The urban heat island (UHI) is a well-documented phenomenon in the United States and around the world. Among the most important factors contributing to the heat island is the lack of vegetation and high amount of impervious surface in cities as compared to rural areas. Actively growing vegetation and pervious soils help to cool the environment by using solar energy for evapotranspiration rather than for heating the air; trees also provide shade for urban environments. Heat-island mitigation strategies often focus on “urban greening” via installation of green roofs, pervious pavements, and adding parks and trees—an explicit acknowledgement of the importance of vegetation within the city. Urban farms, however, have so far been overlooked in terms of their potential to ameliorate the UHI.

Urban farming is expanding in many metropolitan areas, and for good reason: urban farms increase access to local, fresh foods, help to build community and support physical activity, and can be a source of income. Could they also help to mitigate the urban heat island? In theory they should because farms are, by definition, areas with vegetation growing in pervious soil. Urban farms typically do not include trees, however, so they would not provide shading for surrounding urban surfaces. It is not clear whether a lack of trees could offset any temperature mitigation that farms could provide, or whether the active management of farms might enhance it, particularly if the farms are irrigated.

This project focuses on determining whether and how much urban farms might help to mitigate urban heat islands. We have a unique opportunity to evaluate the climatological impact of an urban farm by partnering with Frogtown Farm in St. Paul, which is developing a 5-acre farm on 12 acres of mostly open land formerly owned by the Wilder Foundation (see http://frogtownfarm.org/). Monitoring the site prior to, during, and following the development of the farm will document how this change in land use/land cover may affect temperature and humidity, two important characteristics of urban heat islands. Most observational UHI studies are carried out in already-urbanized areas where it is impossible to know what the local climate was like before any land-use change. Because the farm does not yet exist on this site, we have a rare opportunity to observe urban temperature patterns in and around the neighborhood prior to the development of the farm, and to document if and how temperature and humidity are affected by its presence.
Please provide a summary of the work that was completed for the mini grant project.

Five temperature-humidity sensors with radiation shields were deployed at the Frogtown Farm site and in the surrounding neighborhood beginning in late June 2014. The image below shows the approximate area covered by the sensors, with the diamond showing the approximate location of the Frogtown Farm sensor (for privacy, neighborhood sensor locations are not identified). We had regular problems with damage and theft of sensors at the Farm. It was both impractical and cost-prohibitive to install a deterrent (such as fencing around the sensor) in order to reduce damage/theft, with the result that there is approximately a two-month gap in the Farm record (September-October 2014). The sensor was redeployed in November 2014 but lost again in March 2015. Site construction began in April 2015; I expect to install a new sensor after construction is complete and the winter cover crop is sown. With increased activity at the site, and with some strategic placement of the sensor, we hope to reduce the risk of damage/theft going forward. Neighborhood sensors are still in place.

I have begun analyzing the data we’ve collected so far and am working toward writing up early results for publication. Preliminary analyses show that the Farm was, on average, about 0.35°F cooler than the neighborhood during the summer (late June through late August, 2014) and about 0.20°F cooler than the neighborhood during the winter (November 2014 through February 2015; see Appendix). Frogtown Farm is on a hill approximately 30 feet higher than the surrounding neighborhood. Using a standard atmospheric temperature lapse rate of 3.6°F per 1000 feet, one would expect temperatures measured at the Farm to be about 0.11°F lower than those at the lower-elevation neighborhood sites. In both seasons the temperature difference exceeds what would be expected from the change in elevation alone. Temperature differences were largest during the day (defined, somewhat inappropriately, as 6am-6pm local time), with daytime temperatures at the Farm being cooler than the neighborhood by about 0.45°F during the summer and by about 0.40°F during the winter. Differences in nighttime temperatures (defined as 6pm-6am local time) showed that the Farm was cooler than the neighborhood during the summer (by about 0.3°F) but had the same temperature as the neighborhood during the winter (difference of only 0.02°F, on average) – though it would be on average 0.1°F warmer than the neighborhood if the elevation difference were taken into account. Even accounting for that difference, however, these preliminary data show that the Frogtown Farm site is on average about 0.24°F cooler than the surrounding residential-industrial neighborhood. During the summer, for some hours of the day the temperatures at the Farm are as much as 3°F cooler than in the neighborhood. Cooler temperatures at the Farm might be expected given that the site is dominated by grass cover, whereas the surrounding neighborhood is a mixture of grass, trees, asphalt streets, concrete sidewalks, houses, and light industry; all of these non-vegetated surfaces, as well as car, bus, and truck traffic, contribute to the urban heat island.

