Advancing sustainability, lowering ecological footprints, and educating the public using aquaponics.

1) Project Description

Provide a 1 - 2 page summary of your project with enough detail that reviewers will clearly understand your project goal(s), your approach, and how you expect your project to impact some aspect of sustainability on campus.

Abstract: In this project, The NCSU Recirculating Farms Club, proposes to advance sustainability on campus by having students learn how to install, grow, maintain, and collect data on a model aquaponics system for educational, research, food production, and outreach purposes. Aquaponics is a closed-loop food production method in which crops (*e.g.*, fish and lettuce) are grown together. Following the work of NCSU's renown Dr. McMurtry, we have chosen an easy-to-set-up and maintain aquaponics system. We propose to work with many student groups and departments to run, maintain, collect data on, give tours of, *etc*. the system. Although we will be self-sufficient and able to run the equipment ourselves, the Department of Applied Ecology will ultimately be responsible for the system. Once in place, the aquaponics model will have high immediate impact because we can immediately give tours to groups to educate them and the public about food needs, and how the practice works. This project also has long-term significant potential for high impact because as food grows over time, it can be shared with groups such as University Dining, local food banks, Food Recovery Network, *etc*.

A little about us: The NCSU Recirculating Farms Club (RFC) is an inclusive campus club that encompasses undergraduate students, graduate students, staff, and faculty from many departments.

The RFC mission is to further recirculating farm industries by providing a platform for learning practical skills, connecting undergraduate students with graduate students and faculty researching various aspects of recirculating farming, and to connect students to employers.

Brief introduction to aquaponics: Aquaponics is a closed-loop food production approach in which animals and plants are grown together. The RFC proposes to assemble, maintain, and collect data on an aquaponics system on campus using tilapia fish (*Oreochromis niloticus*), salad greens (*e.g.*, *Lactuca sativa*), and tomatoes (*Solanum lycopersicum*). Once the system produces fish and vegetables for consumption, the club will provide some of the products to University

Dining and food banks.

In a typical aquaponics system, tanks are filled with fish, and the tanks are connected to plant beds. The wastewater from the fish is routed through the plant beds. The plants act as filters for the soiled water. Once the fish waste is 'filtered,' the water then flows back to the fish, and is re-used. In this system, the fish waste provides complete nutrition to the growing plants. We will use an aquaponics system based on NCSU's Dr. Mark McMurtry's research system. Dr. McMurtry is renowned as having created a science of aquaponics in the 1980's (Suits, 2013). Although we will be self-sufficient and able to run the equipment ourselves, as a precaution, the Department of Applied Ecology has graciously agreed to ultimately be responsible for the system. (See Appendix A for MOU.)

Why tilapia, salad greens, and tomatoes? There are many species of aquatic organisms and plants that can be grown using the aquaponics approach. However, we propose to start with three species that are tried and true, and known to be successful – tilapia (*Oreochromis niloticus*), salad greens (*e.g.*, *Lactuca sativa*), and tomatoes (*Solanum lycopersicum*). Most aquaponics systems in the Northern Hemisphere use tilapia for several reasons. It is a hearty and healthy species that grows quickly and easily. Also, tilapia is available year-round (Davis, 2014). As far as lettuce goes, many campuses, such as University of Hawaii and University of Kentucky, have found them to be good growing companions to aquaponics fish (*e.g.*, Alko & Baker, 2009). Last, we've chosen to grow tomatoes not just because they are tasty and easy to grow, but because they often are the most sought-after food grown *via* aquaponics (Davis, 2012).

Advancing sustainability: One of the biggest mottos of the environmental movement is, "Reduce, Reuse, and Recycle." The aquaponics approach does all three. In order to feed the ever growing human population, we need to constantly increase the amount of food we produce. However, agriculture is the world's number one consumer of fossil fuels (Aquaponics UK, 2012). Once the equipment is installed, the amount of energy used with an aquaponics approach is significantly lower than that used in traditional agricultural methods (Damm, 2012). This addresses the "Reduce" component of the green motto. "Reuse" and "Recycle" come into play because the fish waste is reused, providing nutrition to the growing plants. In addition, almost no water is lost. Instead, the water is constantly being recycled through the system. This is a key point, as water shortage is a major global issue (Water Project, 2015). Growing fish and plants works toward solving another major world problem - hunger. If utilized properly, aquaponics practices could make the problem of wasting water obsolete, as well as feed the world.

