Clinton and Kirkland Climate Change Vulnerability Assessment

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1. Introduction and Approach

The climate crisis is already occurring in our community, and the Clinton Kirkland Climate Smart Task Force recognizes that the Village of Clinton and Town of Kirkland need detailed information about the current and future risks of climate change to our communities in order to make informed decisions about adaptation and building resilience. The Clinton Kirkland Climate Vulnerability Assessment seeks to provide information to our communities through a detailed, localized assessment of future climate risk.

The Vulnerability Assessment was developed through iterative interactions with community members. In November 2020, the Clinton Kirkland Climate Smart Task Force organized a participatory meeting to discuss concerns about impacts of climate change to our community. More than fifty people from Kirkland and Clinton attended the meeting, which was held on Zoom due to the on-going COVID-19 pandemic.

At that meeting, community members identified a series of specific climate impacts about which they had concerns: **flooding, impacts to agriculture, changes in biodiversity and species presence, impacts to winter weather, and public health impacts from climate change**. Our Vulnerability Assessment is organized around providing projected climate change information that helps assess each of those impacts that were identified at the community meeting. We also assess the social vulnerability and potential challenges to Clinton and Kirkland's adaptive capacity through a demographic analysis of Clinton and Kirkland and on the basis of surveys and interviews with community members.

This report was produced for the Clinton Kirkland Climate Smart Task Force by Hamilton College students in the course ENVST 305 Climate Risk and Resilience. Report authors are: Prof. Aaron Strong, Gabrielle Buck, Lupita Cabanillas, Jay Carhart, Andrew Court, Ben Given, Emmy Goodwin, Asha Grossberndt, Amy Harff, Jason Kauppila, Francesca Lanni, Nina Merz, Eric Nahm, Ravena Pernanand, Nick Rutigliano, Sean Storr, Emma Stuart and Gab Venne.

2. Conceptualizing Climate Risk

The entire structure of this vulnerability assessment is built on the three-component definition of climate risk below:

Climate Risk = Hazard x Exposure x Adaptive Capacity

This definition is common in climate study and holds credibility in the climate science community. **Hazards** are the dangers of the climate event itself. For example, increased flooding and extreme rainfall events are climate hazards that could cause a variety of damages to Clintin/Kirkland. **Exposure** examines the impacts of climate hazard. For example, increased flooding and extreme rainfall could cause significant damage to many properties within the 100-year floodplain in Clinton/Kirkland and affect the level of biodiversity in the area. **Adaptive Capacity** looks at a community's ability to address the impacts of future climate hazards. For example, a community's overall ability to relocate houses or build levees (adaptation) is their adaptive capacity (or their capacity to adapt to climate change). By assessing each of these components and combining the results, we can determine a standardized level of climate risk in Clinton/Kirkland, as seen in **Figure 1**.

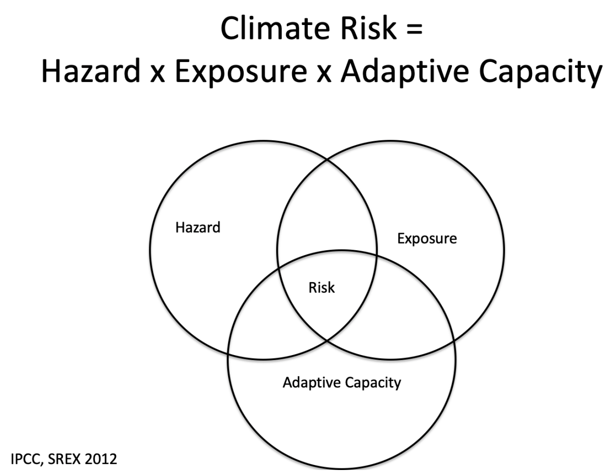

Figure 1. Model of climate risk, adapted from the IPCC Special Report on Extremes

To solve a problem as interdisciplinary as climate change, we have to first identify and standardize the components of the problem. We have to know what makes up the climate risks in our community to analyze their consequences. Using this organized framework, we were able to define climate risk and carry out a well-structured, theme-based vulnerability assessment. Understanding the problem is key to taking effective action. We recommend reading our assessment with this framework in mind.

Interpreting Models and Representative Concentration Pathways

This assessment employs 32 global general circulation models(GCMs) also known as global climate models that are widely used to make projectsi on offuture climate change across major climate reports. The area of focus for our assessment -- which is also the area we are analyzing with the GCMs -- is a 37km^2 (23mi^2) box. To be able to project future climate conditions in an area this small, we used Localized Structured Analogs (LOCA) **statistical downscaling** to obtain an area of 1/16th of a degree of longitude by 1/16th of a degree of latitude. **Downscaling** "estimates finer-scale climate detail...using a new high-resolution historical observation dataset." (Monroe, 2016). Without downscaling, the most precise a Global Climate Model could report data is up to 1° of longitude by 1° of latitude, or a 9,472km^2 (5,886mi^2) box. As this is far too large a region of focus, downscaling is a necessary tool for climate scientists to hone in on areas of interest. The smaller red box in **Figure 2** shows our area of interest in our study. The outer red box represents a 148km^2 (92mi^2) area for reference.

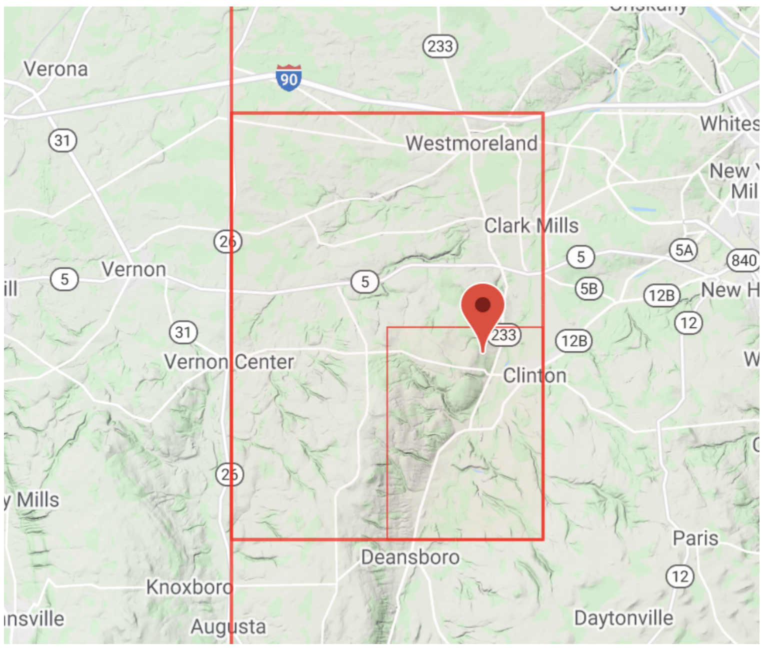

Figure 2. Our downscaled modeled study area is the smaller red box

The GCMs contain data projections up to the year 2100 and can be adjusted based on the level of future climate action we decide to take, with less action resulting in more severe climate impacts. To put it in the terms of our climate risk framework, the different magnitudes of these impacts will affect the severity of the climate hazards experienced in Clinton/Kirkland, which has sequential effects on Clinton/Kirkland's levels of exposure and adaptive capacity. The level of climate action our community decides to take in the future will determine how harsh the effects of climate change are on Clinton/Kirkland, and the window for that action shrinks by the day.

Models need inputs to provide results. In our assessment we used inputs called Representative Concentration Pathways (RCPs) to forecast Clinton/Kirkland climate data from the global climate models. The RCPs are the most credible scenario projections used in climate models worldwide. First introduced by van Vuuren et. al. in 2011and later adopted by the Intergovernmental Panel on Climate Change (IPCC) in their fifth Assessment Report (AR5) in 2014, the RCPs are the latest major global climate scenarios and the most universally accepted model inputs. The main goal of the RCPs are to "provide information on possible development trajectories for the main forcing agents of climate change." (van Vuuren et al. 2011) They draw from various topics in existing climate literature and strive to be representative of climate change's interdisciplinary nature. **Figure 3** visually illustrates how each major RCP scenario compares in their atmospheric concentrations of carbon dioxide equivalent (CO_2e) in parts per million (ppm). CO_2e represents all greenhouse gases in the atmosphere and their effects, using carbon dioxide CO_2 as the standard unit of measurement.

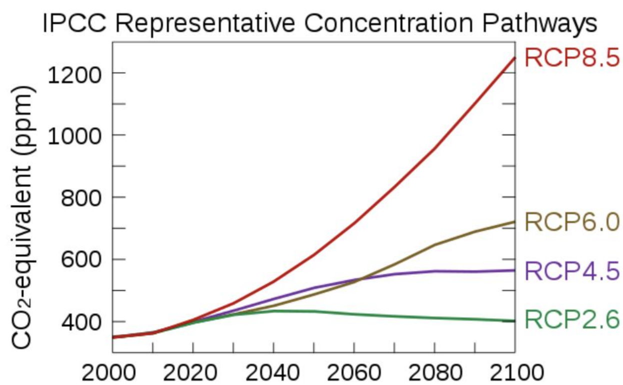

Figure 3 Four RCPs show future atmospheric concentrations of CO_2e

There are four common scenarios -- **RCP2.6**, **RCP4.5**, **RCP6.0**, and **RCP8.5** -- that each represent a level of potential future climate action. The numbers attached to each scenario are measurements of increased radiative forcing in watts per meter squared (W/m^2) projected for the year 2100. For example, RCP4.5 denotes a 4.5 W/m^2 increase in radiative forcing by 2100, which is equivalent to 650ppm of CO_2e, up from our current level of 420ppm CO_2e. The greater the ppm, the higher the concentration of CO_2e, the more severe climate change will become. Thus, **the higher the RCP number, the more severe climate change will become**.

In our assessment for Clinton/Kirkland, we are using **RCP4.5**, which denotes a middle-ground response, and **RCP8.5**, which denotes 'business-as-usual' activity that disregards climate change entirely and is the worst-case scenario. These are the two most common scenarios used in these assessments, with **RCP4.5** considered to be a more realistic climate action target than the optimistic **RCP2.6**. As you progress through this report, this basic understanding of RCPs will help inform the findings presented.

For accuracy, we are also using **hindcasting**, a way of verifying the historical accuracy of our models by comparing our models to observational data. In our assessment report, we did this for observational climate data from 1960-2007. By doing this, we found the models that are best suited for **forecasting** and analyzing our specific climate in Clinton/Kirkland.

3. Climate Hazards

Section Summary

- Minimum and maximum average yearly temperatures are projected to increase throughout the twenty-first century under both RCP 4.5 and RCP 8.5 scenarios.
- Frequency of extreme heat days will skyrocket in the future. By the end of the century, the number of extreme heat days could exceed the number of extreme heat days from the 1980s by 600 percent.
- Average daily precipitation amounts are projected to increase according to the average of 32 future models.
- Frequency of extreme precipitation events is also supposed to drastically increase. By the end of the century, one of these events could occur 9 out of every 10 years.

Introduction

Climate hazards, or dangers that pose a threat to human life or property, are expected to increase in frequency and severity with climate change. Working with community members of the Clinton-Kirkland area, we were able to identify the following hazards as important to our vulnerability assessment: extreme heat and extreme precipitation events. These climate hazards were chosen based on community concerns for how extreme events will impact exposures-- such as property or human health-- and the adaptive capacity of the Clinton-Kirkland area. These concerns were voiced at a community meeting with the Clinton-Kirkland Climate Task Force, held on October 13th, 2020. To put these hazards into the context of increasing annual temperatures in the Clinton-Kirkland area, we also determined the change in average yearly temperatures from 1960 to 2099.

In this assessment, extreme heat is defined as days above 90 degrees Fahrenheit. This definition is reflective of research conducted by the United States Global Change Research Program and the Intergovernmental Panel on Climate Change (CDC, 2016). In addition, this assessment defines extreme precipitation as 2 inches (50 mm) or more of precipitation within 24 hours. This is based on a report by the Environmental Protection Bureau of New York State on extreme precipitation in New York State (Schneiderman, 2014). The goal of this section is to quantify how the hazards of extreme heat and precipitation will increase in frequency and severity within this century. This analysis will help to better inform the vulnerability of the Clinton-Kirkland community to climate change. The specific consequences of these hazards on the population and property of the Clinton-Kirkland area will be detailed in other areas of the report.

Methods

The change in average yearly temperatures was calculated using observational data and global climate models run under RCP 4.5 and RCP 8.5. Observational daily maximum and minimum temperatures from 1960 to 2019 were averaged into annual maximum and minimum values. Future temperature projections for the years 2020 to 2099 were obtained from 32 climate models downscaled to 1/16th of a degree of latitude and longitude to account for the area of Clinton-Kirkland. These 32 models were run under both RCP 4.5 and RCP 8.5. Future average yearly temperatures were then calculated for both RCP scenarios using the model average of daily maximum and minimum temperature projections.

To find the best fit model for both heat and precipitation, the R^2 value was calculated for all of the hindcasted model projections. With the use of the observational data, we were able to find the two models that are the best fit for the observational data. We found that the Miroc-esm.1.rcp45 model was the best fit for temperature, and the Ipsl-cm5a-mr.1.rcp85 was the best fit model for precipitation. The Miroc-esm.1.rcp45 model was found to be the most representative for both daily minimum and maximum temperatures across all of our hindcasted and observational data. Figures 2 and 5 show the relationship that the hindcasted best fit models have with the observational data.

Determining the model of best fit for both temperature and precipitation is essential for showing the true effect of the changing climate. Using the average of all models is important in showing the greater trend of the yearly average, but it loses much of the variance and noise that appears in reality. Using a single model keeps that variation, which we used to calculate the frequency of extreme weather events.

By using the Miroc-esm.1.rcp45 and the Ipsl-cm5a.1.rcp85 models, we were able to calculate the frequency of these extreme events per decade. This allowed us to create histograms that project the frequency of these extreme weather events into the future. While finding the results, it was important to not only illustrate the general trend but also show an increase in heavy precipitation days and extreme heat days.

Results

Average Yearly Temperatures

Global climate projections and historical data for the Clinton-Kirkland area show an increase in average yearly temperatures throughout the twenty-first century. Temperatures are expected to rise under both RCP 4.5 and RCP 8.5, as demonstrated in Figure 1. Under RCP 8.5, average yearly maximum temperatures are projected to rise by 9.0 degrees Fahrenheit from 2020 to 2099. Average yearly minimum temperatures are similarly expected to increase by 9.2 degrees Fahrenheit under RCP 8.5. Although RCP 4.5 projects a less severe increase in average yearly temperatures from 2020 to 2099, the changes will still be substantial; average yearly minimum and maximum temperatures will increase by 3.8 and 3.6 degrees Fahrenheit, respectively.

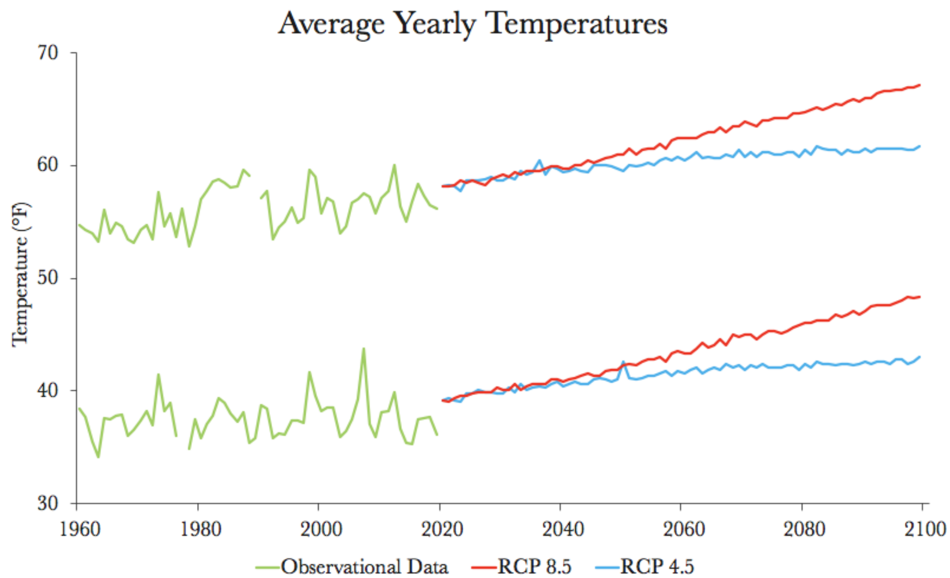

Figure 4. Average yearly maximum and minimum temperatures for 1960 to 2099. The lower value data set shows average yearly temperature minimums; the greater values show average yearly maximum temperatures. Average yearly minimums and maximums from 1960 to 2019 are based on historical data, while average yearly minimums and maximums from 2020 to 2099 are an average of 32 model projections for both RCP 8.5 and RCP 4.5.

Certain years of observational data were removed for clarity's sake. The maximum annual temperature for the year 1989 was removed due to missing temperature data for the months of October, November, and December. The minimum annual temperature for the year 1977 was also removed as a result of missing temperature data for the month of December. Temperature data from 1960 to 2006 was gathered from a weather station in Utica Oneida County Airport and temperature data from 2007 to 2019 was gathered from a weather station in Rome Griffiss Airfield. Although these weather stations are not directly in the Clinton-Kirkland area, they are the best available representative set of observational temperature data. Observational data is noisier than projection data because it represents real-world fluctuations in temperatures, while projected temperature data is calculated from the average of 32 climate models and therefore is more linear.

Extreme Heat

As mentioned previously, the model of best fit used for this research was the miroc-esm.1.rcp45 model. Of the 32 models used to find model average information, this one was found to have the highest correlation with the observational data, which is why it was used. As Figure 2 shows below, the model data is similar year by year to the observational data.

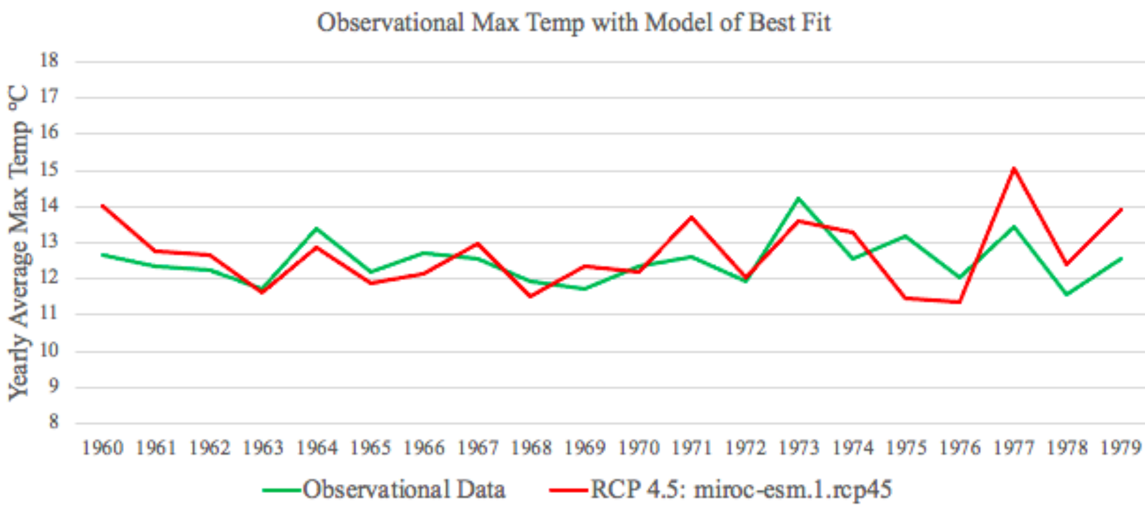

Figure 5: Observational Data compared with the model of best fit from 1960 to 1970.

