1. ***Project Description*** *(Emma Courson and Dr. Trauger)*

The Season Extension on the Green Roof Garden grant project sought to research the feasibility of season extension in a green roof growing environment. Throughout the spring semester, the GEOG 4890/6890 Athens Urban Food Collective Class helped to construct season extension over the raised beds used for vegetable production on the roof, conducted research on the technologies, harvested and weighed produce and wrote parts of the research report. Students in the class worked with Emma Courson to construct 2 cloth row cover mini high tunnels, as well as 2 clear plastic mini high tunnels that covered the raised beds. Construction was begun on the cold frames; however, they were not used this season due to the warm temperatures by the time we began constructing them. Drip irrigation was installed for the whole garden and summer interns were secured to maintain the level of care the garden needs to continue to be a beautiful and productive part of campus and a refuge for pollinators.

The grant project contributed to the goals outlined in the UGA 2020 Strategic Plan, Strategic Direction III – Research, Teaching, and Service. The GEOG 4890/6890 class was engaged in the design, implementation and physical work involved in making this project happen. The students in the class learned many valuable skills including drip irrigation installation, data collection, season extension construction, transplanting, seeding, weeding and harvesting of vegetables, as well as soft skills including teamwork and effective communication. The green roof also embodies the goals within Strategic Direction IV of the 2020 Strategic Plan. The goal of building community within the context of the green roof garden has flourished as students, and community members, and local school groups have come to learn about the benefits of green roofs in an urban setting. Food insecure seniors within Athens/Clarke County have benefited from the grant project, as over 64 pounds of produce was donated to Campus Kitchen UGA. The green roof garden is dedicated to building community around healthy, equitable food system.

This project will take a break over the summer, as season extension is not needed due to warm temperatures. The cold frames will be completed in the fall semester and tested once the fall growing season is underway. Temperature monitoring will continue.

2. ***Project Expenses*** *(Emma and OOS)*

Personnel: $1,800 for summer intern

Equipment/Supplies/General Expenses:

May 22, 2018	Amazon.Com(drip fitting)	$9.85
May 22, 2018	Amazon.Com(gloves, shears, etc)	$221.60
May 22, 2018	Amazon.Com(table)	$54.99
May 22, 2018	Athens Seed Lawn & Garden	$186.88
May 17, 2018	Tranpak(Plastic Crate)	$103.70
March 30, 2018	Amazon.Com(UV plastic film)	$54.00

March 15, 2018	Contagious Grapics (stickers)	$31.50
March 9, 2018	Lowes(cedar boards/hardware)	$291.54
Feb. 27, 2018	Amazon.Com(plastic film, moisture meter, cable ties, etc)	$145.51
Feb. 21, 2018	Items for greenhouse (PVC)	$19.42
Feb. 21, 2018	Items for greenhouse (Iron Hangers)	$1.74
Feb. 21, 2018	Greenhouse Megastore (Cover)	$69.49
		$1190.22

3. Academic Impact *(Students in GEOG 4/6890)*

The Spring 2018 Athens Urban Food Collective Course under the direction of Dr. Amy Trauger learned about organic practices in agriculture related to season-extension technologies. The course taught students how to design and implement a plan, specifically regarding the installment of season extension technologies. Students enhanced their research skills through searching for the most effective season technologies. Students also gained experience with the inevitable trials and errors that come with an experimental project. Throughout the semester, students were also tasked with collecting both quantitative and qualitative data in a way that allowed progress to be tracked and conclusions to be made. Students learned learned organic gardening strategies that they will be able to take with them through the rest of their college years and beyond.

4. ***Research Value*** *(Research Group of 4/6890)*

UGA Green Roof History

Green roofs have many benefits including both environmental and economic impacts. The roofs help to absorb solar radiation in order to reduce urban heat island effects. Concrete surfaces absorb and release more heat, whereas vegetation helps to absorb and release cooled water vapor. So, green roofs help to reduce the amount of heat released by into the atmosphere. They also help to insulate buildings more than normal rooftops. During the winter, it keeps the building warmer which reduces the heating costs. Vice versa, in the summer it keeps the building cooler, reducing the need for air conditioning.

