions, Duluth's environment is still being stressed and might be put under further stress from an increased population.

Karen Diver, the Director of Business Development for the Native American Advancement Initiatives and a member of the Fond du Lac Band of Lake Superior Chippewa tribe, has similar concerns. As a response to the following question: "Do you believe it is reasonable to expect

significant migration across the United States at all? How realistic and relevant is this idea of Duluth being 'climate-proof?'" Diver responded that it is not unrealistic due to Duluth's affordability, its position as an outdoor city destination, and the accessibility of technology (2020). However, Diver also expressed a deep concern for the effect that climate migrants may have on the Fond du Lac Band. According to Diver, "There is no other homeland; by definition, the arrival of others causes stressors on way of life in addition to what already exists" (2020). Her largest concern is water. She says that "Water will be more valuable than copper-nickel," alluding to Duluth's prominent and controversial copper-nickel mining (Diver, 2020). Diver is also concerned that the city's decisions do not have isolated effects, and that the reservation will inherently be affected by decisions or a lack of decisions about climate change (2020). She also reported already noticing climate change and subsequent cultural impacts within the community: "We were seeing climate impacts to the things that we would associate with culture" (Diver, 2020). The Fond du Lac territory sits on the edge of the boreal forest, and the changing climate has impacted birch and maple tree seasons, with increased run-off resulting in local water quality changes, and has caused a decline in moose habitats and populations. Our conversation with Karen Diver shows how important future planning in Duluth is for residents as well as neighboring communities.

Alongside environmental concerns, our research also shows the costs and benefits of business and infrastructure. Alongside the benefits that result from bringing in diverse perspectives, one of the main draws to marketing Duluth as "climate-proof" is the potential economic opportunities. According to Keenan, a flux in climate migrants would bring significant economic benefits to Duluth, providing more opportunities for business and expanding revenue. However, his model fails to address the potential costs to current residents such an influx would

induce. Mayor Larson, Karen Diver, and our survey respondents addressed several concerns that Keenan's model overlooks, namely issues regarding gentrification and infrastructure. While climate migrants may create opportunities for business and bring more revenue in general, opportunities for established lower-income residents, who might encounter rising housing and property costs, may decline. As wealthier migrants move to the city and business begins to flourish, property values may increase, reducing the affordability, and perhaps availability, of low-income housing. This gentrifying effect could exacerbate segregation within Duluth, forcing lower-income residents to move into increasingly limited spaces with relatively low property values. While climate migrants may generate economic prosperity for some, the effects of migration could lead to greater disparities that are economically detrimental and limit lower-income residents' mobility. These concerns are suggested by both Duluth leaders and citizens, which highlights the importance of mitigating potential future disparities while also preparing to support future migrants.

Conclusion

We are certain of several things: the Earth's climate is changing, and those changes increasingly threaten our ecosystems and human populations. Although Duluth may not currently face climate-change consequences as immense as cities in arid or coastal regions do, the city itself is not entirely free of these threats. We also know that "climate migration," or migrants relocating to "safer" destinations, has become a more popular practice in recent years.

While Jesse Keenan's proposal to market Duluth as a "climate-proof" city suggests that climate migrants would bring economic growth to the city and provide a safe haven for those facing climate change-induced hardships across the country, our research provides a deeper

understanding of both the perceived and legitimate effects climate migration could induce on Duluth. Keenan's proposal fails to address the nuances our study recognizes.

Ultimately, we found that residents harbor a variety of perceptions about climate migration. Many expressed concerns about climate migrants' effects on the housing market, while others conveyed strong support for marketing the city to migrants due to the potential for economic growth. Many migrants wanted to preserve Duluth's unique culture, and feared the cultural changes climate migration would induce, while others believed that climate migrants would alter the culture in positive ways.

Another fallacy in Keenan's proposal is that it idealizes the "climate-proof" nature of Duluth. Duluth's ecosystems are currently facing climate change-induced alterations that an increasing population could exacerbate. Due both to Duluth residents' varying perceptions of climate migration and the continued climate change-induced threats its ecosystems face, we believe the city should prepare for climate migrants by first providing support for low-income communities, who will be most affected by the potential gentrifying effects of climate migration, and conservation.