The model of best fit is used to calculate extreme weather days into the future because it contains the noise and variation that is removed with the average of all models. Figure 3 shows the danger that Clinton and Kirkland face with an alarming increase in the number of extreme heat days.

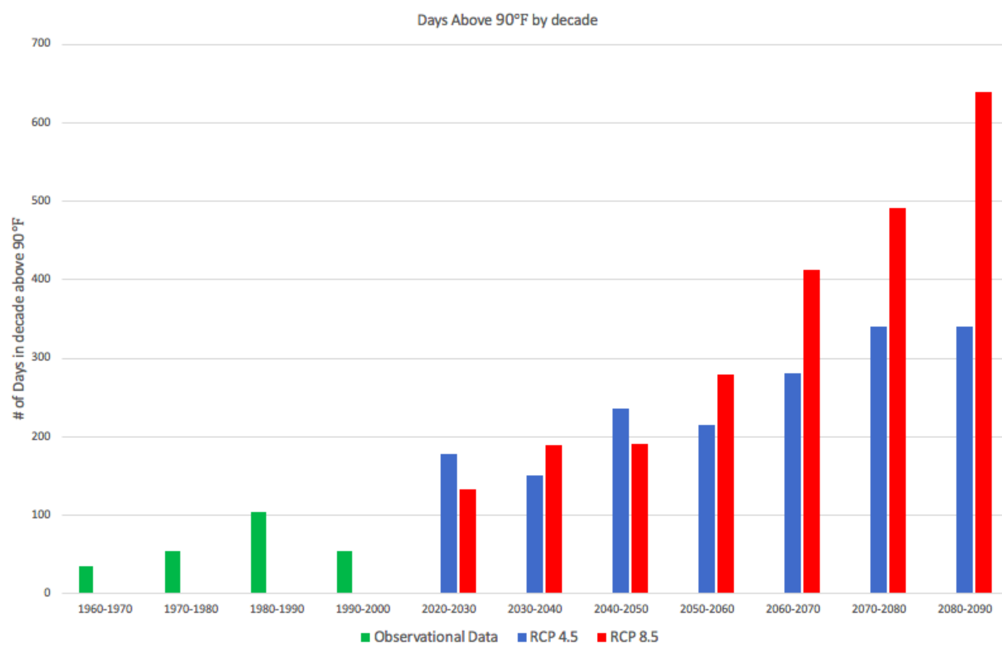

Figure 6: Frequency of Days above 90 °F per decade.

The 1980s were an abnormally warm decade according to the observational decade for the region, with just over 100 days with extreme heat in the 10 year period. On average, that would be roughly 10 days a year above 90°F. By the end of the century, Clinton and Kirkland could experience over 600 days of extreme heat in a 10 year period. 60 days a year at or above 90°F is an alarming and incredibly dangerous increase. The results from RCP 4.5, while not as drastic as

8.5, still suggest that the community should be prepared to experience over one month per year at or above 90°F.

Extreme Precipitation Events

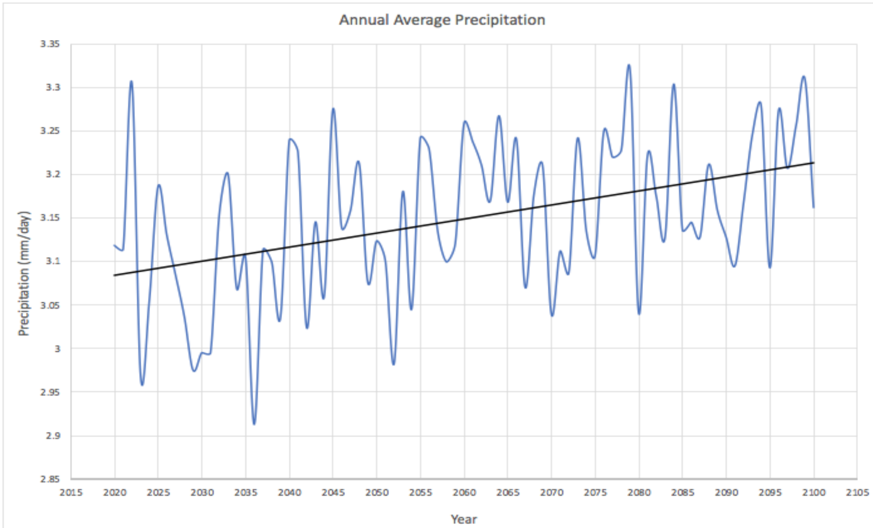

Figure 7: Modelled average precipitation for 2020-2100

This is the graphical representation of the average precipitation projections across all future models. According to the trendline, precipitation will increase from 3.08 mm/day on average to over 3.21 mm/day by the end of the century.

To find the frequency of extreme precipitation days, we calculated the model of best fit for precipitation. Figure 5 shows the hindcasted best fit model for precipitation from 1960 to 2006.

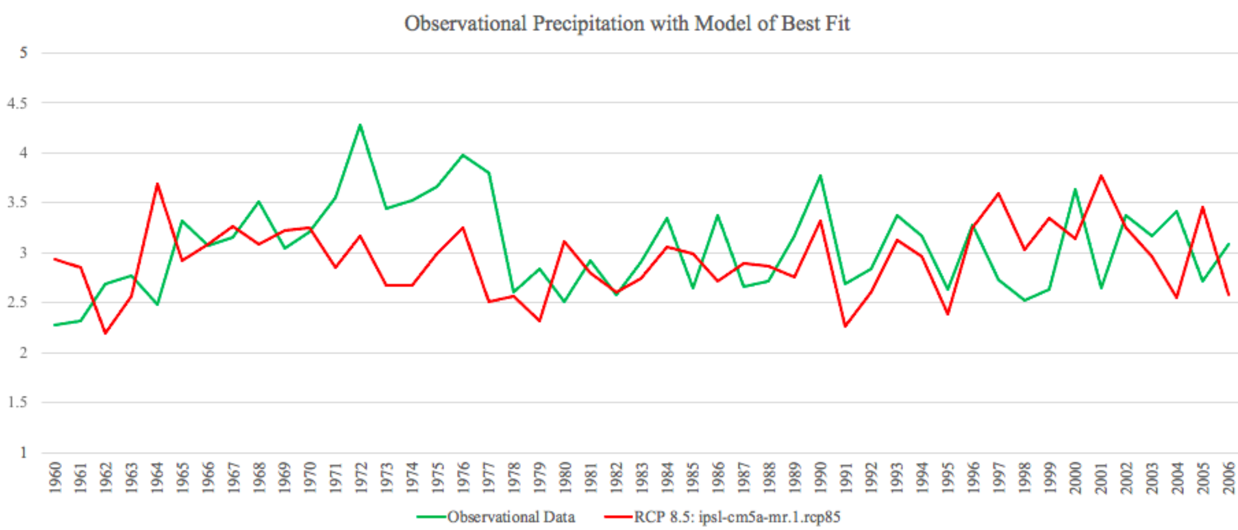

Figure 8: Observational data for precipitation with the model of best fit, to illustrate the high correlation.

The Ipsl-cm5a-mr.1.rcp85 model in Figure 5 allows us to then look at the frequency of extreme precipitation days into the future. Figure 6 shows how many extreme precipitation events there will be in each decade until the end of the century.

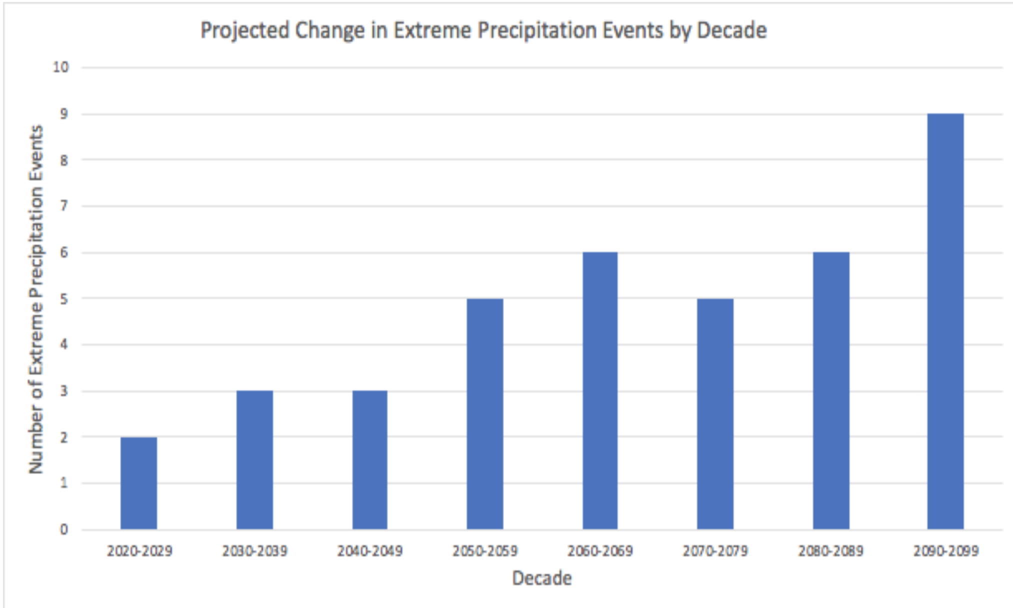

Figure 9: Extreme precipitation events by decade for 2020-2100

This is the projected change in extreme precipitation events according to the future model of best fit. An extreme precipitation event is defined as 2 inches or 50 mm of precipitation within a 24 hour period. According to the graph we can expect to see 2 of these events in the years 2020-2029. This equates to 1 extreme precipitation event every 5 years. By the decade 2090-2099, we can expect 9 of these extreme precipitation events. This equates to almost 1 event every year, which is a substantial increase.

Discussion

In summary, future modeling indicates that the Clinton-Kirkland area is expected to have both increased temperature and precipitation throughout the duration of this century. Under RCP 4.5, average yearly temperatures are expected to increase between 3-4°F and average precipitation is expected to increase 0.13 mm per day. In regards to temperature, it is not only the average yearly values that are increasing but also the intensity. By the end of the century, we could be experiencing over 300 days a decade with temperatures above 90°F. This equates to over a month of each year above 90°F. Similarly with precipitation, the quantity is not the only aspect increasing, but also the distribution and intensity. Extreme precipitation events are projected to increase by around 450%. These increases are quite significant and have the potential to impact many aspects of resident's lives, which will be detailed in later sections of this report.

This data serves as the foundation for this report and potential caveats may arise from the lack of representative data from the Clinton-Kirkland area. However, the data collection sites we used to supplement, Utica Oneida County Airport and Rome Griffiss Airfield, are within reasonable proximity to simulate Clinton climate data.

4. Climate Impacts: Flooding

Section Summary

- Across the Clinton and Kirkland community, more places will flood with greater frequency and intensity as the climate continues to change
- Changing frequency of flows is making a 100-year (1%) risk flood become a 50-year (2%) risk flood
- The flood zone within Clinton and Kirkland will become bigger

Introduction

There is a risk of floods in Clinton and Kirkland. Flooding in the area is caused by extreme rainfall. Specifically, when an extreme precipitation event occurs in Clinton and Kirkland, water can spill over local Creeks such as Oriskany and Sherman Brook, causing flooding. This flooding is exacerbated by development, as the creation of roads, sidewalks and parking lots leads to a decrease in the absorption of water (permeability) which exacerbates the severity of a flood. One of the most recent floods that affected the area occurred on Halloween in 2019, where total rainfall exceeded 5 inches in Oneida County (Coin, 2019). This is a significant amount of rainfall and serves as an example of a flash flood, a phenomenon that Clinton and Kirkland are exposed to where a sudden flood occurs due to a massive influx of water in a short period of time (NOAA, 2020). Many other floods have occurred in Clinton and Kirkland's history. One example is the one that occurred on February 22, 2018, which resulted in inundated homes (Moore, 2018). Another is the one that occurred on July 1, 2017, which caused several families to evacuate their homes, disruptions to local transport in Clinton (Figure 1.0) (Sturtz, 2017), and the formation of a large sinkhole in the middle of highway 233 section 12b (Figure 2.0) (Maddox, 2017), which is located in the town of Kirkland. These floods occurred due to either a combination of snow-pack melt and rainfall (such as the one that occurred on February 22, 2018) or solely rainfall (National Weather Service, 2020). These floods are also increasing in intensity and frequency in Clinton and Kirkland due to our changing climate (EPA, 2016). This exacerbation of floods as a result of anthropogenic climate change merits close attention and analysis in this report, as it was stated in every breakout room during our community and task force climate meeting that flooding was the most pressing and common environmental issue in the area.

To understand the following analysis that outlines our created flood zone maps, we thought it was best to provide the necessary scientific terminology to prepare our readers for flood-related discussions and analysis regarding Clinton and Kirkland. The first term we thought was necessary to provide was **discharge**, which references the specific volume of water moving down a stream at a given time. The second term, **stage** height, refers to the height of the water surface above a stream. Therefore, the higher the discharge, the higher the stage height and the more likely a flood occurs (if the maximum stage height of a creek is exceeded, flooding occurs). The final term, **recurrence interval**, means that the probability of a given flooding event will be equaled or exceeded in a given year. For example, if a flood has a recurrence interval of 100 years, then this means the probability of a flood occurring with that intensity in any given year is one in one hundred. This is also referred to as a **100-year flood.**

Another critical piece of preparatory information that is essential to provide before diving into our analysis is that the current Federal Emergency Management Agency (FEMA) issues flood maps that are outdated (Frank, 2020). This lack of accurate flood data causes the Clinton and Kirkland community to be relatively less able to be climate-resilient, as individuals or families may live in or have purchased homes in flood zones with no idea that they are doing so (Frank, 2020). Therefore, in the following sections, we hope to provide accurate flood maps that allow Clinton and Kirkland residents to get closer in becoming a Climate Smart Community (CSC) and better adapt to and mitigate the effects of climate change.

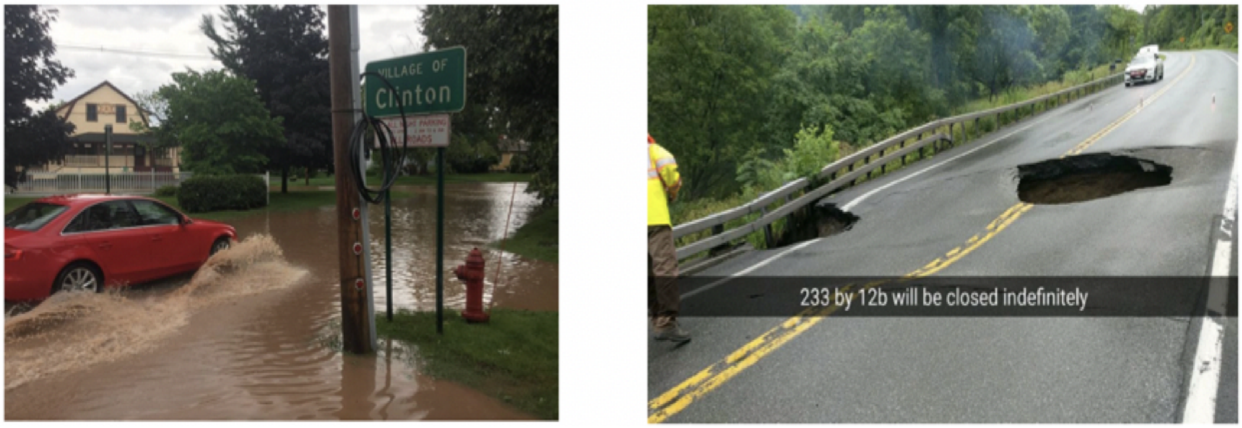

Figure 10. Flooding on July 1, 2017 caused significant damage in Clinton and Kirkland

Methods

To create our desired flood zone maps, we needed to gather data that tells us information about the estimated discharge values of the major creeks in Clinton and Kirkland. The creeks we thought were the most important to analyze were Oriskany Creek and Sherman Brook, as these are the creeks which historically have led to flooding in Clinton and Kirkland (Oneida County, 2013). These are also the largest creeks in the area. To gather this data, we obtained National Water Information System under the United States Geological Survey (USGS) and searched under its Future Flow Explorer page (USGS, 2020) to download data from three different locations along Sherman Brook (Figure 3.0) and Oriskany (Figure 4.0) Creek. This data was for three different time periods and both RCP 4.5 and 8.5. The specific data categories were the recurrence interval, current stream discharge, mean predicted future discharge, and the stage height.

We predicted the future stage height of Oriskany and Sherman Brook creeks. To do this, we used the data of predicted mean future discharge for each recurrence interval that was retrieved from USGS's Future Flow Explorer and correlated it to the rating curves for Sauquoit and Oriskany Creek. Sauquoit's rating curve was used because Sherman Brook Creek does not have one. The rating curve for Oriskany Creek only had discharge values up to 17,800 cubic feet per second (cfs), and we needed a rating curve that reached up to at least 19,000 cfs. To address this, we extrapolated Oriskany Creek's rating curve to reach our desired discharge threshold. This form of extrapolation was not necessary to attain the predicted stage height for Sherman Brook, as Sauquoit Creek had high enough discharge values that we could then correlate to the predicted stage heights. By using the data provided by USGS, we were able to relate the predicted future mean discharges to the discharge values provided in the rating curves, which allowed us to predict the future stage height under many recurrence intervals for the three sites along Oriskany and Sherman Brook creeks, the time periods of 2025-4049, 2050-2074 and 2074-2099 and RCP's 4.5 and 8.5.

FEMA's flood maps, as stated above, are outdated. Despite this, they have provided maps on ArcGIS that show Clinton and Kirkland's flood zone map without anthropogenic climate change. We will compare these maps to our created maps to see the difference in the flood zone area. The First Street Foundation provided accurate flood maps as they consider sea-level rise, changing atmospheric conditions, they use the most up to date data and break down each unique geography in their maps by the causes of flooding (First Street Foundation, 2017). When creating flood data, these considerations mean that The First Street Foundations flood zone maps are much more credible than FEMA's, as they are more up to date and consider more factors that can influence the change in flooding in a given area as it relates to climate change (First Street Foundation, 2017). Therefore, we compared The First Street Foundations flood zone map, FEMA’s, and our own to ensure accurate results (First Street Foundation, 2017).

