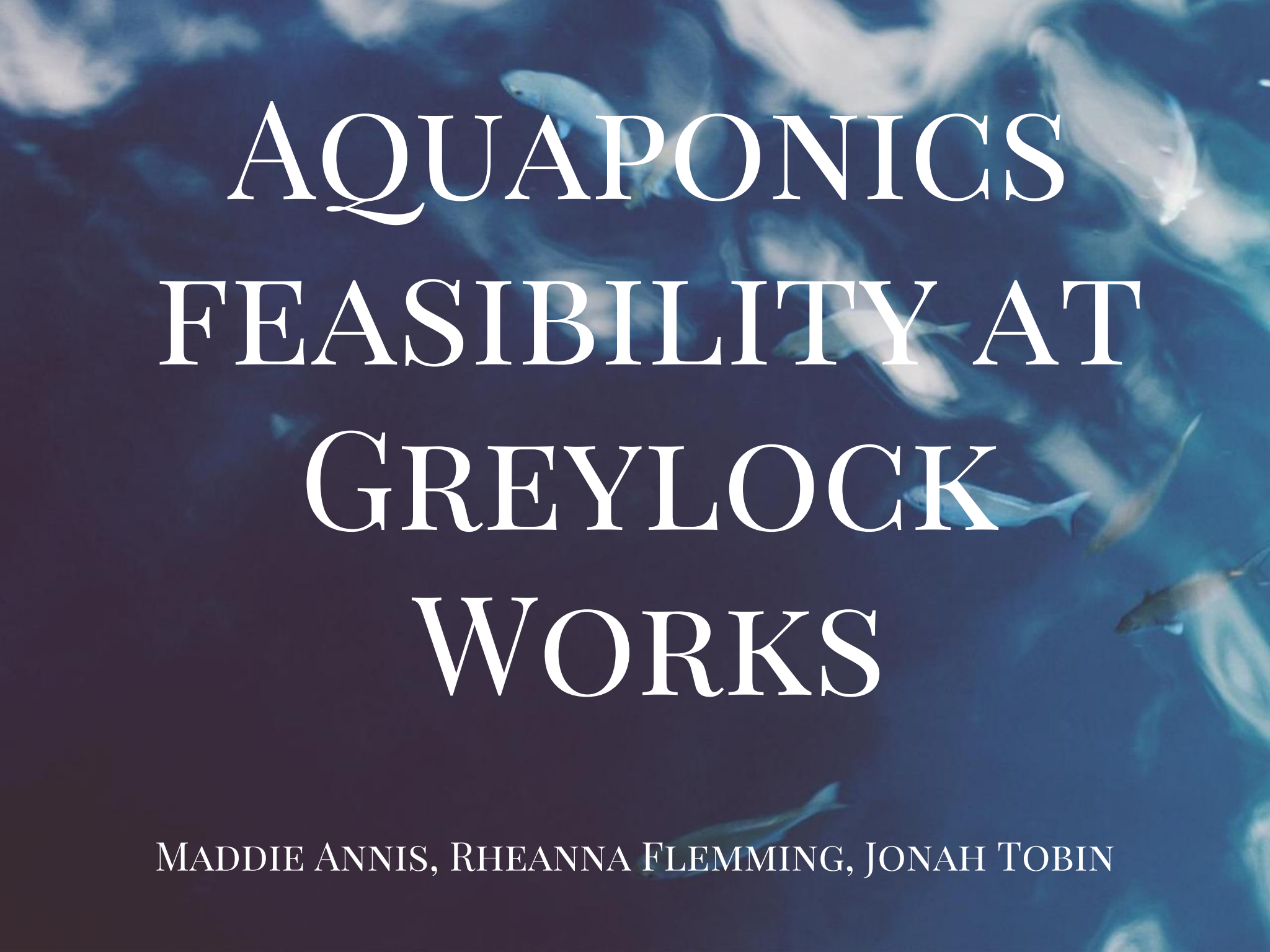


Aquaponics Feasibility at Greylock Works

Maddie Annis, Rheanna Flemming, Jonah Tobin

Project Outline:

Clients and Vision

Susan Abrams

Lee

Venolia

Aquaponics at Greylock Works (AGW) aims to bring innovative and sustainable fish and greens to the Berkshire area through a plastic-free aquaponics system.