The Green Roof Garden at the University of Georgia was constructed in the 1960s on top of the Geography-Geology building. The space is 3,000 square feet. It was originally built to be utilized as a temperature buffer, but has since also been used as a garden run by students, volunteers, and professors. The garden includes pollinator flowers in order to help bee populations. Additionally, produce is also grown on the roof and donated back to Campus Kitchen at UGA in order to help food insecurity in the Athens community.

Types of Season Extension Technologies

There are several different types of season extension technologies including sheet mulch, low tunnels and row covers, cold frames and high tunnels. We chose to implement low tunnels and cold frames on the roof because they are scalable to the small size of our operation, relatively inexpensive and manageable to build and move by one or two people. Each has its own pros and cons, which are discussed below.

The first type of season extension technology is low tunnels and row covers. Low tunnels/row covers are light, porous, permeable fabrics placed over plants in order to retain heat. They can offer up to several degrees of frost protection, as well as protection from wind and insect pests. In comparison to sheet mulch, low tunnels/row covers require less time and skill to install. Additionally, materials can be reused for several years, so low tunnels/row covers are a sustainable season extension technology. Furthermore, low tunnels/row covers are often more portable than high tunnels. Finally, row covers are "scale-neutral" and can work well for crops of different sizes (Coleman,1999). Some of the cons for low tunnels/row covers are if damaged, pests can enter and they must be repaired, which requires additional resources. Additionally, the type of plastic used determines how much light and moisture can enter and and how much insulation is received. The more durable a plastic the more cost intensive the project will be. Also depending on the design, it could be difficult to harvest frequently under low tunnels/row covers. (Coleman, 1999).

The second type of season extension technology is a cold frame. Cold frames are transparent-roofed enclosures, built low to the ground, used to protect plants from cold weather. Cold frames are more typically found in home gardens and on smaller vegetable farms. They are most often used for growing seedlings that are later transplanted into the field (Coleman, 1999). One of the benefits of cold frames are they are often the smallest, simplest and least expensive type of season extension structure. Cons include they can be heavy and easily damaged.

Project Methodology

The methods used for our project directly addressed our research objective to see if the use of various season extension technology could increase vegetable production yields. To test this question, we chose three season extension technology equipment. These included 1) a plastic mini high tunnel, 2) a mini high tunnel with penetrable floating row cover, and 3) a cold frame. There was a total of eight raised beds used in this project. Two beds were used for each of three types of season extension, and two additional beds without any season extension technology. However, due to unplanned circumstances due to delays in acquisition of building materials, extensive pre-implentation work and the early warm weather, we were unable to build the cold frames to include in this report. They will however, be constructed in the Fall Semester of 2018 and will be used throughout the following winter. Thus, four beds were uncovered and the other four had the two types of season extension technology.

Our methods involved four steps. These included preplanting setup, building of seasonal extension equipment, planting, and analyzing and assessment throughout growing and harvest period. Our assessment was completed weekly following the initial planting of the seeds until harvest. The entirety of this project was conducted in a four month time frame.

Step 1: Pre Planting setup

- Methods: Preparation of rooftop garden raised beds which included:
    - Repairing wooden frames of the beds
    - Weeding
    - Mulching
    - Installing of piping irrigation system throughout the raised beds
- Purpose: It is important to prepare beds with high soil quality/nutrients before planting. In addition, due to the use of season extension equipment, proper irrigation methods need to be followed to ensure adequate amounts of water are being delivered to the plants.

Step 2: Building of seasonal extension equipment:

- Mini High Tunnel: Plastic
    - This technology was built using ½ inch PVC piping that was bent over the raised bed to form a half circle. Brackets were used to hold the PVC pipe onto the wood around the bed. Three of these half circles were built on each bed. Then, plastic row cover was placed on top of these half circles to completely cover the bed. Zip ties were used to tie down the row cover on the PVC pipe.
- Mini High Tunnel: Penetrable row cover
    - This season extension technology was also built by placing half circles of PVC pipe over the garden beds. However, instead of a placing a plastic covering over the PVC pipe, a penetrable row cover was placed on top and zip tied to adhere the covering on the PVC pipe.