Figure 11. Locations of Sites 1, 2n and 3 on Sherman Brook (to the left). Each Site is right next to the location the data was retrieved from. On the right, Location of Sites 1, 2 and 3 along Oriskany Creek.

Results

The table of the stream flow data below shows the recurrence interval, the streams current discharge, and the predicted future discharge of different locations along Sherman Brook. The last column and the section of the table that we are focusing on is the stage height of associated with the predicted future discharge.

Table 1. Shows the shift in future stream discharge for Sherman Brook.

Recurrence Interval (yrs)	Current Stream Discharge (cfs)	Predicted Future Discharge (cfs) [Mean]	Stage Height (ft)
100	1350	1712	5.17
200	1540	1938	5.47
500	1820	2284	5.92

Data retrieved from Site 1 along Sherman Brook Creek and predicts its future discharge under RCP 8.5 for the years 2075-2099. Data source: USGS.

Discharge: volume of water moving down a stream or river per unit of time.
Stage Height: height of the water surface above stream. The greater the discharge, the higher the stage height.
Recurrence Interval: the probability that the given event (flood) will be equaled or exceeded in a given year. For example, if you look above, Sherman Brook has a predicted future discharge of 2,284 cfs for a flood event that is likely to occur once in every 500 years.

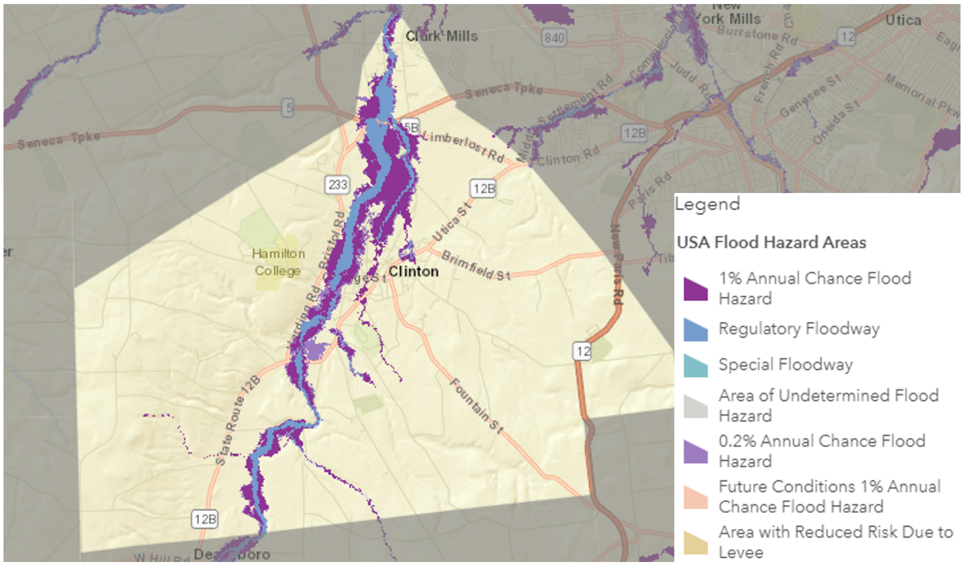

Figure 12. Existing FEMA flood zone map for Clinton and Kirkland denoting both 100-year and 500-year flood risks. Kirkland town boundaries are noted. Source: FEMA

Figure 12 consists of the current FEMA flood zone map clipped to the Kirkland boundaries. We wanted to incorporate this flood zone map into our assessment as this is what the Federal Government uses. The flood zone map shows the current year 500 and 100-year floods. The flooding is mostly concentrated along both Sherman Brook as well as Oriskany Creek. The northern part of Clinton between Utica Street and Bristol Road shows significant flooding. This stretch of land is wedged between the two main bodies of water that flow through the community, Oriskany Creek and Sherman Brook. As we move south closer to the Clinton town center and by the Clinton Middle and Highschool we continue to see significant flooding created by Oriskany Creek. The flooding that is between Brimfield Street and Fountain Street will impact businesses' such as Cliffs Gas station as well as Dunkin's and affect homes located along McBride Avenue. This flooding is a result of Sherman Brook that flows just east of Dunkin's. As we continue to move further south the FEMA flood zone map does not show as significant of flooding further away from Oriskany Creek. Only the individuals who live near the creek will experience flooding. For many communities, the floods that individuals experience often extend beyond the flood zone maps that FEMA provides. So why would we incorporate a flood zone that might be inaccurate? We wanted to include a flood zone map that does not have crucial elements when depicting future floods. FEMA does not include probabilistic future risk of flooding by incorporating anticipated environmental changes when running it's models. Including these elements are crucial to depicting more accurate flood zone maps. As our current climate is not the same as what it once was 5 or 10 years ago nor will it be the same 10, 30, 50, or 100 years from now. That is why we are incorporating other flood zone maps that include these changes. Therefore, this map serves as a good tool for comparison with other flood zone maps that do show climate change variations.

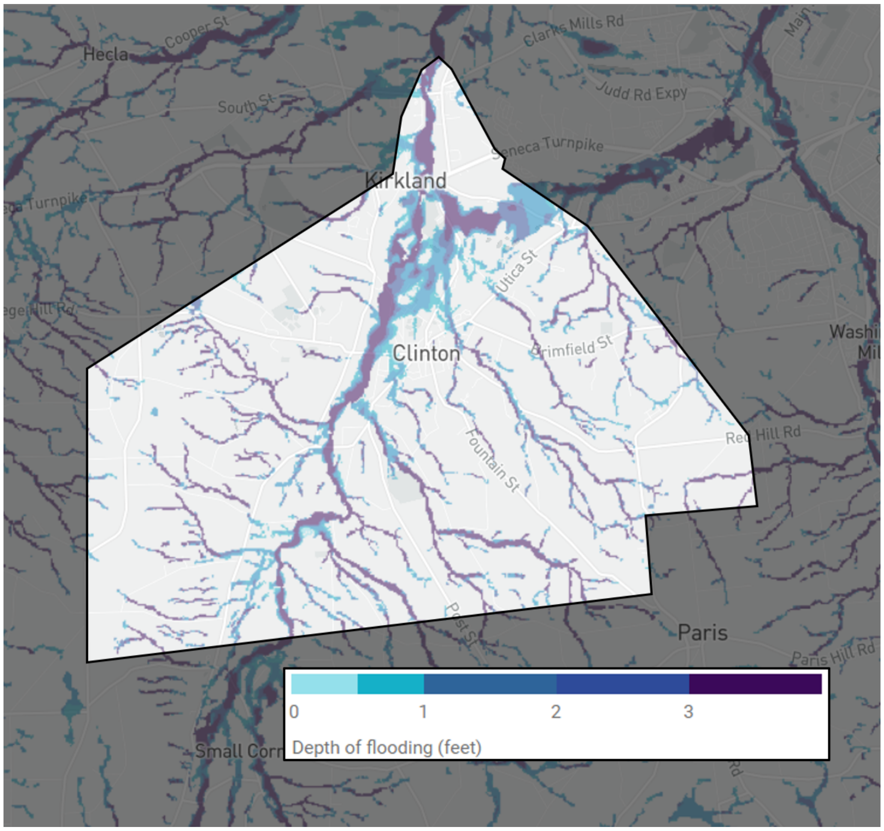

Figure 13. First Street Foundation's flood zone map for a 100-year flood in 2050. Kirkland town boundaries are noted. Colors reflect the depth of flooding expected. Source: First Street Foundation

Figure 13 displays the First Street Foundations flood zone map of the Kirkland boundaries. This flood zone map depicts the 100-year flood zone 30 years from now due to climate change. The first street foundation recreates past storms to calculate the likely flooding for homes across the United States. Additionally, first street calculates the probabilistic future risk of flooding by incorporating anticipated environmental changes. The First Street Foundation uses proprietary data that we did not have access to but incorporates critical information to provide a more accurate representation of what the Clinton/Kirkland community will experience in the future for floods. The flood map consists of different shades of blue representing flooding depth from 0 to 3+ feet. The darker shades display increased flooding compared to the lighter shades.

If we were to compare the first street foundation to the FEMA maps you will notice a lot more flooding is expected. Not only is there more flooding, what once was the 500-year flood for the current year, in 25 years that will become a 100-year flood. Where we see a significant difference between the FEMA map and the First Street Foundation is just south of Seneca Turnpike. Limberlost Road and many of the homes located along this street will experience, according to the First Street Foundation, significant flooding of possibly more than three feet. While FEMA had virtually no flooding in this area of the community. The First Street map also shows more flooding that branches off from other streams. A lot of the streams that stem from Oriskany Creek and Sherman Brook will cause flooding that is more widely spread throughout the entire community. Oriskany Creek will cause flooding that will reach the Hannaford's parking lot and there will be flooding that goes along Post Street, Fountain Street, and Brimfield street that will cause damage to many homes. The usefulness of First Street Foundation displays future floods that incorporate environmental changes that FEMA maps do not. Looking at figures 12 and 13 there are significant differences in what kind of flooding the community will experience and the more accurate the flood map the more beneficial it is to the community for future plans.

Discussion

Flooding in the Clinton and Kirkland community will continue to become more frequent and widespread as climate change continues to get worse, regardless of an RCP 4.5 or 8.5 future. By comparing both climate change flood maps with the existing FEMA maps, we can see that not only will these floods be more frequent, but the risk of flooding extends out of existing FEMA flood zones. The First Street Foundation maps show much larger areas of flood risk along the Oriskany Creek and Sherman Brook, particularly along the tributaries of the Oriskany Creek, than those shown in the FEMA map. This means a higher number of properties, including some that may not have flood insurance, will be at risk of a 1% annual risk flood before the end of the century. It is also likely that as the climate continues to change, annual flood risk will double: a 100-year (1%) risk flood will become a 50-year (2%) risk flood. The increasing frequency and severity of flooding is already beginning to play out in the community. In both 2017 and 2019, there were storms that caused extensive flooding, including flooding in areas that are outside the existing FEMA flood maps. These kinds of extreme flooding events will continue to grow more frequent as the climate continues changing.

The combination of both the doubling of flood frequency and flooding extending out of existing flood zones will have substantial impacts on the community. The increased frequency and severity of flooding has the potential to cause more frequent and more severe property damage for those living in the expanded flood zones. This does not just include homes, businesses and public facilities such as the Hannaford, CVS, Kirkland Highway Department, and Clinton Central Schools also face an increased risk of flood damages. Given these factors, the next steps could include providing resources to allow property owners and communities who may be at risk to adapt and, in some cases pursuing managed retreat and buyout programs. The increasing frequency of flooding will also impact transportation and other public works infrastructure. As the National Climate Assessment notes, much of the transportation and stormwater management infrastructure in the Northeast is not designed for the projected flooding conditions and flow rates (NCA, 2018). Transportation infrastructure such as roads and bridges in the town are at greater risk of being washed out due to the increased frequency and volume of water from flooding events.

It is important to note that our analysis did not fully take into account the role of land use and any future development and increase of non-permeable surfaces; although we do acknowledge that increased development of non-permeable surfaces will likely further exacerbate flood risk (NCA, 2018). Consequently, it is also important that any future community action consider how land-use changes could help the community adapt to the increased flood risk.

From the various data and maps we have compiled, the key takeaway is that across the Clinton and Kirkland community, more places will flood with greater frequency as our climate continues to change. The areas at risk extend beyond the existing FEMA classified flood zones, which puts more properties and infrastructure at risk of damage and/or destruction from the water,

5. Climate Impacts: Agriculture

Section Summary

• Climate change will negatively impact agriculture in the Village of Clinton and Town of Kirkland, New York. This report focuses on how apple, corn (maize), and dairy milk production in these communities are vulnerable to risks from increased temperatures associated with climate change. Given that these crops are some of the largest agricultural commodities in the area, these risks are significant to the community.

• Although the impacts under Business as Usual (RCP 8.5_ are more severe than impacts under mid-range future climate scenario (RCP 4.5), both scenarios require adaptation action.

• Our work here serves as a jumping off point, but it is not exhaustive. In addition to the impacts we address in this section, there are also worries among farmers about extreme precipitation events (droughts and floods), invasive species, and pests migrating north. These concerns will also require adaptation strategies and should be further explored.

Introduction

Another important aspect of the Clinton and Kirkland community is agriculture. According to census data from 2017, there are 967 farms within Oneida County (USDA, 2017). Together, these farms make up a market that is worth more than $100 million dollars (USDA, 2017). More importantly though, farmers rely on their businesses to help sustain themselves. Thus, it is important to include the impacts on agriculture in this vulnerability assessment.

The agricultural industry in Clinton and Kirkland is diverse. Some of the most popular crops in the area are hay, corn, beans, and fruit trees (USDA, 2017). There are also many farms that raise livestock such as cows, sheep, and pigs. Dairy farms, specifically ones that produce milk from cows, are the largest part of the livestock sector (USDA, 2017). In this report, we decided to take a deeper look at how climate change will affect future apple crops, corn crops, and milk production from cows. Specifically, we looked at the shifting bud and blossom dates of apples under RCPs 4.5 and 8.5 to determine vulnerability to spring frosts. We also examined the future frequency of extreme high temperatures (above 35°C) under the RCPs 4.5 and 8.5 to evaluate the vulnerability of corn. Lastly, we looked at a Temperature-Humidity Index to estimate future losses in cows' milk production.

To assess the impacts of climate change on agriculture in our communities, we consulted scientific literature, but we also wanted to emphasize local perspectives to ensure that our analyses were responsive to concerns amongst stakeholders. We reached out to a few local farmers about their thoughts on how climate change will impact their businesses. Almost all of the respondents expressed concerns over how increasing temperatures will affect their crops or products. Many farmers also had anxiety about extreme precipitation events (droughts and floods), invasive species, and pests migrating from the north. Although we did not cover an analysis of these concerns in this report, it is worth noting that they exist amongst farmers.

Methods

Apples

The bud and blossom dates of apples are vulnerable to climate change, because warmer winters may cause trees to bud and blossom earlier, leaving them vulnerable to late season fruit-killing frosts (Unteberger et al.2018). To start our analysis on bud and blossom dates for apples, we consulted a paper by Unterberger et al. that focused on the production of apples, warming temperatures, and the impact of spring frost. In this paper, the authors talk about the potential risk of frost on apples and its effect on the apple industry. Using the two part model in this paper, we wanted to examine the bud and blossom days for the Clinton and Kirkland communities (Unterberger et al., 2018). We decided to analyze the bud and blossom days of apple trees by increments of five years. We started by averaging every daily minimum and maximum temperature values. For each year, we calculated the chilling days starting on August 1st of the year prior (i.e. for data on the 2025 season, we started calculating chilling days on August 1, 2024). From this, we were able to sum the results to create a CF threshold column also known as the chilling requirement, which was a value of 30.5. When this threshold is met, that is the day the apples bud. After finding the bud day, we started a new column to find the forcing rate and forcing sums. We looked for a forcing requirement of 182.5 because this day is considered the blossom day. This method allowed us to evaluate the amount of days between the bud and blossom days that the temperature hit below 0°C (freezing point). We did these calculations for our observational data (from the 1960s to 2005) and from the 2020s through the 2090s for both RCPs of 4.5 and 8.5.

Corn

To begin our analysis of corn vulnerability, we looked at a paper by Prasad et al. that explored climate impacts on corn in the northeastern United States. In this paper, the authors discuss that a daily high temperature that meets or exceeds 35°C can greatly reduce corn's viability and yield (Prasad et al., 2018). Once we identified 35°C as a critical temperature, we examined the future predictions of maximum daily temperatures. For each decade, we looked at the best performing model (miroc-esm.1) and sorted the data by descending value. Then, we were able to count the number of days in that decade that reached or surpassed 35°C. This provided us with the best estimations of how many days per decade in the future corn would be critically vulnerable. We did these calculations for the 2020s through the 2090s for both RCPs 4.5 and 8.5. Once we had these projections, we were able to graph the number of days at or above 35°C for each decade under RCPs 4.5 and 8.5 for the remainder of the 21^{st} century.

Dairy Cows

Milk production is vulnerable to warmer temperatures. To explore the changes in dairy milk production, we consulted a paper by Klinedinst et al. (1993) that focused on the potential direct effects of climate change on dairy cows' milk production during the summer season. In this paper, the authors used a model that analyzed the daily Temperature-Humidity Index (THI). The authors present a formula that quantifies the relationship between hot weather stress, using THI, and the decline in milk production (Klinedinst et al, 1993). The formula is:

$$MPD = -1.075 - 1.736\ NL + 0.02474\ NL\ (THI)$$

where MPD is the absolute loss in milk production (kg/cow/day) and NL is the normal level of milk production (kg/cow/day). We used 30kg of milk produced per cow per day as the standard base of normal milk production. We were able to apply this formula to calculate the loss of milk in kg/cow/day, giving us an actual loss of kg in production. We started these calculations for June 1st and ran them through the end of August.

Once we calculated the projected actual losses of milk per cow (kg milk lost per day) for future years under RCPs 4.5 and 8.5, we found the average daily loss for each year. We used the same method for our observational data. We then had three data sets of averages: one from an observational period (1960-2020) and two for predictions for 2020-2080 for each RCP. Next, we took the average for each data set. This represents the average daily losses in milk production per cow for each year during that time range. Then, we multiplied the average loss per day by 92 because there are 92 days in the summer months. This gave us the average loss per cow per season for each year. To make the numbers more salient, we then converted the loss in kilograms to the loss in gallons.

Results

Apples

Our results, both under the 4.5 and 8.5 RCPs, show a significant shortening of the apple seasons.

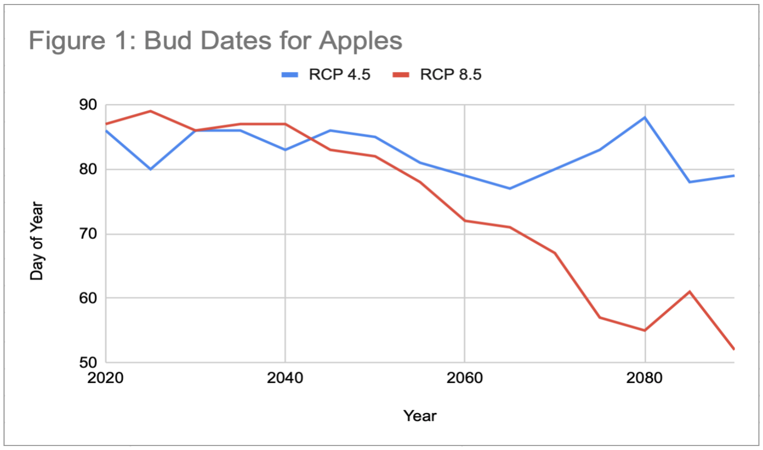

Figure 14. Graph shows the day of the year over the future years using the RCPs 4.5 and 8.5 for the bud dates for apples. In blue we can see the impact of a 4.5 RCP. In red, we can observe the impact of a 8.5 RCP which results in having an earlier bud date as years go on. The observational data is not shown due to the lack of consistency in the data collected.