Project Scope

- Interviews and site visits with aquaponics, aquaculture, and hydroponics facilities to inform feasibility of aquaponics in the region
- Investigate different business and operational models
- Additional market analysis, fish processing, and evaluation of the site at Greylock Works

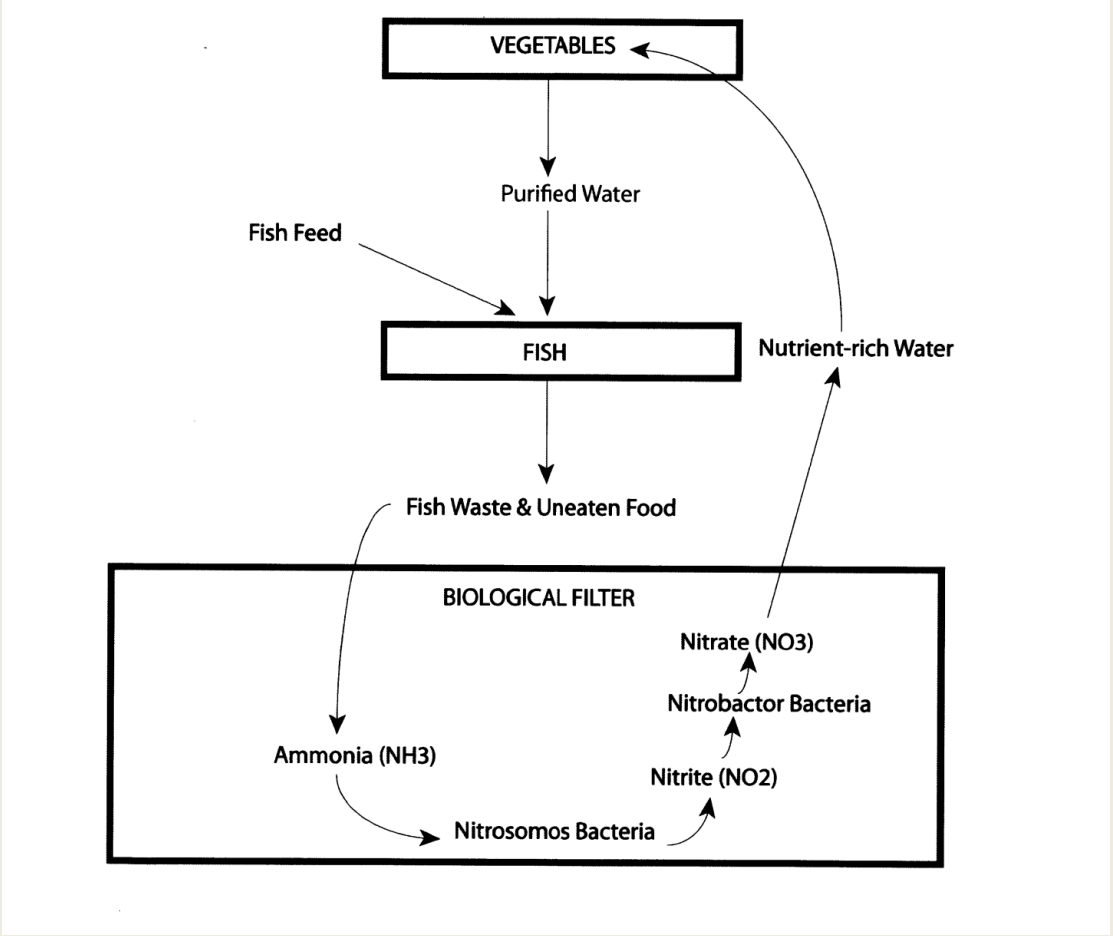
Greylock Works Site

- Greylock Mill was established in 1846 as a cotton goods production facility
- Sal Perry and Karla Rothstein purchased Greylock Mills in 2015. Mission of connecting events, arts, economic development, and with emphasis on food culture
- 100 x 100 ft warehouse that could support up to ~9,000 sq ft aquaponics
- Expected synergies:
  - Ownership support
  - Restaurants, CSA
  - Community design

Context and Background:

General Background

- Long history of aquaponics (Aztec and Chinese)
- Symbiotic relationship through nitrogen
- Filters can be natural filters using bacteria to facilitate reaction
- Developing case studies and research community



Aquaponics vs Aquaculture vs Hydroponics

- Hydroponics systems - only greens
  - Require fertilizer and nutrients often manufactured or processed using fossil fuels
- Aquaculture - only fish
  - Can be closed or open system (in ocean)
  - Loses revenue of greens
- Aquaponics - both fish and greens
  - Circular, symbiotic system
  - Control cleanliness of water and without pollutants
  - Conservation of water, energy, nutrients