Step 3: Planting

- Methods: Collards, kale, and radishes were placed in each of the beds. The plant type and size used was uniform among all beds.
- Purpose: These plants were chosen due to their durability in cooler temperatures.

Step 4: Assessment throughout growing and harvesting

- Methods: The assessment of crop growth was conducted throughout the duration of the growing season. First, the temperature inside of the row covers and outside temperature was closely monitored to not overheat the plants. Plastic covers were removed if 60 degrees F outside or 70 degrees F inside the covers. Secondly, each week following planting, measurements were taken of each of the plants. Multiple measurements were taken on each individual plant and then the average was taken of these measurements. Lastly, following harvest, the weight of each crop from each individual bed was taken using an analog scale.

Step 5: Analysis

- After recording crop growth and production, the total crop height and weight was compiled for each type of season extension technology used. The two types and the control were compared with each other to see if the use of season extension technology did in fact improve vegetable production.

<u>Notes from followed methodology:</u>

- Plastic mini high tunnels: Only one bed was able to be covered with the plastic for this growing season instead of two beds.
- Penetrable row covers: Two beds were covered with this row cover. However, this material was not able to withstand the wind and was constantly being blown off throughout the growing period. In addition, this material tore and sustained damage.
- Analysis: Soil temperature was unable to be measured due to data loggers only measuring soil pH instead of soil temperature.

- Three kale plants died throughout the growing season under the plastic mini high tunnels.

*5. **Engagement** (Emma)*

Partnerships formed and enhanced through the project: Our partnerships with UGArden, Campus Kitchen UGA, and the Office of Sustainability were enhanced and strengthened as we worked together throughout the semester. The partnership formed with the GEOG 4890/6890 students was invaluable in accomplishing all that we did this semester. We also partnered with Dr. Grundstein in the Geography department for the use of temperature sensors and a data logger.

Beneficiaries of the project: This project directly benefited the seniors in Athens aided by Campus Kitchen UGA who received the produce grown (64 pounds) on the roof in the form of produce bags or prepared meals. The food grown on the roof was donated to Campus Kitchens who then distributed it to their clients, thus fighting food insecurity and hunger within our community.

Ways the grant project was featured: The grant project was featured through the Green Roof Garden's Instagram page, the Office of Sustainability Instagram page and website (via a video that the FMD communications intern, Becca Wright made) and at the Semester in Review event put on by the Office of Sustainability. A poster was presented at the Semester in Review event where over 100 people were present. The poster will hang in the Department of Geography to continue to educate people about the roof and our work. The garden's Instagram page experienced an increase in the number of followers this semester, reaching over 200 followers as the semester progressed.

*6. **Project-specific Metrics** (Assessment Group of GEOG 4/6890)*

Measurements:
The Assessment group took on the responsibility of deciding what to measure and when, and directed data collection for the project. We measured the growth of plants, the light and moisture of raised beds using guidance from these resources (light measurement chart, soil moisture measuring), produce grown, and the measure of qualitative difference in crops (flavor, size, discoloration, disease).

Methodology (Quantitative and Qualitative):
We compared the growth of plants in centimeters between beds of different season-extension technologies. We used a light and moisture sensor to compare between raised beds.We weighed the produce harvested per bed in pounds and compared the weights between beds with different season-extension technologies. We reached families through Campus Kitchens. We collaboratively assessed the taste and health of the plants in each of the beds with two different season extension technologies.

Results:
The technologies we used were relatively easy to assemble for one person with some help. However, the extension technologies were not as durable, nor as effective as we would have

liked. Our first observation was that the fabric cover was not a viable option on the roof because of the high winds. The plastic low tunnel was effective with cooler temperatures, but quickly suffocated many plants as temperatures rose and three kale plants died. The rooftop presented challenges to assessing the efficacy of each of the technologies and given the time frame of our semester, we missed part of the winter season that the season extension technologies would have been most useful. Specifically, the plastic cover most likely would have yielded high results had it been installed in late fall and removed in early spring. The fabric cover was also unable to stand the winds present on the rooftop, resulting in the conclusion that if high or even moderate winds are present, the fabric cover will likely be ineffective. We were not able to assess the usefulness of the cold frame.