When looking at RCP 8.5, there is a steady decline in bud day in correlation to the day of the year. For example, when looking at the RCP 8.5 for the year of 2040, we estimate the bud day to be around the 85th day (which is around the end of March). When looking for the year of 2080, using the same RCP, we can estimate the bud day to be around the 55th day (around the end of February). Comparing these two results demonstrates worrisome information for the future of the apple industry in the Clinton and Kirkland community. Although our projections only show up until the 2090s, we still hold enough data to prove that climate change is happening and that apple crops will suffer greatly if placed on an 8.5 RCP trajectory.

Looking back to the Unterberger et al. paper, its main finding was that farms are struggling facing spring frost and they need to adapt to it. Spring frost is when there is a day that drops below the freezing point after the bud day. Through our data, we did take this into consideration and checked if the community of Clinton and Kirkland would be facing the same issues. Under RCP 4.5, starting in the 2030s there is no prediction of any days being below the freezing point. When comparing this with our 8.5 RCP, we see this change happening much sooner, beginning in the 2020s and on.

Figure 2 compares the blossom days of apples under RCPs, 4.5 and 8.5. In this graph, we are able to see that for the RCP 4.5, there is still a steady decrease in the blossom days. When comparing the RCP 4.5 with the RCP 8.5, we can see a pretty sharp decline in the day of the year. For example, when looking at the year 2040 under the RCP 8.5, the blossom day is estimated to be near 130 days, while looking later on in 2080, it is estimated to be 117 days. The difference between a 4.5 and 8.5 RCP will greatly affect the apple crops in the Clinton and Kikland communities.

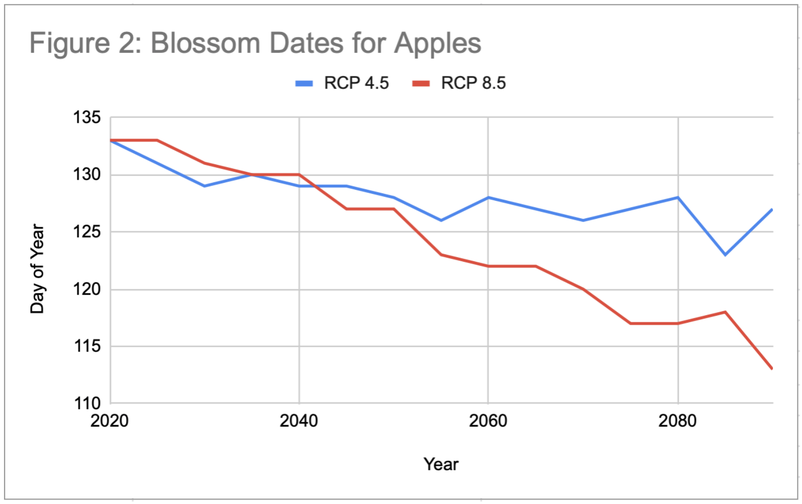

Figure 15. Graph shows the day of the year of the blossom dates for apples over future years, using the RCPs 4.5 and 8.5. In blue we can see the impact of a 4.5 RCP. In red, we can observe the impact of a 8.5 RCP which results in having an earlier blossom date as years go on. The observational data is not shown due to the lack of consistency in the data collected.

Given that the apple industry is something that many citizens in surrounding areas rely on, these results shown in the graphs create big worries. Thus, the projected decrease in the number of days of the year in the bud and blossom day is concerning. Growers in Kirkland and Clinton will need to worry more about how much longer they will be able to have apple farms in the area, as well as if pests or invasive species will have an impact on the production of their product. It is very unlikely that we will be able to continue with our current apple production when facing these scenarios.

Corn

Under both RCP 4.5 and RCP 8.5, the area of Clinton and Kirkland will experience an increase in the number of days at or above 35°C. The number of days at or above 35°C in each decade is shown in Table 1. Under RCP 4.5, there will be a slow yet steady increase. In the 2030s, we can expect 27 days at or above 35°C (which is 95°F); while that will be spread out over the decade, that is the equivalent of almost an entire month in extreme heat. This number increases in the 2060s to 61 days, which is the equivalent of about 2 months at or above 35°C. As we progress further into the future, that number will continue to climb until surpassing 100 days (which is almost 3.5 months) in the 2090s. Although our projections only go through the 2090s, with these trends we would expect to see a continued increase past those years in the 22nd century. Thus, even though this scenario is less severe than RCP 8.5, we would still feel the impact for generations.

Table 1: Number of Days at or Above 35°C in Each Decade for RCP 4.5 and RCP 8.5

Decade	RCP 4.5	RCP 8.5
2020s	45	18
2030s	27	35
2040s	50	35
2050s	52	60
2060s	61	138
2070s	74	190
2080s	95	312
2090s	106	349

The numbers are even more staggering in the projections for RCP 8.5. In this scenario, we estimate that in the 2060s, the area of Clinton and Kirkland will experience 138 days at or above 35°C. That is about 4.5 months at or above 95°F. Under RCP 8.5, the number of these extreme hot days will surpass the end of century projections for RCP 4.5 by the 2060s. The end of century predictions under RCP 8.5 are even more alarming; we estimate that in the 2090s, there will be 349 days with maximum temperatures at or above 35°C. That is almost a full year in extreme heat.

According to the paper by Prasad et al., even one occurrence of a maximum temperature at or above 35°C during the growing or pollinating season of corn is enough to jeopardize the crop. Once the crop meets or exceeds that critical threshold, its viability and yield are significantly at risk.

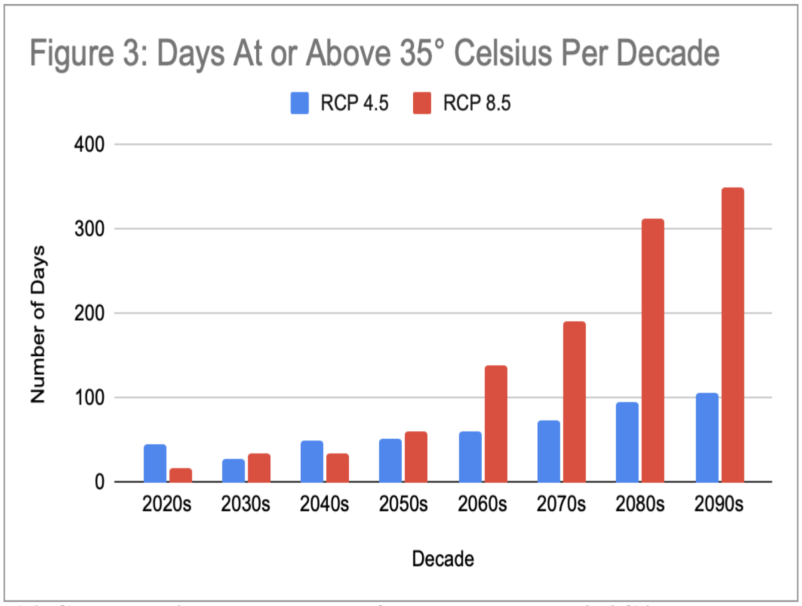

Figure 16. Graph depicts the number of days at or above 35°C in each decade for RCPs 4.5 and 8.5. Specific data is presented in Table 1. For both RCPs, the number of days at or above 35°C is increasing in future decades. This impacts corn production because when the crop is exposed to temperatures of 35°C or above, yield and viability is reduced. There is a more drastic increase under RCP 8.5 compared to RCP 4.5, but both scenarios show increases

According to census data, corn is one of the most prominent crops in the Clinton and Kirkland area; there are more than 27,000 acres of corn grown in Oneida County (USDA, 2017). Not only is it produced for human consumption, but it is also grown for feed for livestock (including cows). Given that the dairy industry is another large part of the agricultural sector in the area, corn is an incredibly important crop for this community. Thus, the projected increase in the number of days at or above 35°C is concerning because it will significantly affect corn production. It is unlikely that we will be able to continue with our current yields under these scenarios.

Dairy Cows

Once we applied the formula for the temperature humidity index (THI), we were able to calculate the projected daily average loss per cow during the summer months for years between 2020 and 2080 under RCPs 4.5 and 8.5 For both RCPs, as time progresses further into the 21st century, the daily loss of milk production (kg) per cow increases. While these numbers start off relatively similar in the near future (for years 2020 to 2035), we see more of a difference in later years. For example, the projected average daily losses in milk per cow in 2025 are 1.98kg and 2.09kg for RCPs 4.5 and 8.5, respectively. However in 2080, the projected average daily losses in milk per cow are 3.88kg and 6.01kg. Here, the difference between the two RCPs is staggering.

While both scenarios are worrisome, the future of cow milk production under RCP 8.5 would be seriously jeopardized.

Once we calculated the projected average daily losses for each year in kilograms, we found the average daily loss for years between 2020-2080 and the average loss during the summer months (see methods for more information). Then, we converted the average loss per cow in kilograms to gallons. The results of those calculations are presented in Table 3. Like most other projections in this report, the impacts under RCP 8.5 are much more severe than under RCP 4.5. Still, both future projected average losses under RCPs 4.5 and 8.5, are much worse than observed average losses from 1960-2020.

It is important to remember that all results in this section are given in losses per cow. However, there are more than 18,000 dairy cows in Oneida County according to an Oneida County report from 2018 (*Oneida County*, 2018). This means that a projected average loss of 90.6 gallons per cow in one year is equivalent to an approximate total average loss of 1,630,800 gallons of milk for that year. Thus, the losses in cow milk production that Clinton and Kirkland would face in the future under RCPs 4.5 and 8.5 are significant.

Table 2: Projected Daily Average Loss (kg) Per Cow During the Summer Months

	RCP 4.5	**RCP 8.5**
2020	2.17	2.17
2025	1.98	2.09
2030	2.31	2.66
2035	2.71	2.88
2040	2.53	2.97
2045	2.87	3.23
2050	3.15	3.74
2055	2.99	3.73
2060	3.51	4.64
2065	3.41	4.84
2070	3.69	5.26
2075	3.54	5.71
2080	3.88	6.01

Above: This table shows the projected average daily losses in milk production (kg) per cow for the years 2020-2080 under RCPs 4.5 and 8.5. As the century progresses, the amount of loss increases. The projected losses under RCP 8.5 are larger than the losses under RCP 4.5, but both scenarios project significant losses.

Table 3: Annual Average Losses in Cow Milk During the Summer Months for Observational Data and for Future Projections Under RCPs 4.5 and 8.5

	Observational Data (1960-2020)	RCP 4.5 Projections (2020-2080)	RCP 8.5 Projections (2020-2080)
Annual Average Losses in Milk for Each Year Within Time Period	45 gallons **per cow**	70 gallons **per cow**	90.6 gallons **per cow**

Above: Table 3 presents the annual average losses in a cow's milk production during the summer months for each year within the given time period. The projected annual average loss under RCP 4.5 during the years 2020-2085 is 70 gallons of milk per cow for any given year ("year" refers to the summer season in this context). This means that for each year between 2020 and 2085, on average a single cow will produce 70 fewer gallons of milk than it would in ideal conditions. There is even more of a loss under RCP 8.5 projections, with a projected average annual loss of 91 gallons per cow between 2020-2085. Both of these projections are significantly higher than the observed average annual loss of 45 g per cow from 1960-2020.

Conclusion

Under both RCP 4.5 and RCP 8.5, the production of apples, corn, and dairy milk will be impacted by climate change in the Clinton and Kirkland area. The bud and blossom dates of apples will shift to earlier and earlier in the year, thus putting the crops at risk of a spring frost that could greatly diminish or decimate yields. Additionally, extreme heat will challenge future corn crops because exposure to 35°C or above can significantly reduce the viability and yield of corn. Furthermore, the rising temperatures will alter the temperature-humidity index (THI), thereby negatively impacting the average milk production per cow. Given that apples, corn, and dairy are important crops for the Clinton and Kirkland community, these projections suggest that the area will face significant agricultural risks due to climate change. Farmers should consider how their own business will be impacted, and they should explore adaptation strategies to prepare. Although RCP 8.5 shows more severe consequences, RCP 4.5 will also require adaptation action. Some examples of adaptation include frost protection sprinkling, diversifying crops, and installing heat mitigation systems in dairy facilities. It is also worth noting that producers and consumers will likely feel economic pressure because of these impacts due to climate change. Less agricultural production will mean the value of agricultural goods will be higher. This is yet another reason why we need to mitigate the impacts of climate change and also reduce climate change factors. The impacts on agriculture presented in this report are not exhaustive. As we mentioned earlier, farmers who responded to our inquiries also expressed concerns over extreme precipitation events (droughts and floods), invasive species, and pests that are migrating north due to climate change. These are all valid, real concerns that should be further explored. Still, this report covers some of the most critical impacts that the area of Clinton and Kirkland will face in the coming years.

6. Biodiversity Impacts

Section Summary

• As temperatures rise, current forest makeups will change from maple, elm, and ash to hickory and oak

• Bird species will change, bird species from the south will migrate north as birds currently in New York will migrate north as well.

• Invasive insect species, specifically hemlock woolly adelgids, will spread northward and impact New York's forests.

Introduction

As temperatures increase across the United States, the issue of biodiversity change will become more apparent. In Clinton, this will result in a change in the kinds of forests in the surrounding area as well as countless animal species migrating away or dying off. There is also likely to be an increase in invasive species as the climate becomes more suitable for them. This section gives a look into how the biodiversity of the Clinton/Kirkland community will change and what to expect in terms of forest change and new species as we approach 2100. All data for these predictions comes from the US Forest Service Climate Atlas or from New York weather stations.

Methods

When looking for forest change in the United States, we used a modelling system developed by the United States Forest Service that modelled the change in forested areas between 2010 and 2100. The climate atlas used an inhouse modelling system called DISTIRB-II which utilized precipitation data and temperature data from 1981-2010 and end of century projections of precipitation and temperature means from 2070-2090 (Iverson et al., 2019). These projections were taken from three General Circulation Models (GCM), under the 4.5 and 8.5 Representative Concentration Pathways (RCP) (Iverson et al., 2019).The weather data was then combined with data from the Forest Inventory and Analysis database which provided stem counts and basal area for 125 different species across the Eastern United States. These data points were then also integrated with ModFac, a model that uses literature to understand outside disturbances, like pests, storms and other biological and disturbance factors that may affect tree species spread and colonization (Iverson et al., 2019). Paired with a model system called SHIFT, which determines the ability for a tree species to migrate and colonize different areas, the US Forest Service was able to determine how each individual tree species will migrate and adapt to climate change over the course of the next 90 years across the Eastern United States, and assign an importance value, or how dominant a species is in a region, to each of these species.

The Bird Atlas also created by the US Forest Service uses the data taken from the DISTIRB-II model as an input along with the species-specific elevation and climate variables of 124 different bird species. The combined inputs allowed the forest service to determine how bird species biodiversity will change over the next 90 years based on the types of forests available.

The models accurately model the types of forests that Clinton/Kirkland will have at the end of the century. Importantly, the models give an outline of how biodiversity will change as the Clinton/Kirkland community warms.

The main invasive insect that we looked at was the hemlock woolly adelgid because this species' success is particularly linked to temperature. In order to determine the likelihood of an outbreak over the next century, we decided to look at the predicted winter die-off rate of the adelgids. We used a linear regression equation from Paradis, et al (2008) that measured the relationship between average daily mean winter temperature and adelgid mortality. Average daily mean winter temperature refers to the average temperature across the months of December, January, February, and March. We used the future projected temperature data from a local New York weather station to calculate the average mean winter temperature for each year from 2020 to 2099. We did this for both RCP 4.5 and RCP 8.5. Once we got the average mean winter temperatures, we ran them through the linear regression to get the predicted adelgid mortality over the years. Mortality is shown as a result from zero to one, and tells us what proportion of the adelgids will likely die during winter. The adelgid mortality rate has to be at least 0.91 or higher in order to sufficiently prevent the population from growing.

Results

As temperatures rise, the makeup of forests in the Clinton/Kirkland area will change. Primarily made of maple, ash, birch and elm, these trees will begin migrating north for colder temperatures. According to the Tree Climate Atlas from the United States Forest service, there will be no change under a RCP 4.5 scenario for red maple in New York, however, any increase, such as under a RCP 8.5 scenario will result in a small decline (Iverson et al., 2019).

Red Maple (Acer rubrum)

Current Forest Inventory and Analysis 3 GCM RCP 4.5

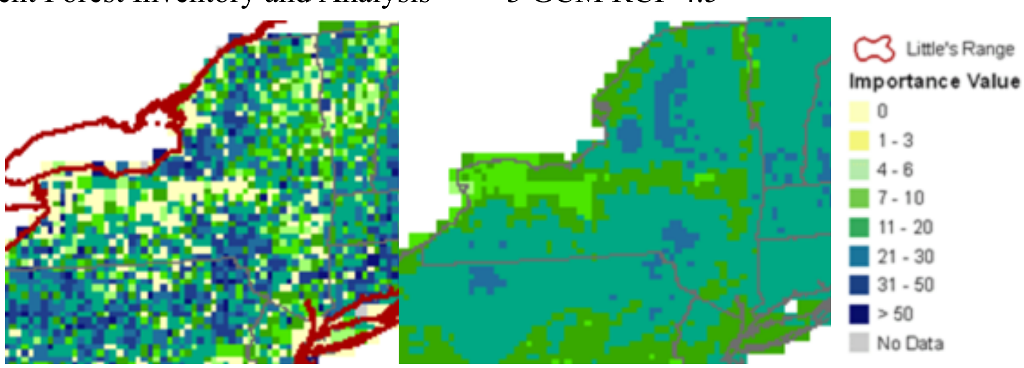

Fig. 17. While Red Maple will continue to grow in Clinton/Kirkland, the concentration will be less.

Sugar maples will see a decline under an RCP 4.5 scenario, their importance value shrinking by a mean of -3.11 and a decline under a RCP 8.5 decline of -6.32. American Beech will experience a small decline under an RCP 4.5 scenario, with its importance value dropping by a mean of -2.9 (Iverson et al., 2019).