Fisheries Collapse

- Overfishing could lead to a total collapse of global fisheries by 2050
- 80% of global fisheries are currently exploited, depleted, or in collapse
- Frequent topic among aquaponics facilities

Climate Patterns

- Rising temperatures
- Extreme weather events
- More intense wet and dry periods
- Changes in crop and livestock viability

→

- disrupted food availability
- reduced access to food
- reduced food quality
- reduced overall farm productivity
- harsh working conditions

PLASTICS

- Concern: Microplastics and plastic chemicals entering the aquaponics system and propagating through the fish and greens
- Microplastics accumulate in the food chain and our bodies
- Can cause inflammation & organ damage
- Promising research developments:
  - Biobiocarrier- Aquaculture growth media made of biopolymers for biological water treatment with no microplastics

Image Source: Nelson and Pade

Image Source: Hof University of Applied Sciences

Interviews:

Interviews and Site Visits

- Radix Ecological Sustainability Center
- Berkshire County House of Corrections
- Shushan Valley Hydro Farm: Shushan, NY
- Victory Aquaponics: Londonderry, NH
- 302 Aquaponics: Dover, DE
- Great Falls Aquaculture: MA and NH
- Sam Fleming, MCLA Vadnais Environmental Issues

Takeaways: Energy

- Terrascope (2022) found that energy can represent about 30% of total costs. Shushan Valley, The Lab, and 302 reported similar estimates.
- The Lab estimates they spend about $2500 per month on energy.
- Creative ideas: Shushan turns on their grow lights at night to get off-peak rates, Victory and Great Falls
  store tanks underground
- Some sites use green energy like
  Great Falls and MassMoCA. Increased
  support through federal grants, tax
  credits, and loan systems.

Takeaways: Scale

- Scaling up = better energy costs and a smaller ratio of open airspace that can affect temperature (40,000 sq. ft +)
- Commercial-scale aquaponics facilities are more likely to be profitable

Image Source: Superior Fresh, WI

Takeaways: Market

- Greens are generally easy to sell
  - Grocery stores
  - Farmers markets
  - Restaurants
  - Partnership with school system (302 Aquaponics)
- Fish are challenging to process, but once processed can sell to fish markets, restaurants, grocery stores

Takeaways: Labor/Feed

- Labor and feed costs tend to account for another huge portion of costs.
- Variability in labor but consistent pattern that time intensive and 24/7 on call Shushan Valley has a 18,000 sq. ft. facility with 4 full time and 3 part time
    - 302 Aquaponics has a 20,000 sq. ft. facility with 3 full time and 8 part time.
- Feed is another major input. The Lab and 302 are doing proportionately the same amount of feed

TAKEAWAYS: PROFITABILITY

- Greens constitute the bulk of profit in aquaponics
  - Fish make a negligible contribution to total profit
- Profitable facilities benefit from larger scale

- Challenges:
- During startup, high fish mortality, nutrient deficiencies, root rot can all increase costs (Engle & Beam, 2017)
- US Department of Agriculture plant hardiness zones 7–13 have been found more ideal for profitable aquaponics
  - 5a = Berkshire mountains

Secondary Steps:

Market Analysis

Wild Oats Grocery Co-Op

- Willing to consider partnership
- Needs processed and filleted fish
  - don't currently sell tilapia
- Could fill a void of fresh, local greens in the winter, especially basil

MEZZE
BISTRO + BAR

Mezze Bistro & Bar

- Low interest in purchasing aquaponic grown greens
- Purchase aquaculture steelhead trout but worried about marketing challenges for tilapia

Market Analysis

Williams College Dining

- Importance of scale, consistency, and safety
- Currently buys leafy greens from hydroponics Little Leaf Farms
- Fish come from all over but exploring a partnership with BerkShore to source from their fisheries
- Temesgen does not expect to be interested but would be willing to have further conversations

Fish Buyer Options

Fish Buyer/Processor	Background	Pricing	Ability to Sell Locally
Tai Huik	Fish buying company in Boston area to sell to Asian markets. Minimum pick up of 2,500 lbs	$5.50/lb for tilapia, $6/lb for rainbow trout, and $7.50/lb for barramundi	No
Sean Hilpi	Fish buyer who buys from the Lab and sells in local area and further. Minimum of 600 lbs	Pays $2.70/lb for tilapia	Not directly
BerkShore (Wes Malzone)	Fish processor in Boston who supplies Berkshire restaurants and markets. Would discuss possibility of transporting to process.	Unknown	Yes
Great Falls Aquaculture (Keith Wilda)	Aquaculture facility that mostly sells live but seems to do some on site processing. Potential for partnership.	Unknown	Yes