For future research, we suggest investigating risk perceptions of climate migrations among particularly vulnerable communities, such as the Lake Superior Chippewa on the Fond Du Lac reservation, as well as a variety of other potential climate refuge locations. As we noted in the section "Limitations to Our Study" (p. 22), more diverse and robust information might reveal significant trends relevant to our theory, such as significant correlations between cultural values and support for climate migration and significant correlations between socioeconomic status and support for climate migration. Expanding research samples to include diverse communities would reveal a more inclusive understanding of the results. Furthermore, the issue of climate

migration is here to stay and will undoubtedly remain a crucial element of the human response to the consequences of climate change, one with far reaching societal and economic ramifications, so it deserves to be studied more fully in multiple locations around the country. The concept of climate migration is relatively new, thus research approaches are continuously changing. This Capstone report serves as one kind of case study for how that further research might proceed.

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Appendix 1: Tables

Table 1: Ordered Logistic Regression Results

	perception of climate migrants			
	(1)	(2)	(3)	(4)
	Residual Deviance: 174.8737 AIC: 278.8737	Residual Deviance: 300.018 AIC: 348.018	Residual Deviance: 201.5613 AIC: 241.5613	Residual Deviance: 212.2644 AIC: 236.2644
Aware of climate proof?	-1.451**		-0.960**	-0.795**
	(0.589)		(0.424)	(0.391)
Preserve culture - somewhat unimportant	-13.508***		-11.152***	
	(0.928)		(0.569)	
Preserve culture - neutral	-12.515***		-10.576***	
	(0.962)		(0.467)	

Preserve culture - somewhat imporant	-14.513***		-11.738***	
	(0.868)		(0.402)	
Preserve culture - very important	-12.858***		-10.701***	
	(0.925)		(0.446)	
Prioritize social welfare over free market	-2.762**		-1.099	
	(1.161)		(0.757)	
Population growth increases housing costs over revitalizes	-1.668**		-1.124**	-1.290***
	(0.673)		(0.505)	(0.478)
Prioritize environment over economic growth	1.059			

	(0.852)			
climate change is serious in Duluth - disagree	0.970			
	(1.775)			
climate change is serious in Duluth - neutral	1.831			
	(1.675)			
climate change is serious in Duluth - agree	1.378			
	(1.618)			
climate change is serious in Duluth - strongly agree	1.947			
	(1.532)			

dissatisfied with Duluth weather - disagree	0.895			
	(0.632)			
dissatisfied with Duluth weather - neutral	0.996			
	(0.848)			
dissatisfied with Duluth weather - agree	0.336			
	(0.822)			
dissatisfied with Duluth weather - strongly agree	0.793			
	(1.497)			
property value increase good - disagree	2.631***		2.460***	1.999***
	(0.986)		(0.770)	(0.698)

property value increase good - neutral	3.152***		2.817***	2.227***
	(1.013)		(0.800)	(0.714)
property value increase good - agree	3.892***		3.539***	2.826***
	(1.140)		(0.854)	(0.763)
property value increase good - strongly agree	2.199*		2.605***	2.053**
	(1.329)		(0.973)	(0.889)
satisfied with local government - disagree	0.310			
	(1.146)			
satisfied with local government - neutral	0.846			

	(1.242)			
satisfied with local government - agree	0.977			
	(1.242)			
satisfied with local government - strongly agree	1.937			
	(1.907)			
population increase harms environment - disagree	-0.963		-1.121	-1.411*
	(1.157)		(0.823)	(0.752)
population increase harms environment - neutral	-1.898		-1.714*	-1.922**
	(1.160)		(0.878)	(0.818)

population increase harms environment - agree	-3.727***		-3.304***	-3.489***
	(1.198)		(0.893)	(0.851)
population increase harms environment - strongly agree	-5.213***		-4.377***	-4.242***
	(1.441)		(1.052)	(0.968)
some types of people are better suited to living in northern Minnesota than others - disagree	-1.976			
	(1.402)			
some types of people are better suited to living in northern Minnesota than others - neutral	-1.855			
	(1.145)			

some types of people are better suited to living in northern Minnesota than others - agree	-0.993			
	(1.039)			
some types of people are better suited to living in northern Minnesota than others - strongly agree	-0.625			
	(1.116)			
live within 50 miles of Duluth	0.129	-0.113		
	(0.635)	(0.381)		
lived in area 1-4 years	-1.950	-0.465		
	(1.860)	(1.230)		

lived in area 5-10 years	-1.327	-1.006		
	(1.960)	(1.219)		
lived in area 10-19 years	-0.725	-0.925		
	(2.081)	(1.298)		
lived in area 20 or more years	-2.124	-1.444		
	(1.966)	(1.182)		
age 18-29	0.075	-0.939		
	(1.055)	(0.750)		
age 30-44	-0.728	-0.294		
	(0.700)	(0.459)		
age 45-59	-0.040	-0.258		
	(0.684)	(0.474)		