American Beech (Fagus grandifolia)

Current Forest inventory and analysis 3 GCM RCP 4.5

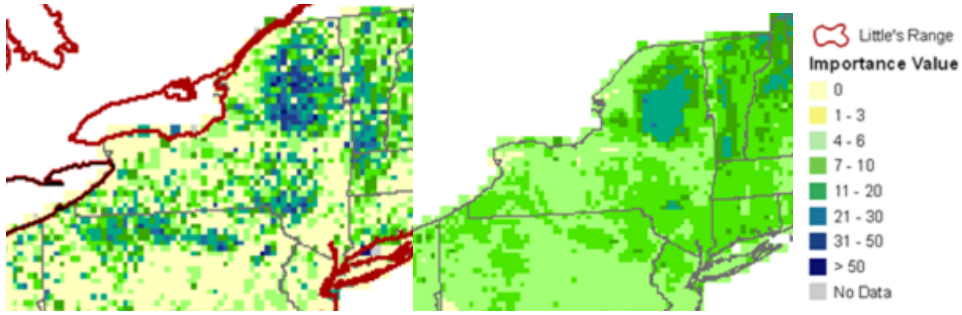

Fig 18. American Beech will still be present but in lesser numbers. while more southerly species like Black hickory, which has no history of habitat in New York will arrive with an importance value of 28.

Black Hickory (Carya Texana)

Current Forest Inventory and Analysis 3 GCM RCP 4.5

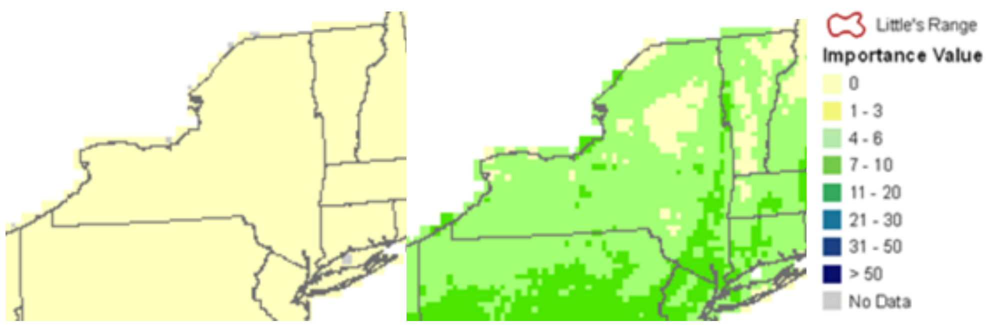

Fig 19. Black Hickory, a Southern tree, will make inroads into our forests.

Other hickories, and some oaks like laurel and shingle oak will begin to colonize forests around Clinton in greater numbers, increasing their importance value to the area. The current types of wood, maple elm and ash will give way to harder woods from the south over the coming century.

Birds as well, will begin migrating as the forest types change in our region. As warmer climates prevail, birds in the Clinton/Kirkland community will move northward as their food supply and desired habitat shifts.

Tufted Titmouse (Baelophus bicolor)

Current Distribution 3 GCM RCP 4.5

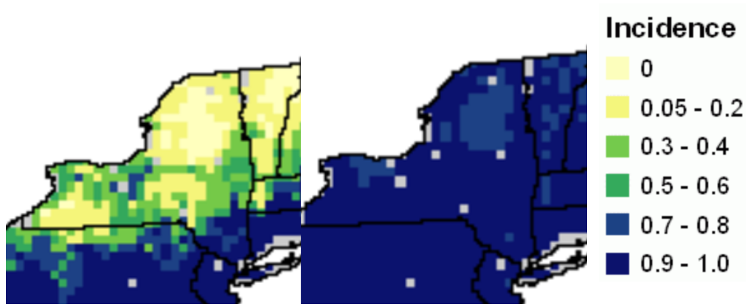

Figure 20. The Tufted Titmouse will become more synonymous within the Clinton/Kirkland community. More southerly species, like turkey vultures or tufted titmouses will have higher incidence rates in our area while birds that were once common, like Savannah Sparrows and others will decrease in incidence (Iverson et al., 2019).

Savannah Sparrow (Passerculus Sandwichensis)

Current Distribution 3 GCM RCP 4.5

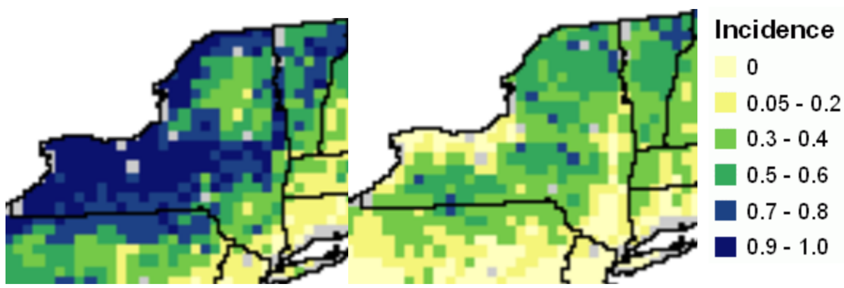

Fig. 21. The Savannah Sparrow will decrease in numbers as temperatures increase.

Vultures will see an increase in incidence of 1.24 While tufted titmouses will increase in incidence by 1.08 and savannah sparrows will see a decrease of -0.094. As we move closer and closer to 2100 the birds we are accustomed to will begin departing as our forests become more akin to those in the south, so will the bird species reflect that.

The hemlock woolly adelgid will likely spread into our region and begin to impact the forest ecosystems here. In RCP 4.5, the adelgid mortality rate is expected to be around 60% by the end of the century, which will put us at risk of spread. In RCP 8.5, it's even worse, with an end of century mortality rate of about 30%. Also, it should be noted that we are already at risk of an infestation since the current adelgid mortality rate is around 70%, which is not enough to prevent the expansion of the population.

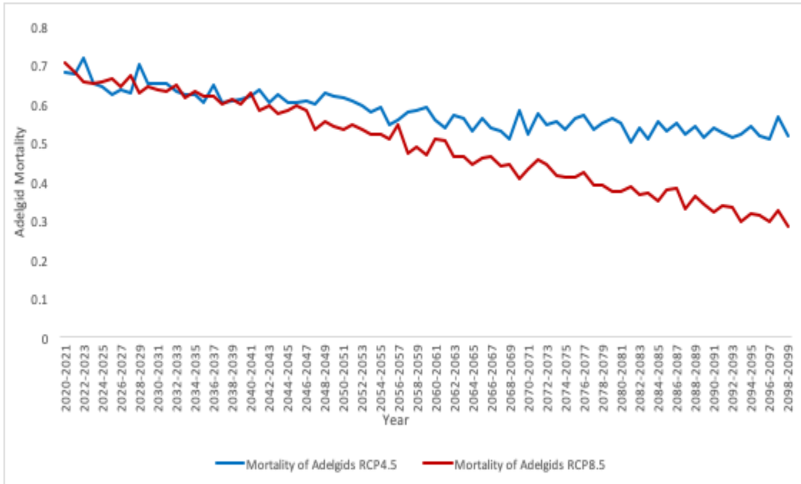

Fig. 22. Hemlock woolly adelgid mortality decreases over time in both RCPs, with RCP 8.5 seeing a more drastic decrease in mortality.

Discussion

As the new century approaches, the climate in and around the Clinton/Kirkland township will be vastly different than today. Tree species that once thrived in the temperate climate will move northward as our forests begin to resemble the current forests of southern states like Kentucky and Georgia. As the climate begins to affect our trees here, be cognizant that they will be more prone to disease, dying, and external weather events. Begin monitoring susceptible tree species as well as considering planting different species that will do better as temperatures rise. The types of birds will also change as we begin to move towards 2100, and that may change what types of birds we see normally in town.

We are also likely to see an increase in certain invasive pests, like the hemlock woolly adelgid. The adelgid will be able to spread once the temperature restriction no longer exists. This spread doesn't just represent a species change, but also presents a threat to New York ecosystems. Hemlocks play a critical role in maintaining certain ecosystems that many species are dependent upon. If these trees were to be destroyed, it is likely that many other species would be lost as well. This is especially important in New York because the most common species of hemlock here is the Eastern hemlock, which is also one of the two hemlock species that are most susceptible to death due to adelgid infestations. Another, less researched, pest is the southern pine beetle, which has not made its way into much of New York yet, but is expected to. This could be very detrimental to the pine forests. In order to slow the spread of any invasive pest, make sure to clean any equipment that was used near an infestation and leave infested material where you found. If you find an infestation, report it immediately. However, prepare for the altered ecosystem we are likely to see as a result of infestations.

While temperature increase will lead to different species of birds, trees and insects, they are not the only factors that will affect forest makeup. American Elm's one of the predominant species in our area currently, has been affected heavily by the Dutch Elm Disease, and will continue to die off, and maybe accelerated by the rise in temperature. The Emerald Ash Borer has plagued Ash trees across the nation and has steadily increased its numbers in New York, meaning that the Ash around us will also be battling more than just climate change into the future. While these biological factors are present in our current ecosystem, climate change will only make them worse.

7. Climate Impacts: Winter Weather

Section Summary

- The number of days per decade at or below freezing has been decreasing since 1960 and is projected to continue decreasing in both the RCP 4.5 and RCP 8.5 scenarios reaching under 100 days per decade at or below freezing by the 2060s in both scenarios.
- The amount of snowfall per decade is projected to decrease by 93% meaning that there will be 15 times less snowfall in the 21st century than in the 20th century using the RCP 4.5 projected temperatures and the 20th century observational precipitation.
- Winter temperature variability is projected to decrease in both RCP 4.5 and RCP 8.5 scenarios after peaking in the 2050 decade. This decrease follows from the increases in both maximum and minimum temperatures in these decades with larger increases in minimum temperatures compared to previous decades.

Introduction:

This portion of the risk assessment addresses the impacts that climate change has and will have on the Clinton and Kirkland's township winters. Under both RCP 4.5 and RCP 8.5 by 2035, the projections for the Northeast are: "more than 3.6°F (2°C) warmer on average than during the preindustrial era" (U.S. Global Change Research Program, 2018). Regarding the rural Northeast, one of the most significant projected concerns of the RCP 8.5 scenario would be how the warmer winters will impact its ecosystems (U.S. Global Change Research Program, 2018). The winters of the Northeast have recently been warming: "three times faster than summers" (U.S. Global Change Research Program, 2018). It is explicitly focusing on depicting observed and projected days below freezing, snowfall comparisons in the 20th and 21st centuries, and winter variability through the figures constructed below. The individuals of the township of Clinton and Kirkland, located in central New York, expressed concerns about how their winters had been changing over time. Some community members well received the experienced increase in milder winters and warmer temperatures. Although many viewed the warmer weather as a positive factor, it is essential to note that the observed changes and past conditions will be shifting due to climate change.

Methods

In this section, observational data and RCP 4.5 and 8.5 were used to look at the projected changes in winter between 1960 and 2090. For this assessment, winter was defined as days in the months of January, February and March.

Freezing Days:

To determine the number of days per decade at or below freezing, maximum temperatures in the observational data and RCP 4.5 and RCP 8.5 maximum model average temperatures were used. Freezing days defined as days in the year that were at or below 0 degrees Celsius and not confined to only days in the winter months. There are no data for the RCP 8.5 temperature projection for 2020.

Snowfall Comparison:

To examine how snowfall will change with the RCP 4.5 projection, the observational snowfall was compared to the snowfall that would occur in the 21st century with the precipitation profile of the observational data, 20th century, and the temperature profile of the projected data, 21st century. The data used in this assessment provided information about the amount of precipitation in millimeters. The conversion of precipitation to snow is that one centimeter of rain is 10 centimeters of snow (Day, 2019). Therefore, one millimeter of precipitation is equivalent to one centimeter of snow, so the data provided with millimeters of precipitation was directly converted to centimeters of snow.

Winter Variability Metric:

In determining a metric winter variability, the maximum and minimum daily temperatures during the winter months were used. These maximum and minimum temperatures for the RCP 4.5 and RCP 8.5 were taken from the best fit model, mirco-esm-1. The maximum temperature from day 1 was compared to the minimum temperature from day 3 and this two day lag of maximum and minimum temperature comparisons continued for the full winter months data set. The differences between the maximum temperature and the two day lag minimum temperature were averaged across decades to find an average value for two day lag per decade. For the observational data, the same method was used for the observed maximums and minimum temperatures in the observational decades.

Results

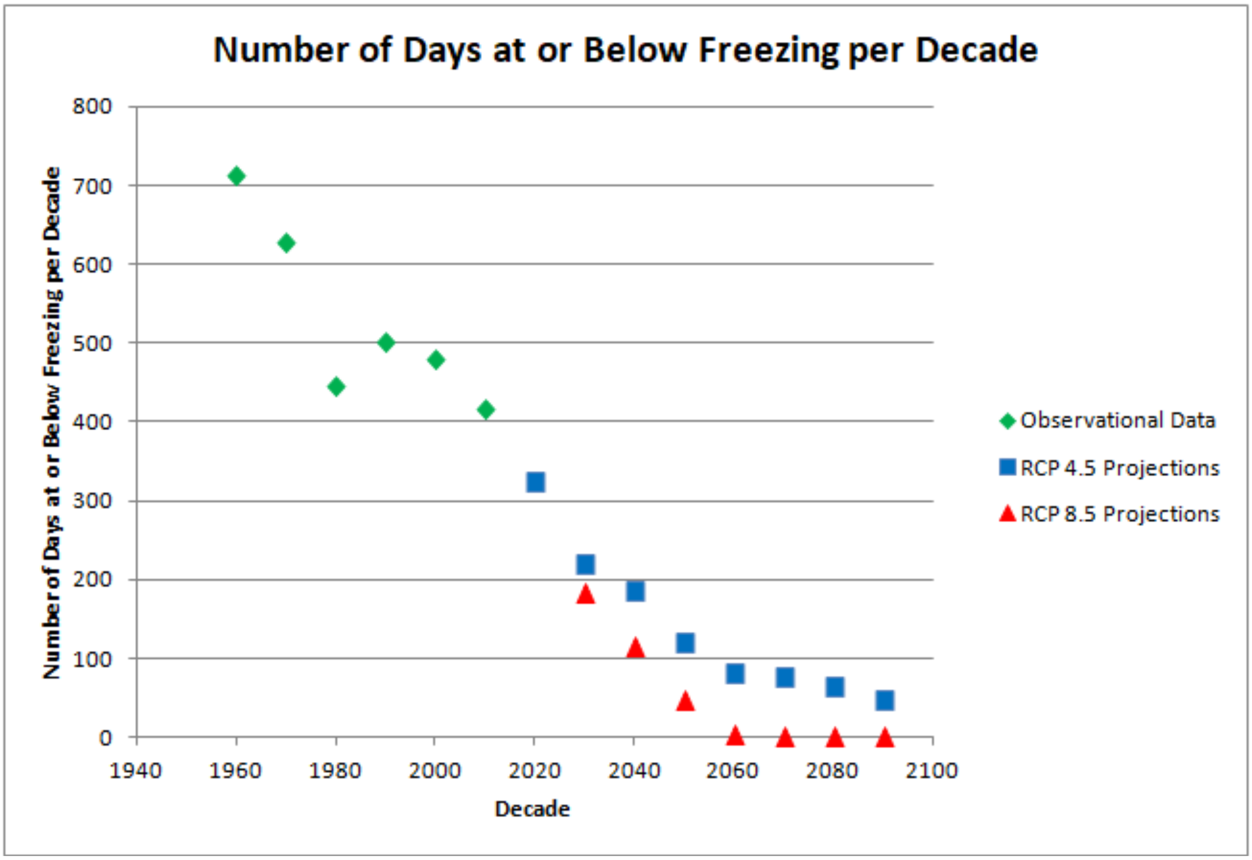

Figure 23: The "Observational and Projected Days at or Below Freezing per Decade" figure depicts how observational data from the 1960s to 2010s has a steady decrease continued by the projections of RCP 4.5 and RCP 8.5 for future decades. The projections of RCP 4.5 display a decline in the number of days at or below freezing, represented by the blue squares. The projections of RCP 8.5, characterized by red triangles in the figure, show even fewer days that reach temperatures at or below freezing than the previously mentioned RCP 4.5. Considering this, the winters experienced by the Clinton and Kirkland township will be very different from the winters in the past.

Figure 23 depicts the decrease in days at or below freezing from 1960 to 2090. The decrease is evident in the observational data between 1960 and 2010 with a change of 295 days per decade at or below freezing fewer in 2010 than in 1960. This decrease continues with the RCP projections. In the RCP 8.5 scenario, starting in the 2060 decade, there will be zero days at or below freezing in the decade. Even in the RCP 4.5 scenario, starting in the 2060 decade, there will be under 100 days per decade that are at or below freezing. This means there will be less than 10 days per year that are at or below freezing after 2060. This is a stark change from the approximately 70 days per year at or below freezing in 1960.

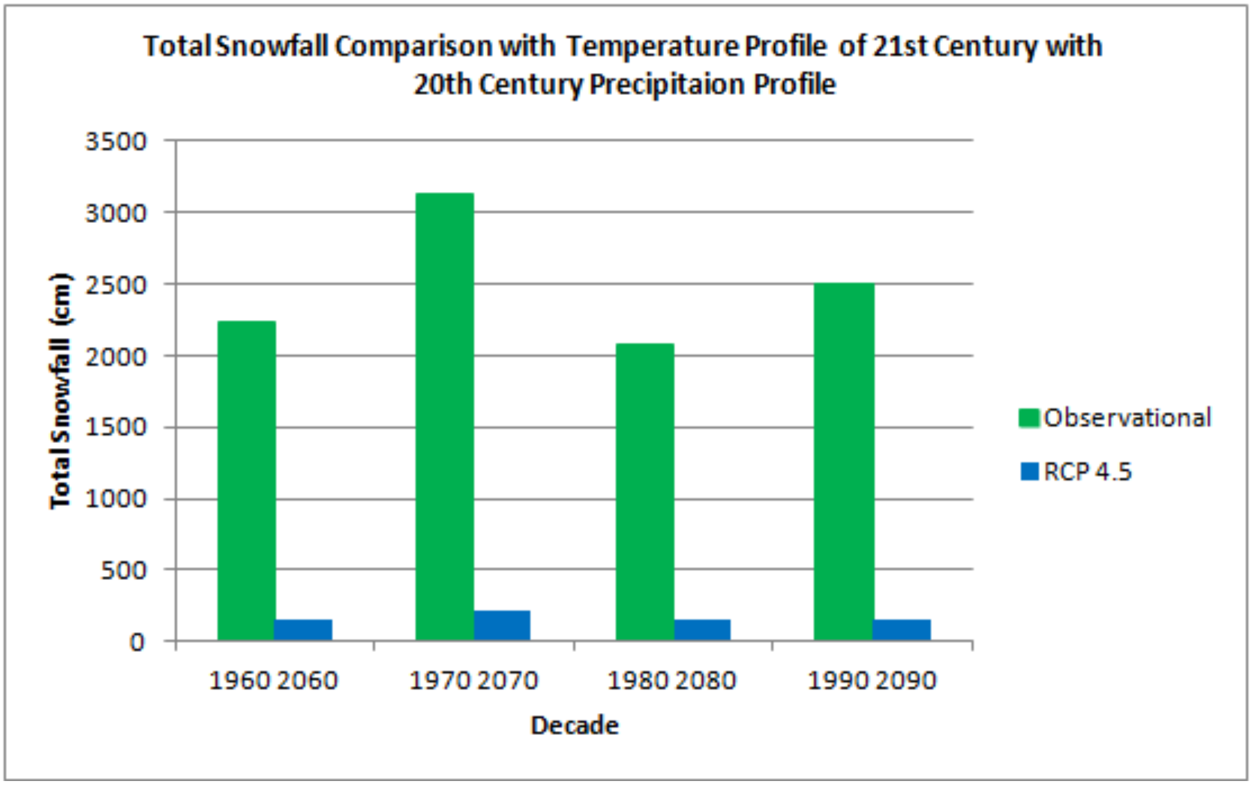

Figure 24. The "Total Snowfall Comparison with Temperature Profile of 21st Century with 20th Century Precipitation Profile" is the second figure. The graph's green bars represent the observed snowfall in centimeters from observed precipitation and observed temperatures from 1960, 1970, 1980, and 1990. The figure's blue bars are composed of the observed precipitation just as the green bars but with the projected temperatures of RCP 4.5 for the same decades in the 21st century.