As part of this project I developed a web page so that the data would be available to the Frogtown Farm community and the people hosting the neighborhood sites, as well as to the general public (find it at https://sites.google.com/a/umn.edu/klink/ff_uhi). About every six weeks I send all participants an e-mail update on the project, including brief discussions of interesting features of the past few weeks’ data. I also developed and offered a new undergraduate course (Geog 3900 – Topics: Urban Climatology, Spring 2015) in which I used Frogtown Farm and neighborhood data to illustrate urban climatological concepts and as the basis for a collaborative student lab project.
### Partnerships & Collaborations

*Please provide a summary of the project personnel, partnerships and collaborations that worked directly on the project or were started as a direct result of the mini grant project.*

In addition to myself, project personnel include Jay Bell (Department of Soil, Water and Climate in the College of Food, Agricultural and Natural Resource Sciences, and Frogtown Farm Board of Directors) and Seitu Jones (Frogtown Farm Board of Directors). Jay and Seitu contributed to evaluating monitoring sites for the Farm and the neighborhood and assisted in recruiting neighbors to host additional sensors. I am responsible for installing and maintaining the sensor network and serve as the primary contact for the project. Eartha Bell, the new Executive Director of Frogtown Farm, has been assisting as the primary on-site contact and community liaison for the project.

I’m not quite sure if this would be considered a collaboration, but in December 2014 both Eartha Bell and I participated in the upcoming TPT documentary “Minnesota Stories in a Changing Climate.” The producers were interested in the Frogtown Farm urban heat island project and arranged to interview me out at the site. (It was a cold, rainy December day.) The crew then filmed Eartha and me as we visited the sensors at the farm and in the neighborhood. A screening of the documentary is tentatively set for October with broadcast to follow shortly thereafter.

### Project Outcomes & Impacts

*Please provide a summary of the outcomes and/or impacts of the mini grant project including future plans for the project.*

Frogtown neighbors were enthusiastic about participating and they continue to be willing to have the sensors in their back (and sometimes front) yards. Problems with damage and theft at the Farm have been a bit of a setback in that we were unable to collect a full year’s worth of baseline data at our core location. Soil remediation and amendment is currently underway at the Farm, with a cover crop to be planted soon thereafter. We hope to deploy a new Farm sensor (purchased with funds from the Department of Geography, Environment and Society) once major construction is complete. Our goal is to collect another year’s worth of data that we can compare to available pre-construction values. We expect to continue measurements at the Farm and in the neighborhood for another several years in order to determine how year-to-year weather variability (snowy vs. non-snowy winters, warm vs. cool summers, dry conditions vs. wet conditions, and so on) may interact with the local climate to minimize or accentuate the ability of urban farms to help ameliorate the urban heat island.

The initial two months of summer measurements and four months of autumn/winter measurements are being analyzed and written up for a peer-reviewed journal (submission targeted for September/October 2015). This analysis also will be shared with the Frogtown Farm Board of Directors and the hosts of the neighborhood monitoring sites. In addition to ongoing monitoring as noted above, future plans for the project include involvement and mentoring of undergraduate student researchers, ideally through the Undergraduate Research Opportunities Program (UROP).
APPENDIX

Weekly average temperature differences, computed as neighborhood minus Frogtown Farm (FF). Positive differences indicate that the neighborhood site is warmer than the Farm site. Larger versions available at https://sites.google.com/a/umn.edu/klink/ff_uhi/seasonal_graphs.