The total of our first harvest on April 5th was 18 pounds which consisted mainly of radishes and greens. This varies greatly from our second harvest on April 17th on which we harvested 46 pounds of combined produce. Bed 8 which was uncovered yielded the highest amount of produce with 7.3 pounds of produce; however, Bed 2 which had a fabric cover yielded 7.2 pounds of produce. Beds 4 and 5 which used plastic covers yielded similar, but lower amounts at 6 pounds and 6.8 pounds, respectively; the covers were installed earlier on Bed 4 which may explain the lower yield of produce. The plastic cover on Bed 5 was only in place for about 2 weeks which we believe is the reason it yielded more because it was not in place long enough to make a large (negative, in this case) impact on the plants.

Interpretation:
We believe the plastic cover would have worked better if installed in the late fall and removed in the beginning of spring due the rapid temperature increase in the spring. It's clear from the project that plastic is too intense for mid to late spring season extension on the roof, and perhaps the implementation of plastic November to February will have the most benefits. Heavier fabric row covers could be tried to mitigate the damage from win, although this needs to be balanced against light and moisture concerns. We will assess the usefulness and effectiveness of cold frames using the above methodologies in the winter of 2018-19. The implementation of mulch to insulate the plants and prevent growth of weeds would also be beneficial prior to the beginning of a similar project, and will be conducted in the summer and fall of 2018.

7. Photo / Video Documentation

Photo 1: Radishes on April 5, 2018 (Photo by Aileen Nicolas)

Photo 2: Harvest from April 5, 2018 (Photo by Aileen Nicolas)

Photo 3: Broken fabric cover from strong winds from March 20, 2018 (Photo by Aileen Nicolas)

Photo 4: Fabric Cover/Season Extension Technology from March 29, 2018 (Photo by Aileen Nicolas)

Photo 5: Plastic cover/Season Extension Technology Showing Plant Mortality from March 20, 2018 (Photo by Aileen Nicolas)

8. Project Assessment (Emma)

Applying for a Campus Sustainability Grant proposal, and then implementing the project was an incredible learning experience. This was the first grant proposal that I had written and grant project I had implemented. The logistics of creating a plan for the project, obtaining supplies, and organizing work days with the GEOG 4890/6890 class, volunteers, and supervisors within the Office of Sustainability helped me gain stronger leadership skills, learn to explain skills/expectations more clearly, and learn the importance of flexibility for this type of project. Being in charge of a group of college students (peers) who are looking to you for explanation and guidance for installing irrigation, or seeding and transplanting crops into raised beds was a great responsibility and opportunity to lead and teach while working alongside the class. I also was reminded of the importance of community while working on this project. This grant project would not have materialized if it had not been for the students, volunteers, and supervisors engaged in helping and working alongside me. Truly, every hand that had a part in the project was a great help. I know that the experience of grant writing and project implementation is a beneficial skill to have as I pursue a career in sustainable agriculture.

Addendum: Due to the early warm weather and other delays we were not able to fully implement the entire research project within the allotted time frame. We employed the help of Dr. Andy Grundstein in the Department of Geography who installed continuous temperature data loggers for us which will record soil temperatures throughout the year. We will resume the project in the fall with the construction of the cold frames and with insights gleaned from Phase 1, described above. Emma Courson will continue to direct the project with community volunteers and we will conclude our research study at the end of her internship in the spring semester of 2019.

References

Coleman, Eliot. Four-season harvest: organic vegetables from your home garden all year around. White River Junction, VT: Chelsea Green Pub., 1999.
"The Green Roof Garden." Sustainable UGA. Accessed April 19, 2018. https://sustainability.uga.edu/greenroofgarden/.