Figure 24 depicts how much snowfall would be able to fall with the combination of the temperature profile of the 21st century and the precipitation profile of the 20th century. There is a vast difference between the observed number of centimeters of snowfall and the combination of observed precipitation and projected temperatures. The observational data has an average of 2487 centimeters of snow per decade whereas the RCP 4.5 projection has an average of 166 centimeters of snow per decade. This means that while the 20th century saw on average 249 centimeters of snow per year, the 21st century is projected to have 17 centimeters of snow per year using the precipitation profile from the 20th century. This is an average of 15 times less snow in the 21st century than in the 20th century per decade.

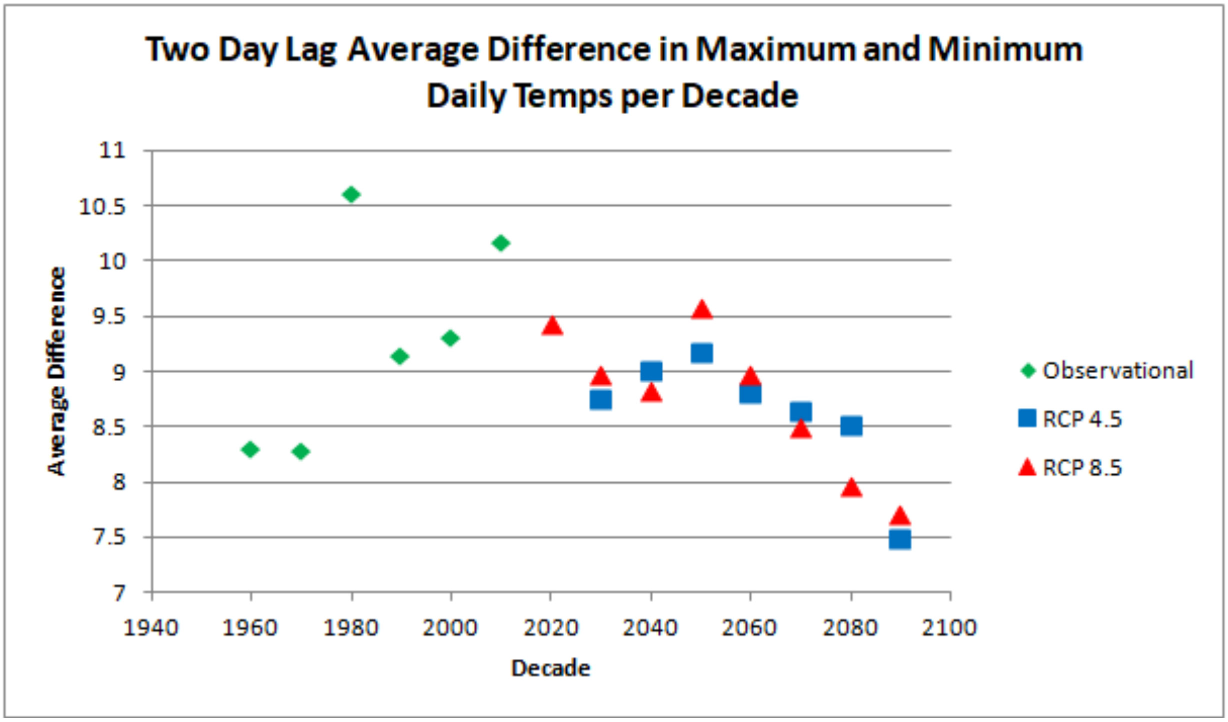

Figure 25. This figure depicts a metric for winter variability. The values for the average difference between maximum and minimum daily temperatures with a two day lag ranged from 7.5 to 10.6 for all the data. The RCP 4.5 and RCP 8.5 projections show a peak in variability in the 2050s and then a decrease in variability following that decade.

The information in Figure 25 about variability is less striking than the data in Figures 23 and 24. Although winters are being perceived to be more variable as a result of climate change, Figure 25 highlights that variability is not projected to increase dramatically with the continuation of the climate crisis. The projected variability shown in red triangles and blue squares in Figure 25 shows that variability will peak in the 2050 decade and then decrease in subsequent decades. This lines up well with the information shown in Figure 23 about the days at or below freezing per decade. Overall, temperatures are predicted to increase and this increase is being seen in both the maximum and minimum temperatures. Figure 25 indicates that the difference between those maximum and minimum temperatures will decrease as the overall values of those temperatures increase because of a larger increase in minimum temperature values.

Recommendations

Surrounding the conversations and concerns that have surfaced in the community from the already observed changes in winter, they should expect further changes. It is essential to acknowledge that snow projections and the methodological approach to display winter data are part of a novel climate science area that has yet to reach standardization. The Clinton and Kirkland township community should be prepared to experience fewer freezing temperatures and less snowfall from the figures above. The community should keep milder winters in mind and how it will impact winter dependent occurrences. Warmer temperatures will directly affect recreational winter activities such as skiing and ice fishing, and potentially their particular economic flows. The U.S. Global Change Research (2018) also highlights how climate change will impact the rural Northeast's winter recreation economics. Milder winters will most likely affect these activities' seasons and potentially make ice fishing more dangerous as these warmer temperatures affect ice thickness (WETM - MyTwinTiers.com, 2020). It is vital for those who partake in such activities to be aware of the increased risks with safety in mind. In response to this, it is advisable to have more planning, additional precautions, and further investigation into ice fishing risks as temperatures rise. The rural and urban parts of the Northeast have an economic co-dependence threatened by climate change, and exploring interdependence-friendly solutions could be a plausible potential avenue for adaptation (U.S. Global Change Research Program, 2018). The brevity of the assessment and other areas of uncertainty regarding winter changes are to be acknowledged. The community also held interests in whiplash winters, which are also part of a novel climate study area.

8. Climate Impacts: Public Health

Section Summary

- Tick reproductive rate is projected to be 2 to 4 times greater by the year 2099, than present day, resulting in more Lyme disease in Clinton.
- RCP 8.5 is predicted to result in 25 more heat-related premature deaths per 100,000 people during the 2090s than projected RCP 4.5 rates. This is a 17% increase from current heat-related mortality rates.
- Increased flooding frequency and severity will likely have negative mental health impacts due to the economic and personal damages caused.

Introduction

Climate change is projected to have widespread consequences for public health around the planet. While public health impacts will differ by location, virtually all communities will be affected. For Clinton, the primary public health concerns include an increased prevalence of Lyme disease, increased mortality due to hotter temperatures, and negative mental health impacts from increased severity and frequency of flooding events.

The Northeast of the United States is home to the highest incidence rates of Lyme disease in the entire country (CDC, 2018). Much like the rest of New York State, Clinton is already experiencing relatively high rates of Lyme disease. In 2016, Oneida County experienced approximately 14.2 cases of Lyme disease for every 100,000 residents (Coinn, 2018). As temperatures continue to warm, the incidence of Lyme disease in Clinton is expected to increase. Ticks, which are the main vectors for Lyme disease, are very dependant on their environment, specifically the temperature. Tick populations are more successful in warmer temperatures. Therefore, as temperatures in Clinton increase, tick populations are expected to grow as well, ultimately increasing the amount of Lyme disease in the area.

Lyme disease is not the only worrisome public health impact associated with climate change. In the US, extreme heat events cause more deaths every year than the combined sum of all other extreme weather events (Luber and McGeehin, 2008). Premature mortality rates due to heat-related events are projected to increase as summer temperatures continue to rise due to climate change. Not only are mean air temperatures predicted to increase, but enhanced climatic variability is also expected to cause more severe, frequent and prolonged heat waves (Limaye et al., 2019). These temperature increases are significantly more likely to cause heat-related cardiovascular disease in people aged 65+ and in non-Hispanic blacks (CDC, 2016). Exposure to extreme heat can also lead to heat exhaustion, heat stroke, heart attacks, strokes and other cardiovascular diseases which can be deadly.

Methods

Lyme Disease Projections

In determining projected increase in Lyme disease prevalence in Clinton, a model of future tick reproductive rate was chosen as the best indicator. Ticks are heavily dependent on appropriate temperature for population success, so the relationship between tick reproductive rates and temperature increase was chosen as the most accurate for this assessment. To model basic tick reproductive rate (R_0), a linear regression function that was first presented by Ogden et al. (2014) was applied: $R_0 = a \cdot DD > 0 + c$ where $a = 0.002367$, $c = -7.1206$, and DD = calculated degree days.

Daily observational temperature data for the local area was collected from the Utica weather station from 1960 until the time of its closing in 2007, and the Rome Griffis Airfield from 2007-2020. The daily maximum and minimum for the observational period were then averaged to determine DD. If the daily average temperature was greater than 0°C, then it was equivalent to its own value in DD. If the daily average temperature was equal to, or less than 0°C, then it counted as 0 DD. The sum of all DD was calculated for use in a linear regression function.

DD for RCP4.5 and RCP8.5 were calculated similarly to that of the observational data. 32 climate models were compiled to determine projected daily maximum and minimum temperatures for 2021-2099. 32 climate models were chosen to reduce the influence of any outliers or noise and include the best current knowledge of future temperature projections. The same process used for calculating the DD of the observational data was used for calculating DD of the forecasted data.

Heat Mortality Projections

In order to understand projected heat-related mortality risk, a risk assessment for Clinton and Kirkland was conducted by looking at excess mortality when temperatures from June through October exceed 73.54 degrees Fahrenheit. While mortality is not the only health impact associated with heat exposure, it is by far the most extreme. Previous heat-related mortality risk assessments have used historical classifications of heat-related deaths to look at past mortality rate, however, many deaths that are associated with heat exposure are not reported as heat related (CDC, 2016). This reduces the legitimacy of such findings, as it allows for significant year to year variability in data.

To avoid such subjectivity, the Kirkland Clinton Heat-Related Mortality Risk Assessment was conducted using the Knowlton et al., (2007) approach. This study assessed mortality risk by examining daily mortality impacts using the equation $H=(P/100000)\times M\times ERC,$ where H is excess daily heat-related deaths, P is the current population of Kirkland, M is Oneida County's baseline summer non-accidental daily mortality rate per 100,000, and ERC is the exposure-risk coefficient of mortality based on daily mean temperature changes. $ERC=\exp(b\ \Delta Tave) - 1$, where b is the parameter estimate of a 13.05% increase in non-accidental mortality rates per 10ºF change in daily mean temperatures above the threshold of 73.54ºF. $\Delta Tave$ is the difference between daily mean temperature ($Tave$) exposure and the threshold temperature when $Tave$ is above 73.54ºF. The same observational and predicted temperature data from the Tick reproductive rate risk assessment was used to calculate the daily mean temperature, $Tave.$ Table 3 shows the numbers that were used for the Knowlton equation.

Table 3. Numbers used based on current data for Kirkland and Clinton

Threshold ºF	73.54
Threshold ºC	23.0778
P	10,315
M	2.7206
b	0.075636

Results

Tick populations in Clinton are expected to increase dramatically throughout the end of the 21st century. Tick reproductive rate is measured on a numerical scale, where 1 is the maintenance of existing population abundance, <1 is a declining tick population, and >1 is an increasing tick population. The estimated tick reproductive rate in 2018 from the observational temperature data was 1.40. Under RCP4.5, tick reproductive rate is projected to double, increasing to 2.85 by the end of the century. Under RCP8.5, tick reproductive rate is projected to increase almost 4-fold to 5.25.

The projected increase of tick reproductive rate, and ultimately tick populations, in Clinton is quite alarming when considering Lyme disease statistics. In 2019, the New York State Department of Health found that 56% percent of ticks sampled tested positive the Lyme disease causing bacteria, a number that is consistent throughout the state. (Health.data.ny.gov, 2019). In 2019, the statewide average of ticks that contained Lyme disease causing bacteria was 61% (Health.data.ny.gov, 2019).

The projected increase in tick populations is far from benign; over half of all ticks in Clinton likely have the potential to spread Lyme disease to humans. Therefore, the projected increase in tick populations with warmer temperatures is very likely to increase the prevalence of Lyme disease in Clinton, leading to a host of potential short term and long-term health impacts for residents.

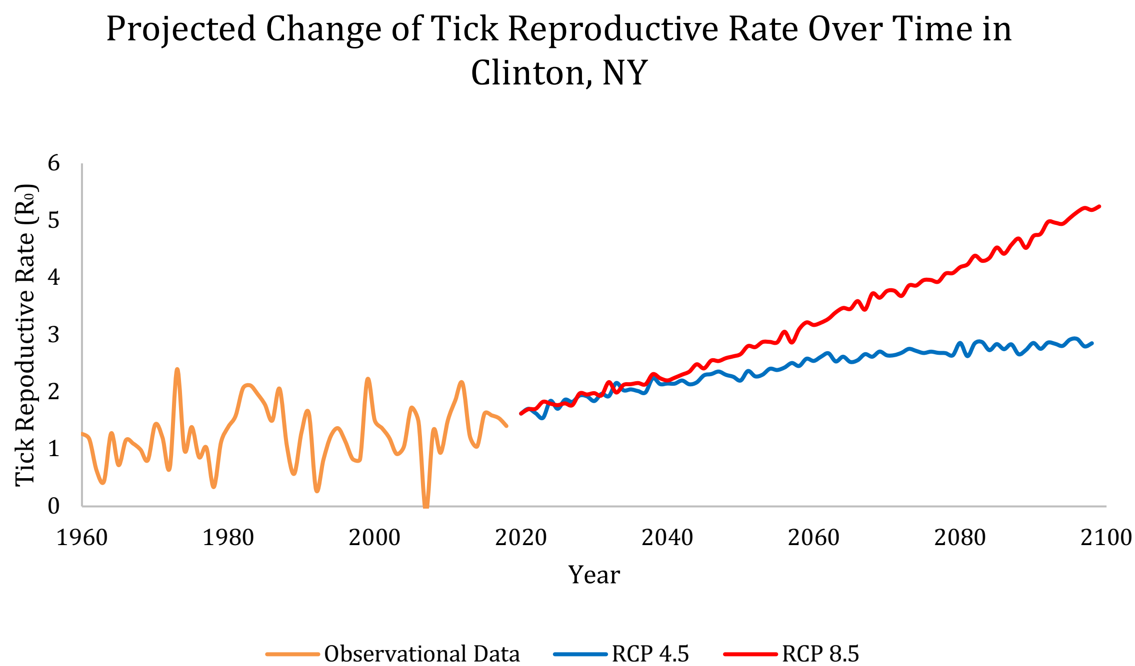

Figure 26. Projected change of tick reproductive rate in Clinton, NY, from present day (2020) until 2099.

Table 4. Each number represents one death per 100,000 per decade based on observed data and projected RCP 4.5 and 8.5 temperature models.

Decade	Observed Data	RCP 4.5	RCP 8.5
1960	157.21	-	-
1970	161.29	-	-
1980	159.07	-	-
1990	160.49	-	-
2000	159.83	-	-
2010	160.87	-	-
2020	-	157.98	158.58
2030	-	159.23	159.42
2040	-	159.72	161.11
2050	-	160.60	164.59
2060	-	162.09	169.54
2070	-	162.67	175.00
2080	-	162.69	180.47
2090	-	162.96	188.75

The daily mortality impacts from June 1st through October 31st were totaled for each decade from 1960 and until 2100. The sum from each decade is shown in Table 4, where each number is one death per 100,000.

Approximately 189 people per 100,000 are predicted to die prematurely due to heat-related causes under RCP 8.5 during the last decade of the 21st century. Given that the population of Kirkland is around 10,315 at the time of this report, this means that roughly 19 people per decade are projected to die prematurely due to increased temperatures caused by climate change.

RCP 4.5 model projections do not differ much from the observed data from 1960-2020, whereas RCP 8.5 projections increase by about 15%. Heat-related premature mortality is predicted to increase by about 25 cases per 100,000 people from 2090-2100 when comparing RCP 8.5 to RCP 4.5. Compared to historic observed data, approximately 28 more people are projected to die **prematurely due to increased temperatures caused by climate change.**

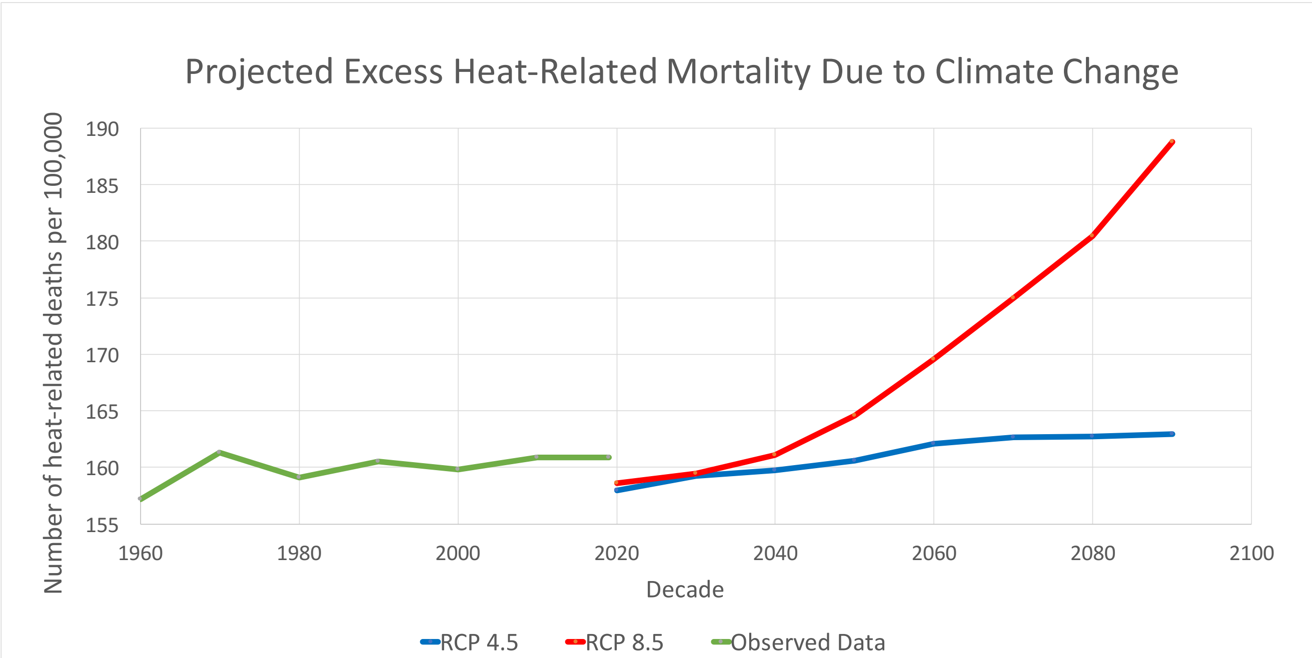

Figure 267 Projected change in excess heat-related deaths per 100,000 individuals each decade in Upstate New York from present day (2020) until 2100.