Advancing sustainability on campus in a collaborative manner: We propose to offer our aquaponics system to students across campus for various uses. We envision engaging students from Agro Ecology, Chemistry, Applied Ecology, *etc*. to help monitor pH levels, temperature, and water quality. We hope to join forces with the College of Education and University Admissions to put the aquaponics installation on the tour circuit. We especially look forward to K through 12 students coming to campus to see the facility, and learn about innovative food production methods. We feel that Biology, Food Science, Biological Agricultural Engineering, Fish and Wildlife, Plant Biology, Landscape Architecture, Zoology, Urban Planning, *etc*. students could conduct labs and collect data on the fish, plants, equipment, and interactions among them. When the plants and fish are ready for harvest, we will invite students in programs such as The MBA in Entrepreneurship & Technology Commercialization, Design in the Food

System, Poole College of Management, Center for Environmental Farming Systems, Department of Agricultural and Resource Economics, and more, to conduct studies on the economic feasibility of our set-up.

2) Anticipated Outcomes/Impact: We anticipate having significant outcomes and impact. The immediate impact will be to advance sustainability education and outreach on and off campus because many students will participate in, and visit, the facility. This includes class groups, labs, campus tours, *etc*. Another significant impact will be to lower ecological footprints by providing locally grown products to the Farmer's Market, University Dining, and local food banks. Long-term benefits include providing a great resource for many research projects.

3) Project Benchmarking & Innovation: Have similar projects been implemented on other campuses? Why should this be done at NC State? Yes, similar projects have been implemented on other campuses. Please see detailed information below. Notwithstanding, there are still a lot of untapped research opportunities in aquaponics. Specifically, more research is needed into wastewater reuse and disposal methods for set-ups like the, "Recirculating Aquaculture Systems (RAS)." The current research of NCSU Applied Ecology graduate student and Recirculating Farms Club President and Founder, Paul Begue, on RAS wastewater treatment and its reuse potentials through aquaponics begins to address this need. Among other things, Mr. Begue is interested in the efficacy of aquaponics as an effective waste treatment method and supplemental income source.

List of Similar Projects:

- Cornell University - Floating Raft Hydroponic Bibb lettuce.
  Case Study: http://aesop.rutgers.edu/~horteng/floating_hydroponics.htm "Two full-time and one part-time greenhouse grower operate the facility and produce 945 heads of lettuce each day, seven days per week."
- Kentucky State University (Research Collaborator) - Graduate student, Andy McDonald (andrew.mcdonald@kysu.edu), is researching small-scale urban aquaponics and constructed wetlands for aquaculture wastewater treatment.
- Lethbridge College - Aquaculture Centre of Excellence - Charlie Shultz (Research Collaborator) was a graduate student at KSU. "Aquaponics has been a part of the college's Aquaculture Centre of Excellence (ACE) for about 13 years. The efforts show the beneficial relationship between fish and plants and demonstrate how the symbiotic relationship can provide a form of agriculture that minimizes water and energy use. The research and its results are getting noticed around the country and the world." http://www.lethbridgecollege.ca/news/all/lethbridge-college-named-one-canada%E2%80%99s-50-top-research-colleges

Why should this be done at NC State? This project is in line with the university's goals and mission. NCSU is a land grant university, and was recently named a Research Consortium by President Obama. The campus has a growing interest in sustainability and encourages inter-departmental collaboration. The university also has a renowned agricultural extension program with a large focus on aquaculture and innovations in farming. There is an increasing interest in aquaculture / aquaponics spanning from the at-home "do-it-yourselfers" to commercial farmers.

NCSU researchers and Recirculating Farms Club members, are approached *bi-weekly*, for information, advice, and/or collaboration on similar projects.

4) Metrics for Assessment: How will you measure and evaluate your project's success?