gender male	-0.700	-0.725*		
	(0.639)	(0.403)		
income 25,000-50,000	-2.210**	-0.707		
	(1.122)	(0.646)		
income 50,000-100,000	-1.198	0.129		
	(1.010)	(0.670)		
income 100,000-200,000	-1.653	0.126		
	(1.123)	(0.730)		
income more than 200,000	-0.272	-0.076		
	(2.625)	(1.851)		
education high school	1.353	-0.475		
	(1.794)	(1.186)		

education Bachelor's degree	1.962	-0.156		
	(1.330)	(0.858)		
education Master's degree	0.547	-1.260		
	(1.799)	(1.448)		
education PhD or higher		0.386		
		(0.674)		
rent home		-0.123		
		(0.546)		
live with family or friends		0.797		
		(0.557)		
D7_5		-0.139		
		(0.834)		

D6_3			0.564	
			(1.005)	
D8_3	0.208	0.580	0.347	
	(0.951)	(0.573)	(0.541)	
D8_4	-0.198	0.950	0.904	
	(1.434)	(0.994)	(0.976)	
Observations	148	148	148	148
Note:				*p<0.1;* ***p<0.05;*** p<0.01

Appendix II--Boxplots for Chi-squared results

For all plots, on the dependent axis, 1 indicates strong opposition to climate migration while 5 indicates strong support for climate migration.

Figure 1 Relationships between how long a respondent had lived in Duluth (independent variable) and how much they favored climate migrants moving to the city (dependent variable) were insignificant, with a p-value of 0.5467. On the independent axis, 1 represents respondents who have lived in Duluth for less than 1 year, 2 represents respondents who have lived in Duluth for 1-4 years, 3 represents respondents who have lived in Duluth for 5-10 years, 4 represents respondents who have lived in Duluth for 10-19 years, and 5 represents respondents who have lived in Duluth for 20 or more years.

Figure 2 Relationships between age (independent variable) and perceptions of climate migration (dependent variable) were highly significant, with a p-value of 0.01081. On the independent axis, 1 represents respondents who are under 18, 2 represents respondents who are 18-29 years old, 3 represents respondents 30-44 years old, 4 represents respondents 45-59 years old, and 5 represents respondents who are at least 60 years old.

Figure 3 Relationships between gender (independent) and respondents' perceptions of climate migrants (dependent) were insignificant, with a p-value of 0.2564. On the independent axis, 1

represents female respondents, 2 represents male respondents, 77 represents respondents who chose the "other" category, and 999 represents respondents who chose not to reveal their gender.

Figure 4 Relationships between income (independent) and respondents' perceptions of climate migrants (dependent) were insignificant, with a p-value of 0.8409. On the independent axis, 1 represents respondents whose household incomes were less than $25,000, 2 represents respondents whose household incomes were $25,000-$50,000, 3 represents respondents whose household incomes were $50,000-$100,000, 4 represents respondents whose household incomes were $100,000-$200,000, 5 represents respondents whose household incomes were greater than $200,000, and 999 represents respondents who chose not to reveal their income.

Figure 5 Relationships between race (independent) and respondents' perceptions of climate migrants (dependent) were insignificant, with a p-value of 0.4753. On the independent axis, 1 represents respondents who identified as white, 2 represents respondents who identified as Black or African American, 3 represents respondents who identified as American Indian or Alaska Native, 4 represents respondents who identified as Asian, 5 represents respondents who identified as Pacific Islanders, 77 represents respondents who chose "other", and 999 represents respondents who chose not to reveal their race.

Figure 6 Relationships between education level (independent) and climate migrants' perceptions (dependent) were significant, with a p-value of 0.07345. On the independent axis, 1 represents respondents who did not graduate from high school, 2 represents respondents who received a high school diploma, 3 represents respondents who received bachelor's degrees, 4 represents respondents who received Master's degrees, 5 represents respondents who received PHds or higher, and 6 represents respondents who graduated from trade schools.

Figure 7 Relationships between living arrangements (independent) and perceptions of climate migrants (dependent) were insignificant, with a p-value of 0.6345. On the independent axis, 1 represents respondents who own homes, 2 represents respondents who own homes and are paying off a mortgage, 3 represents respondents who rent a home or apartment, 4 represents respondents who live with family or friends, and 5 represents respondents who have no permanent residence.