If current emissions are reduced to the RCP 4.5 model projections, then approximately 3 Kirkland residents' lives will be saved in the last decade of the 21st century. While this may not seem like a significant difference, such mortality rates will likely continue to increase into the future, and these premature deaths are avoidable if we take climate action and reduce emissions.

Climate change is also projected to impact mental health due to increased frequency and severity of extreme weather events (Berry et al., 2009). Such events may impact mental health directly, by exposing people to traumas and anxiety, or indirectly, by affecting physical health and community wellbeing. It will not only increase risk of injury, but will also result in more physical health complications such as those discussed earlier like Lyme Disease, other tick or vector-borne illnesses, and heat-related cardiovascular challenges and mortality.

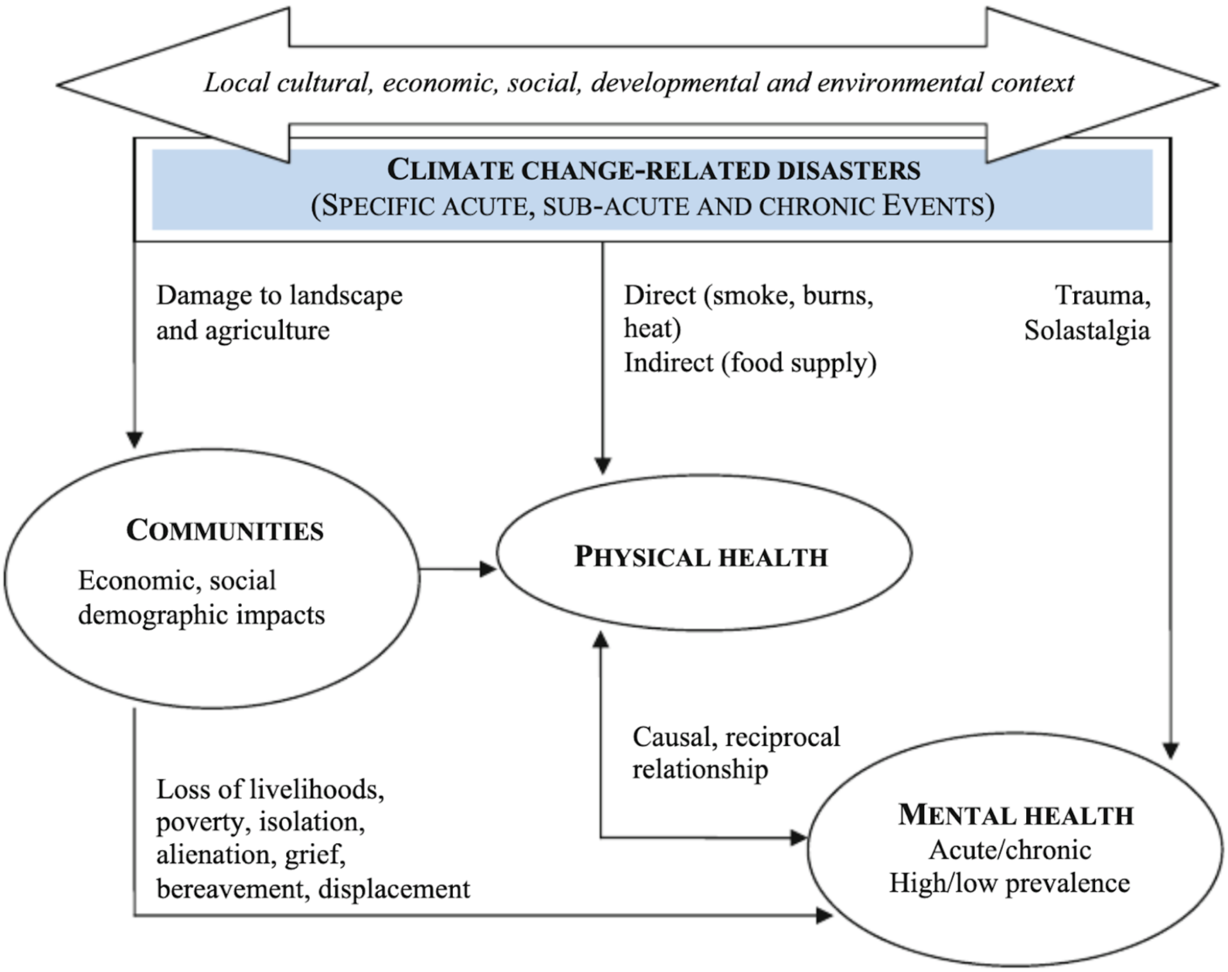

Figure 28. This figure from Berry et al., (2009) shows a causal pathways framework for how climate change is projected to impact mental health.

Community wellbeing is also impacted as climate change damages public infrastructure and outdoor spaces. For Kirkland and Clinton, increased flooding will also likely leave some areas uninhabitable, forcing people to move and potentially leave the community for higher ground. This not only damages community cohesiveness, but it may also impact the individual or family that is moving as they now must leave their home and establish roots elsewhere. Flooding and other extreme weather events can also cause damage to infrastructure and housing, resulting in necessary repairs and decreasing property value. Such repairs are costly and may not be affordable for some people. Without repairs, mold can grow in previously flooded buildings, exacerbating existing health complications for the inhabitants.

Mental health and general health concerns are likely to disproportionately impact vulnerable and especially low-income communities as they often have fewer financial resources to from lost income, debt and damaged housing from weather events and also fewer resources for mental and physical health support (Berry et al., 2009).

Recommendations

Stopping the spread of Lyme disease is a difficult task. The best method to stop the spread of Lyme disease is to limit contact with ticks in the first place. Lyme disease is acquired when a tick begins feeding on an individual and passes the disease-causing bacteria along. Ticks cannot jump or fly; they can only find a new host through direct contact. Ticks find new hosts by waiting at the top of grass blades and climbing aboard a host when the grass is touched. In order to prevent tick transmission to humans, it is recommended, when entering grassy or wooded areas, that individuals take care to ensure they are wearing long pants and long sleeves. Additionally, if pets are brought on walks into grassy or wooded areas, or play in such areas, you should check them regularly for ticks.

Instituting an educational campaign to inform all residents about the growing danger of Lyme disease in Clinton, and how to avoid ticks is recommended. By educating as many individuals as possible, the threat of Lyme disease can be greatly reduced even as tick populations increase in the area.

Extreme temperature events are less common in an RCP 4.5 model than in an RCP 8.5 model. This means that fewer heat-related mortality events occur under RCP 4.5 than RCP 8.5. The best way to save lives would be to reduce emissions so that they are consistent with RCP 4.5 projections. This would keep current heat-related mortality rates fairly stable compared to historical observed data. If emissions are not reduced, and RCP 8.5 becomes the more realistic scenario, then education and communication can be important tools for community leaders and government officials to spread important information during extreme heat events. Increasing accessibility of air conditioners and other portable fans is another way to temporarily address excessive heat challenges.

For mental health related concerns, communities with stronger support, more resources, cohesion, and resilience have been observed to fair better than communities where less support was available (Berry et al., 2009). Destigmatizing mental health may also help to strengthen community resilience so that more people feel comfortable and supported by their peers in vocalizing their challenges and seeking professional help. Again, reducing emissions will also result in fewer extreme weather events which are predicted to increase mental health challenges.

9. Social Vulnerability to Climate Change

Section Summary

- The Kirkland/Clinton community is equipped to adapt to and mitigate climate hazards based on its social demographics
- There is no significant difference between monetary home values inside and outside of flood zones both in Clinton Village and the Town of Kirkland
- Kirkland/Clinton has a higher percentage of population over the age of 65 relative to the national average, which indicates that the elderly community requires more support when the community implements adaptation and mitigation strategies

Introduction

The assessment of Kirkland and Clinton's ability to adapt intersects with the assessment of the community's social vulnerability. The International Panel on Climate Change (IPCC) describes adaptive capacity as "the ability of a system to adjust to climate change' which relate to the factors that assist social systems to manage and adjust to changing environmental and socioeconomic conditions." (Barnett and Mortreux, 2017, 2). In measuring the ability for a community to adapt, vulnerability must be assessed in order to understand the barriers or motivations a community might have to climate change impacts and adaptive strategies. Mortreaux and Barnett in their paper, "Adaptive capacity: exploring the research frontier (2017)," describe social vulnerability as being associated with risk: "vulnerability is a latent condition that is a function of exposure to risk, sensitivity to risk, and the capacity to adapt to avoid, reduce, or capitalize risk." (2). Social vulnerabilities can create a greater exposure to climate hazards, therefore an analysis of adaptive capacity is a method to approach and aid in alleviating potential risks.

Because there is no universal method for measuring social vulnerability, most researchers conducting vulnerability assessments rely on popular conceptual framing and methodological approaches to remain consistent with other studies in the field. The CDC's Social Vulnerability Index (SOVI) is a prominent framework, which uses U.S. Census Data to determine the social vulnerability of each census tract, specifically by ranking each tract on 15 social factors. The four main themes encompassing these factors are socioeconomic status, household composition, race/ethnicity/language, and housing/transportation. In measuring social vulnerability, it is critical to include stakeholders when conducting the research objectives and making judgements as to the quality of the results. Otherwise, researchers run the risk of creating a relevance gap between the information on social vulnerability and community members affected by such information.

Like social vulnerability, there is no single method to assess adaptive capacity. Studies apply "different factors and indicators to capture the outcomes of entitlement processes" (Montreux and Barnett, 2) making it difficult to compare results across studies. However, the most widely used framework comes from the sustainable livelihood assessments developed in the 1980s and 1990s that were inspired by Sen's capabilities theory. The framework, coined as the First Generation approach, incorporated five capitals into measuring adaptive capacity: natural, physical, financial, social, and human (2-3). While these factors determine what is required to adapt to a *generic* range of threats, they do not apply to a "diverse range of scales and risks" (3) as they are solely asset based. Studies found that those with "high adaptive capacity" were not adapting under the First Generation approach, while those with "low adaptive capacity" were adapting. Alas, a new psychosocial model which includes "people's intentions to adapt" (3) helps explain the connection between capacity and action that was missing in the First Generation approach. In fact, a study conducted by Truelove et al. found that efficacy beliefs were the strongest predictor of adaptation intentions (3). The newer model, known as the Second Generation approach, incorporates risk attitudes, personal experiences, trust and expectation in authorities, place attachment, competing concerns, and household composition/dynamics.

The literature of Montreux and Barnett, as well as the CDC, provide us with a groundwork to measure social vulnerability and adaptive capacity within the Clinton/Kirkland community. We recognize that adaptive capacity is a complex social phenomenon that does not necessarily equate to successful adaptation of a particular community, however, we hope our research establishes a solid foundation of knowledge that inspires implementation of climate based adaptation within the Clinton/Kirkland community.

Methods

In line with the First Generation and Second Generation methods described above, the social vulnerability and adaptive capacity assessment for Kirkland and Clinton employs a combined approach that involves stakeholder participation/feedback and statistical analyses. Given time and resource constraints, a full Second Generation approach cannot be implemented, but engaging methodologies from both adaptive capacity assessment theories allows us to measure the community's social vulnerabilities and concerns in a multifaceted manner. This specific assessment uses a combination of survey data from stakeholders, interviews with community members, community census data, and home value data in relation to flood zones to calculate social vulnerability.

On October 13. 2020, Hamilton College students in Aaron Strong's Climate Risk and Resilience class in collaboration with the Kirkland/Clinton Climate Task Force held a meeting that invited members of the Kirkland and Clinton community to share their concerns, experiences, and ideas regarding climate change impacts and the risk assessment being conducted for the region. During this meeting, students and the task force received feedback from the community regarding an array of climate change issues in the region. After the community meeting, a survey was sent out to the attendees and others who registered their emails to receive contact from the task force. To get a sense of the community demographics and additional feedback, a post meeting survey was sent out. From this survey, attendant demographics and answers to questions on Kirkland/Clinton's ability to adapt were pulled and placed into figures to best demonstrate the sample group's identity characteristics and level of confidence in the community's adaptive capacity. The survey result data was compiled into an excel file and transformed into various pie charts using excel tools. This data helps provide a partial representation of the community social demographics as well as potential stakeholder concerns regarding climate adaptation.

On November 5. 2020, Hamilton students spoke with Clinton resident Ben Fehlner via Zoom about climate impacts within the Clinton/Kirkland community. Ben was asked a series of questions related to climate impacts in Clinton/Kirkland, residents' adaptation efforts to climate impacts, and the path towards greater mitigation and adaptation efforts in the community. Because Ben is a lifetime resident and business owner in the community, he provided us with important information related to climate change in the community overtime.

Members of the Clinton Environmental Club held a meeting with Clinton High School students in regards to the prevalence of and adaptation to climate change in the community. They created a document that compiled student's general concerns about climate impacts within the community, emotional effects of said impacts, and steps towards adaptation efforts in the future. The document was shared with Hamilton College students.

Census data related to social demographics was collected to compare Clinton/Kirkland's social vulnerability to the United States'. Four social demographics were measured, including age, race, income, and education. Using the United States Census Bureau website, census data tables containing statistics related to each social demographic and location (either Oneida County or the U.S.) were downloaded into Excel. The Oneida County data was condensed in Excel so that only Clinton/Kirkland census tracts would be visible. Four tables related to each social demographic were created, highlighting key data from Clinton/Kirkland and the U.S. These tables allow for quick comparison between Clinton/Kirkland and the U.S, and are easily readable. Collecting quantitative data on social demographics is a key method to measuring social vulnerability in a particular community, as this approach is highly unbiased and encompasses the entire population. Most importantly, social demographic data reveals whether or not a populations' characteristics have an impact on a community's ability to adapt and mitigate climate change.

Monetary home value data was analyzed using Zillow.com and the ArcGIS Online map "clinton flood-Copy". This map contained several layers: ESRI data on USA Flood Hazard Areas and Civil/Town Boundaries from ArcGIS Online author, ruffinom_ChautauquaC ounty. The Zillow site contains information on home and property costs for properties that are sold or for sale. By navigating the Zillow satellite map containing home costs in comparison to the flood map of Kirkland and Clinton on ArcGIS Online, home values were manually compiled into an excel file that allowed for an analysis of values inside and outside of the 100 year and 500 year flood zones. This data was averaged for four separate categories: 100 year flood zone, 500 year flood zone, 100 year and 500 year flood zone, and outside of flood zone. Each category contained the corresponding compilations of property prices and calculated averages for home values. In terms of measuring social vulnerability, it is important to assess whether or not homes existing within flood zones are valued differently than homes outside of flood zones as this can have implications for home buyers and owners in the community who are at risk of having their property experience a flood. Disparities in home value can signal vulnerabilities regarding financial capital. For example, in a hypothetical situation where homes within a flood zone were valued higher or vice versa, this trend would be indicative of socioeconomic disparities or trends associated with who is more likely to purchase property inside or outside of a flood zone.

Analysis

Social Demographics

	Age	Race	Income	Education
United States of America	**Percent of Population Over 65**	**Percent White Population**	**$150,000 to $200,000+**	**Graduate or professional degree**
	13%	**72.04%**	**15.70%**	**11.27%**
Kirkland/Clinton	**Percent of Population Over 65**	**Percent White Population**	**$150,000 to $200,000+**	**Graduate or professional degree**
	20.09%	**91.55%**	**15.04%**	**17.80%**

Table 5. Age, race, income and education in Kirkland and Clinton relative to US averages

The Table above is a consolidation of demographic data for Kirkland/Clinton compared to the US which displays comparisons of age, race, income, and education. The resulting statistics indicate that Kirkland and Clinton have a higher population percentage of white persons, persons with graduate or professional degrees, and persons over the age of 65. In contrast, for the higher bracket annual household income of $150,000 to $200,000+ , Kirkland/Clinton residents have a slightly smaller percentage of people who fall under this category compared to national standards. This consolidated data comparison indicates that Kirkland and Clinton have an older population of mostly white residents who are likely to have acquired higher education compared to the rest of the United States. Given the SOVI index factors regarding socioeconomic status and minority status (Agency for Toxic Substances and Disease Registry), the Kirkland/Clinton community is equipped to adapt according to the assumption that the majority of the population is not of minority status, likely has acquired a higher education, and does not fall below the poverty level in terms of annual income.

United States of America			
$35,000 to $74,000	$75,000 to $149,000	$150,000 to $200,000	Average Median Income
29.30%	28.50%	15.70%	$65,712
Kirkland/Clinton			
$35,000 to $74,000	$75,000 to $149,000	$150,000 to $200,000	Average Median Income
29.19%	30.75%	15.04%	$72,999

Table 6. Annual Household Income Breakdown for Kirkland/Clinton Compared to Nationwide Statistics 2018/2019 Data, adjusted for inflation

The above table is an expanded version of Kirkland/Clinton and United States annual household income and comparisons. The important figures to pay attention to in this chart are Kirkland/Clinton's average median household income and the percentage of households earning an annual income within the $75,000 to $149,000 bracket. These statistics indicate a community with some level of affluence that is making an average median household annual income that is higher than the nation wide baseline.

United States of America		
Population Total (18-65+)	255,271,738	**Percent of Total Population**
High School Graduate	70,403,684	27.58%
Bachelor's Degree (only)	49,351,958	19.33%
Graduate or professional degree	28,771,172	11.27%
Kirkland/Clinton		
Population Total	7,429	**Percent of Total Population**
High School Graduate	1,972	26.54%
Bachelor's Degree (only)	1,468	19.76%
Graduate or professional degree	1,322	17.80%

Table 7: Education Level in Kirkland/Clinton Compared to Nationwide Statistics
2018 (K/C) and 2019 (USA) census survey data

Table 6 is a breakdown and comparison of education level in Kirkland/Clinton and the United States. Regarding high school graduates, the percentage of population for the nation as a whole and Kirkland/Clinton is close, only off by about one percent. The statistical comparison does indicate that Kirkland/Clinton residents are more likely to have attained a bachelor's degree or graduate/professional degree compared to national standards. This is indicative of the fact that the Kirkland/Clinton community is less socially vulnerable when it comes to education level, and these statistics can instead increase the adaptive capacity of the community.