Grant Funding

- USDA Urban Agriculture and Innovative Production Grants Program
    - more sustainable, productive, and economically viable agricultural systems
    - Specific Calls for aquaponics on a year to year basis
    - $50,000 - $1,000,000 is awarded to individual projects
- Massachusetts Department of Agricultural Resources - Climate Smart Agricultural Grants
    - Great Falls Aquaculture's Cape Cod facility runs on 80% solar energy, partially funded by MDAR
    - up to $50,000

Feasibility and cost analysis:

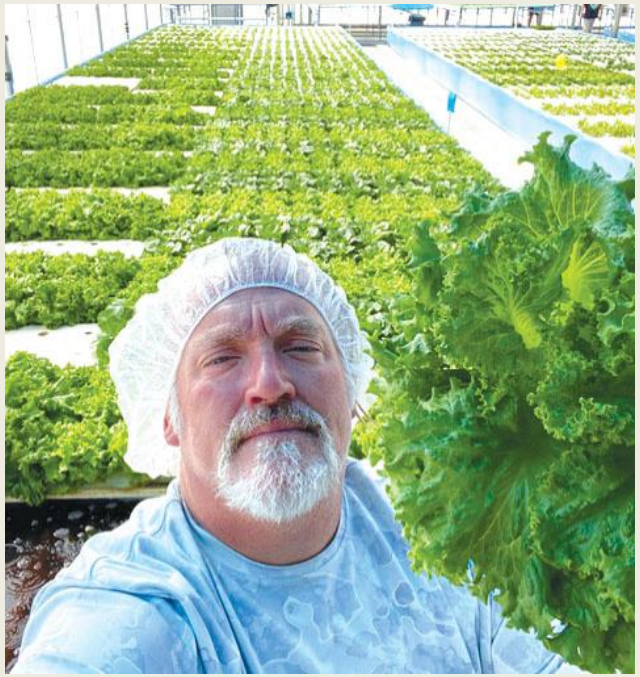
The Lab at Berkshire County Correctional Facility

- Educational facility
- 3600 sq ft greenhouse
- Four 1,000 gallon tanks, each holding 350 tilapia
  - sell 750 lbs of fish every 6 months
- 2 grow beds, 32 feet long, 16-24 feet wide
  - harvest 500 heads of lettuce per week
- Requires 3 full time employees to maintain

302 Aquaponics

- 20,000 sq ft greenhouse

- grows tilapia and varieties of lettuce
  - harvesting 300-400 lbs of unprocessed fish every 3 weeks
  - produces 1000 heads of lettuce/day
  - 3 full time, 8-10 part time employees



Rough Cost-Benefit Analysis

Cost Estimates	**Dollar Value**	**Total**
Operating costs without rent and labor	$100,000 x 2.5 (square foot scale)	$250,000
Labor (at least 2 full time and 5 part time employees). Using minimum wage and no benefits.	180 hours/week x 50 weeks/year x $15/hour	$135,000 (at $30,000 for a full time employee)
Rent	Unknown	Unknown
Total Costs		**$385,000 plus rent**

These rough estimates were done with numbers given during interviews. They do not represent business plans and should be seen as purely an estimation exercise.

Rough Cost-Benefit Analysis

Revenue Estimates		
302 Aquaponics	$500,000 x 0.5 (square foot scale)	$250,000
Total Estimate		**$250,000**
BCC Estimates		
Fish	750 pounds x 2 pick ups per year x $5/pound x 2.5 (square foot scale)	$18,750
Greens	500 heads/week x 50 weeks/year x $4/head x 2.5 (square foot scale)	$250,000
Total Estimate		**$270,000**

These rough estimates were done with numbers given during interviews. They do not represent business plans and should be seen as purely an estimation exercise.