We will measure and evaluate the project's success in several ways.

1. The project's advancement of sustainability education and outreach on campus will be evaluated by recording the number of students that participate in the project. We will keep a log of every person (be they part of a group, with a class, on a tour, *etc*.) who enters the aquaponics facility, their affiliation, the purpose of the visit, the time entered and exited, *etc*.
2. We will collect data on the number of plant seeds and fish seedlings 'planted' *vs*. harvested.
3. We will record what happens to each batch of food harvested – whether we eat it ourselves, sell it at the Farmer's Market, sell it to University Dining, donate it to a food bank, *etc*.
4. We will keep track of any monies made from the sale of harvested foods.
5. We will feel successful when we see our data on pH levels, temperature, water quality, *etc*. and organism growth reach appropriate ranges.
6. We will keep track of the number, names, and types of research projects conducted by graduate and undergraduate students.
7. We will communicate our progress to the campus community 24/7 *via* blogs, a live camera feed, and other social media.
8. We will feel successful when we've communicated our project history and data to the larger community at the World Aquaculture Society's, Aquaculture America conference in Las Vegas February 22 – 26, 2016, and the Global Forums for Innovations in Agriculture March 9-10 2016 in ADNEC, Abu-Dhabi.

5) Cost Savings

Will the project result in cost savings? xYes □ No

If yes, what is the payback period?

The Recirculating Farms Club has identified numerous scalable options for producing food in a safe, pesticide free, energy efficient manner. Some of these options are tried and true techniques, yet many are just now becoming sustainable from a business standpoint. We have chosen to pursue the City Blooms Micro Greenhouses in combination with the educational aquaculture system for the ease of operation, portability, cloud based monitoring and control system and competitive 3-4 year return on investment (ROI). Not only does this proposed system create usable, local, healthy food in a sustainable manner by using, on average, 5-10% of water use of traditional agriculture, but the potential exposure and research opportunity to the campus community and beyond through the Blogging done by students and real time monitoring is enormous. Furthermore, by using aquaponics to grow food, we are providing people with more local food options and therefore lowering the ecological footprint of the campus community.

6) Broader Vision: What potential does this project have for long term benefits to the campus community? Is there potential for your project to be scaled for broader community application? This project has great potential for long term benefits to the campus, and surrounding community, as well. It takes approximately 35 days for lettuce greens grown in an aquaponics system to be ready for harvest. It takes about nine months for the fish to grow large enough to be eaten. We envision organizing a schedule whereby we sell food to University Dining at designated times as well as get permission to sell food at the Campus Farmer's Market on Wednesdays. More importantly, surplus food will be donated to the many needy food banks and organizations on and off campus, including NCSU Feed the Pack (Food) Pantry, NC Food Bank, Food Bank of Central & Eastern NC, Inter-Faith Food Shuttle, Food Runners Collaborative, the Community Garden group, Food Recovery Network, *etc*. For now though, we will start small, by sharing our bounty with University Dining, who would like to use our salad greens at a handful of events. (See Appendix B for MOU.)

7) Project Milestone: Indicate your major project milestones including dates (month/year) of expected completion. The following are some of our project milestones.

Milestone	Time	Year	Notes
Visitor's Log	Day 1	1	All Facility Guests
Install System	Month 1	1	
Plant Seeds	Month 2	1	Repeat every ~35 days
Stock Fish	Month 2	1	Repeat every 9 months
Hire Students	Month 2	1	3 Undergrads (2 Sci. Ed. & 1 PR)
Harvest Produce	Month 3	1	Repeat every ~35 days
Start Tours	Month 4	1	
Farmer's Market	Month 4	1	
Food Banks	Month 6	1	
Harvest Fish	Month 9	1	Repeat every 9 months
Conference	Month 12	1	

Note: Data will be collected daily on pH levels, temperature, water quality, *etc*., as well as plant and fish growth.

8) Project Budget & Justification: What is the total project budget? What is your plan for sustained funding? ***Please include a detailed budget that includes each of the following categories: personnel, supplies and materials, travel, and other.***