United States			
	Percent of Individuals **Under** 65	Percent of Individuals **Over** 65	Total Individuals
Male	88.60%	11.50%	152,089,450
Female	84.50%	14.60%	157,260,239
Clinton/Kirkland			
	Percent of Individuals **Under** 65	Percent of Individuals **Over** 65	Total Individuals
Male	84%	18%	4,723
Female	78%	22%	5,398

Table 8. Sex and Age Data in Clinton/Kirkland Compared to Nationwide Statistics 2019 (C/K) and 2019 (USA) survey census data

The above table displays percentages of individuals over and under the age of 65 in Clinton/Kirkland and the U.S. For individuals over 65, Clinton/Kirkland has 6.5% more men and 7.4% more women compared to the national average. A high elederly population increases Clinton/Kirkland's social vulnerability, as those over the age of 65 are more likely to suffer from health risks related to climate impacts.

Table 9. Race Breakdown in Clinton/Kirkland Compared to Nationwide Statistics 2018 (C/K) and 2019 (USA)

United States		
Race	**Number of Individuals**	**% of Individuals**
White	236,475,401	72.04%
Black or African American alone	41,989,671	12.79%
American Indian and Alaska Native alone	2,847,336	.87%
Asian alone	18,636,984	5.68%
Native Hawaiian and Other Pacific Islander alone	628,683	.19%
Some other race alone	16,352,553	4.98%
Two or more races	11,308,895	3.46%
Two races including Some other race	1,666,175	.51%
Two races excluding Some other race, and three or more races	9,642,720	2.94%
	Total: 328,239,523	
	Clinton/Kirkland	

Race	Number of Individuals	% of Individuals
White	9,266	91.55%
Black or African American alone	236	2.33%
American Indian and Alaska Native alone	22	.22%
Asian alone	257	2.54%
Native Hawaiian and Other Pacific Islander alone	0	0.00%
Some other race alone	134	1.32%
Two or more races	206	2.04%
Two races including Some other race	30	.30%
Two races excluding Some other race, and three or more races	176	1.74%
	Total: 10,121	

Table 10. Sex and Age Data in Clinton/Kirkland Compared to Nationwide Statistics 2019 (C/K) and 2019 (USA) survey census data

Table 8. breaks down race in Clinton/Kirkland and the U.S. It shows that Clinton/Kirkland is 91.55% white compared to the U.S. which is 72.04% white, and that no other race within the community exceeds 2.55% of the population. The small minority and large white population of Clinton/Kirkland decreases the social vulnerability of the community, as white individuals are not discriminated upon on the basis of race. With that said, it is critical to recognize, account for, and integrate minority stakeholders when making adaptation/mitigation plans. Climate change

disproportionately affects minorities, including indigenous peoples who are closely tied to their natural environments. The Clinton/Kirkland community falls on the ancestral lands of the Oneida Nation, thus, it is important to ensure the emotional and spiritual ties of this land are recognized in any future decision-making.

Survey Data from Community Meeting on October 19, 2020

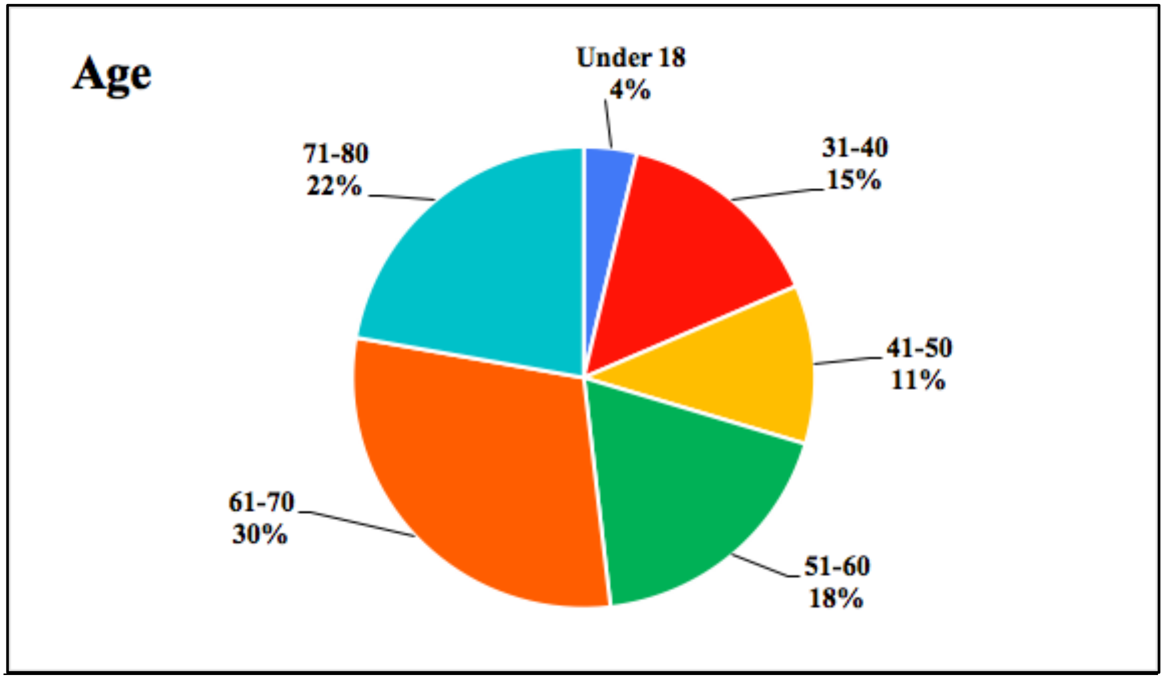

Figure 29. Age demographics of survey takers

The above figure is a pie chart visualizing the ages/age groups of survey takers in the Kirkland/Clinton Community. The chart indicates that the majority of attendees of the community meeting and those who took the post meeting survey were middle aged to elderly, with a higher percentage of survey takers aged 61-80 years old. This sample group supports the notion that the Kirkland/Clinton community has a higher percentage of elderly population.

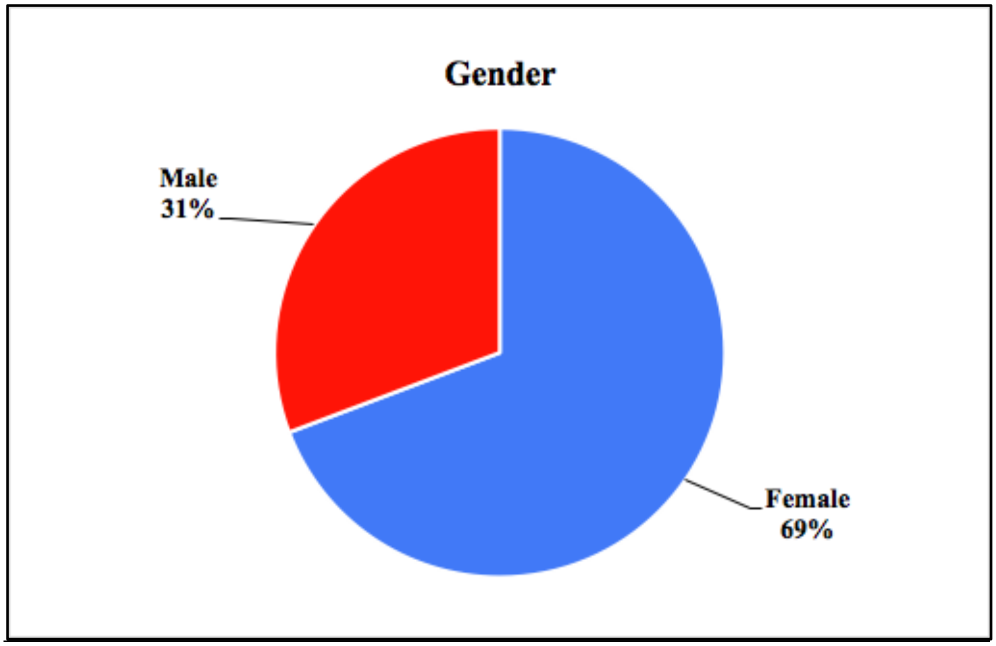

Figure 30 Gender demographics of survey takers

Figure 30 displays the gender breakdown of survey takers and community meeting attendees. All attendees identified within the male/female binary. A significantly larger percentage of women completed the survey compared to men.

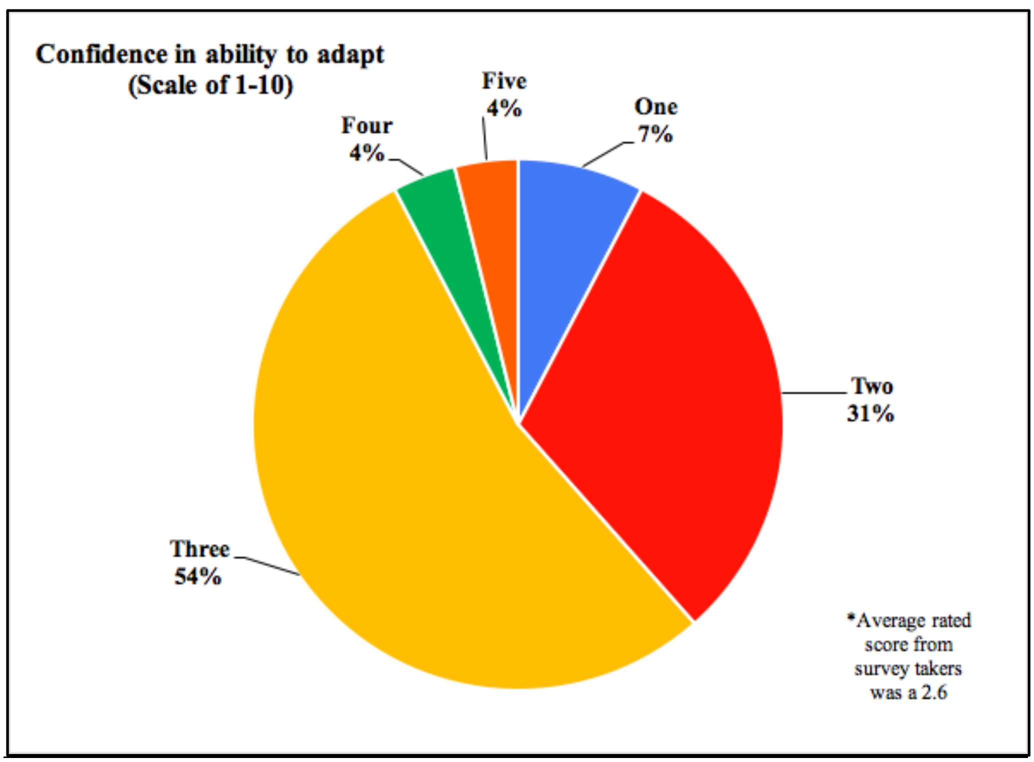

Figure 31. Confidence in adaptive capacity of Kirkland/Clinton

In the post meeting survey, members of the community were asked about their confidence in the Kirkland/Clinton community's ability to adapt. The question asked takers to rate their confidence on a scale of 1-10, 1 being a very low confidence and 10 being a very high confidence. As seen in the graph, more than half of the survey takers rated their confidence at a 3 on a scale of 1-10, indicating that survey takers in the Kirkland/Clinton community are low in confidence when it comes to perception of the community's adaptive capacity. It is also important to note that the higher ratings given by survey participants, for example the 4 and 5 ratings, were given by survey takers who did not attend the community meeting beforehand. This difference between the low and high ratings from survey participants may show a negative correlation between knowledge of climate impacts and perception of adaptive capacity, with those who are less aware of the intricacies of climate impacts may have a heightened sense of confidence in combatting it.

Home Value Inside and Outside of Flood Zones in Kirkland and Clinton

	100 Yr Flood Zone	500 Yr Flood Zone	100 Yr and 500 Yr Flood Zone	Outside Flood Zone
Clinton	$206,500	$204,500	$211,889	$209,505
Kirkland	$201,972	$187,826	$199.042	$257, 101

Table 10. Average Value of Homes in Town of Kirkland and Clinton Village (Inside and Outside of Flood Zones)

The above table shows the monetary values of homes within and outside of flood zones. The 100 year flood zone indicates an area has a 1% annual chance of flooding, and the 500 year flood zone indicates an area has a .2% chance of annual flooding. The data shows that in Clinton, there was little change in monetary home values from within flood zones and outside of flood zones. In fact, the price for homes in the "100 year and 500 year flood zone" averaged higher than those outside the flood zone. The Kirkland data, however, indicates there is a correlation between flood zones and monetary home value. Property outside floods zones price, on average, at least $55,000 more than those within flood zones. The price discrepancy creates implications for those trying to sell or buy homes within flood zones, as such homes become devalued due to proximity to flood basins. If homes continue to devalue over time due to flooding, greater socio economic problems within the community may arise, signaling a possible need for government intervention through buyouts or managed retreat in the most dire of cases.

Recommendations and Next Steps

The first step to addressing climate impacts within Clinton/Kirkland is to distribute climate-related information to the community in a way that is salient to all stakeholders. If individuals understand climate impacts within their community, they are more likely to develop an interest in adapting to/mitigating these impacts. Many community members recognize the importance in the diffusion of knowledge, including a group of Clinton High School students of the Clinton Environmental Club, who state: "Information on Climate Change should be updated and people [should be] informed regularly." The group noted that adaptation and mitigation efforts should have "pro-business and pro-climate" philosophies to satisfy community needs in both capacities. Participatory decision-making is necessary to satisfying the needs of stakeholders while still furthering adaptation/mitigation developments.

In regards to flooding, a long-time Clinton resident and Village Trustee, accredits the more recent, devastating floods that have taken place in "the last six, seven years" to the climate crisis. The aftermath of flooding creates "piles of debris on the side of the street" for weeks, along with damage to the interior and exterior of many homes. Apart from its most noticeable physical effects, flooding can have significant emotional tolls on community members, especially due to its frequency over the past decade. Ben notes that if homes suffer considerable damage, residents may consider moving their belongings into storage or selling their homes. Overall, he notes that early flood risk planning, which takes into account a multitude of stakeholders, could minimize some of the physical and emotional damage that flooding creates.

It is important to factor the COVID-19 pandemic into any future adaptation/mitigation planning, as it has affected the ways in which people live, work, and relate to nature. The pandemic has impacted businesses significantly as the Village trustee notes: "Now I know that people are out of work, I know that businesses have closed. I know that others are struggling. And I know the uncertainty has never been higher than it is right now in every aspect of our lives." As the pandemic continues, it is critical to observe how Clinton/Kirkland responds to its progression, and how this response can be telling of the community's adaptive capacity to climate impacts as well.

Moving forward in a more general sense, in order to promote a high adaptive capacity, the Kirkland/Clinton community, including stakeholders, businesses, and local governance, should work to include stakeholder voices as often as possible in decision making and climate planning. This can range anywhere from community meetings, public information sessions, and surveys sent out to the public. The diffusion of knowledge on climate change hazards and adaptation throughout the Kirkland/Clinton community is essential to helping citizens understand and prepare for potential risks. Regarding vulnerable sectors of the population, the elderly and property owners within flood zones potentially require accommodation and aid in adapting to climate change and preparing for climate hazards. Through bottom up and community led approaches in collaboration with political entities, the community can listen to the most socially vulnerable members of Kirkland/Clinton and provide them with the resources to combat potential hazards. It is also essential to provide care and aid to all other vulnerable sectors of the Kirkland/Clinton community, including women, people with disabilities, low income persons, those with limited access to higher education, and people of color. Though the Kirkland/Clinton community is mostly homogenous and affluent in race and class, which can work to the benefit of small pockets of the community or individual households, those who fall outside of these norms should have a voice and adequate support in climate adaptation.

10. Next Steps

As a component of the New York State Climate Smart Communities (CSC) initiative, this **Climate Vulnerability Assessment** lays the important groundwork for completing future CSC actions that enable Clinton/Kirkland to become a certified Climate Smart Community, which grants Clinton/Kirkland eligibility to receive state funding.

The creation of a **Community Climate Action Plan** is the most important next step to take in the CSC process. Using the results of this Vulnerability Assessment -- structured by theory that **Climate Risk = Hazard x Exposure x Adaptive Capacity** -- Clinton/Kirkland can immediately start working on a Climate Action Plan. The goal of this plan would be to interpret the different climate risks provided by this Vulnerability Assessment and come up with a plan to address those risks effectively.

Beyond the Community Climate Action Plan, we also recommend the following CSC actions that are now even more viable given the completion of this assessment. They are listed below

Future CSC Action	Brief Rationale
PE2 Action: Government Operations Climate Action Plan	Similar to the Community Climate Action Plan, this action would address the municipal government's ability to address the discussed climate risks.
PE7 Action: Hazard Mitigation Plan	This action would specifically address the **Hazards** section of the Vulnerability Assessment.
PE7 Action: Evaluate Policies for Climate Resilience	This action could focus more specifically on the **Exposure** component of the Vulnerability Assessment, servicing community areas that are most vulnerable.
PE7 Action: Climate Adaptation Plan	More specific than the Climate Action Plans, this action would focus on the **Adaptive Capacity** section of the Vulnerability Assessment.
PE7 Action: Watershed-based Flood Mitigation Plan	This action would address the flooding component of this assessment by focusing on evaluating nearby watersheds.
PE7 Action: Design Flood Elevation & Flood Maps	This action is very achievable after the completion of the flooding portion of this Vulnerability Assessment.
PE9 Action: Climate Change Education & Engagement	A recommendation throughout the report was to continue to educate the community around issues in climate change. Quality education and engagement programs are crucial to the **Adaptive Capacity** of Clinton/Kirkland.

Conclusions
To understand a problem as interdisciplinary and complex as climate change, you need to appropriately organize and identify the many aspects of the problem you are looking at. By using the framework of **Climate Risk = Hazard x Exposure x Adaptive Capacity**, we believe we were able to define the many different climate risks facing the Clinton/Kirkland community. We believe this Vulnerability Assessment enables Clinton/Kirkland to continue to pursue Climate Smart Community certification by providing the groundwork for many of the other CSC actions listed on the CSC website. Finally, we hope that this assessment may provide a template for other communities in New York State to take the pledge to become a Climate Smart Community. For any additional inquiries or information, please visit Clinton/Kirkland's climate Smart Community website at http://kirklandclintonclimatesmart.org. We thank you for engaging with the climate crisis.

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