Evaluation matrix

Fish								
Species	Temper-ature	Mainten-ance	Timeline	Market Price	Processing	Demand	Diet	Feasibility
Tilapia	68-75 deg	medium	1 lb in 7-8 months	$5.50/lb live, $12/lb fileted	sold live to be processed	generally low, but might be higher demand for aquaponic grown	fry fed algae, adults fed plant-based chow	High (low maintenance, high density, low cost diet)
Rainbow/ Steelhead Trout	50-68 deg	high	1 lb in 7-8 months	$6/lb live, $26/lb fileted	sold live to markets or to be processed	high, used as salmon replacement	carnivorous: meat-based trout feed	Moderate-low (high maintenance, high cost diet)
Barramundi	74-86 deg	high	2lb in 7 months	$5.85/lb live	sold live to markets or to be processed	high demand at Asian markets	carnivorous:- shrimp, small fish, crayfish, worms, pellets	Moderate-low (high maintenance, high cost diet, high water temp)
Koi/Goldfish	cold hardy	low	long lived	n/a (potential to sell ornamental)	n/a	n/a (how much demand if sold ornamentall y?)	catfish chow	Moderate (easy to maintain and feed, but slow growing and no market)
Carp	cold hardy	low	long lived	n/a	n/a	n/a	catfish chow	Moderate (easy to

Evaluation matrix

Greens			
Type	Grow Medium	Approx.Growing Cycle	Nutrient Intensive
Lettuce Heads (many varieties)	Floating	Short	Low
Herbs	Floating/ Seed bed	Short	Low
Bok Choi (purple or green)	Floating	8-11 weeks	Low
Basil	Floating	Short	Low
Kale	Floating/Solid	5-6 weeks	Low
Baby Sorrel	Floating or Solic	17-30 days	Low
Microgreens	Seed bed	Short	Low
Watercress	Floating/Seed Bed	Short	Low
Cucumbers	Solid	55 Days	High
Tomatoes	Solid	5 weeks	Medium
Quinoa	Solid	Months	Medium
Wasabi	Solid (clay balls)	Up to 24 months for full maturity	Low/Med.
Strawberries	Vertical	4-6 weeks after blossom	Med./High

Evaluation matrix

System	Size	Goals	Consumer Market	Mantenience	Labor	Plastic Involvement	Overall Feasibliity
Large For Profit	Full envelope (8000-9000 sq. ft)	Develop fresh, organic, low plastic use, high end greens and fish for surrounding communities	Restaraunts, Wild Oats, farm stands, farmers markets, Williams College	High, constant (24/7)	2 full time, 4-10 part-time workers	Fully necessary, needed to bring down costs	Very low feasibility
Large Non-Profit	Full envelope (8000-9000 sq. ft)	Develop fresh greens and fish for surrounding communities that have donation components to schools or pantries and teach about aquaponics farming	Restaraunts, Wild Oats, farm stands, farmers markets, Williams College, and donations	High, constant (24/7)	2 full time, 4-10 part-time workers	Highly probably, needed to bring down costs	Low feasibility (greater with labor looking to contribute without pay or no rent)
Small Non-Profit	~3000 sq. ft	Teach local students about aquaponics and the environment, incorporate local college students or volunteers into the farming process, and become a tourist feature for Greylock Works	Largely donation of greens to local schools and pantries, fish sold to processor	Potential for constant mantenience	2-3 full time workers	Variable, potential to demonstrate plastic free facility	Low feasibility (likely need no rent payments and some form of continous grant revenue)
Miniature, Demonstrative Non-Profit	~500 sq. ft	Teach local students about aquaponics and the environment and become mild tourist attraction	Potential for small personal buying, donations	Moderate (with use of hardy fish and greens), would still need daily check ins	2-3 part time volunteers	Unlikely (perhaps PVC for ease of use)	Moderate to high feasibility

Next Steps:

Small Educational Facility

- Proximity to Greylock Elementary School
- Allows for innovation, such as plastic-free equipment, soldier fly larvae, logoponics, ect... without the pressure of meeting production goals
- Has educational value for all ages, perfect for public schools and local colleges
- Produce could be incorporated with an in-house CSA, still meeting the goals of of food production within Greylock Works
- Opens doors to educational grant opportunities
    - 100 Gardens charges an annual partnership fee
- Potential to scale up!

Image Source: 100 Gardens Innovation Barn

Future Innovations and Need

- Aquaponics will only become more important to the fish and greens economy with the climate crisis impacting farms and fisheries
- Some businesses have new innovations in aquaponics that are proprietary
- Innovations like grow racks and enclosed fish tanks may make aquaponics more profitable
- Clients are working to address the limitations we identified

Image Source: 100 Gardens Innovation Barn

Thank you

Deeply grateful to all those who have supported us:

- Professor Sarah Gardner
- Clients Lee Venolia and Susan Abrams
- Partners Sal Perry and Karla Rothstein
- Numerous facilities, fish buyers, restaurants, and others who made time for interviews and were eager to support

Questions?