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Project OASIS: Optimizing Aquaponic Systems for Improved Sustainability

Making waves with *farm-scale* research.

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Agricultural Engineering Research Agenda

- Engineering addresses scalability
  - Scalable, modular designs needed for seasonal crop production
- Controlled environment agriculture
  - High tunnel production
  - Integrated agricultural systems
- Energy efficiency
  - Alternative agricultural energy sources
    - Anaerobic digestion for methane production (Methane → CHP)
    - Biomass for energy
  - Dynamic energy gain/loss models – Cost estimation for future investment
    - Sensitivity analysis
    - Principle component analysis (PCA)
- Nutrient capture and reuse
  - Reduced utilization of inorganically-derived fertilizers
    - Waste capture/reuse
    - Compost
  - Best Management Practices
- Multi-disciplinary approaches needed for agriculture

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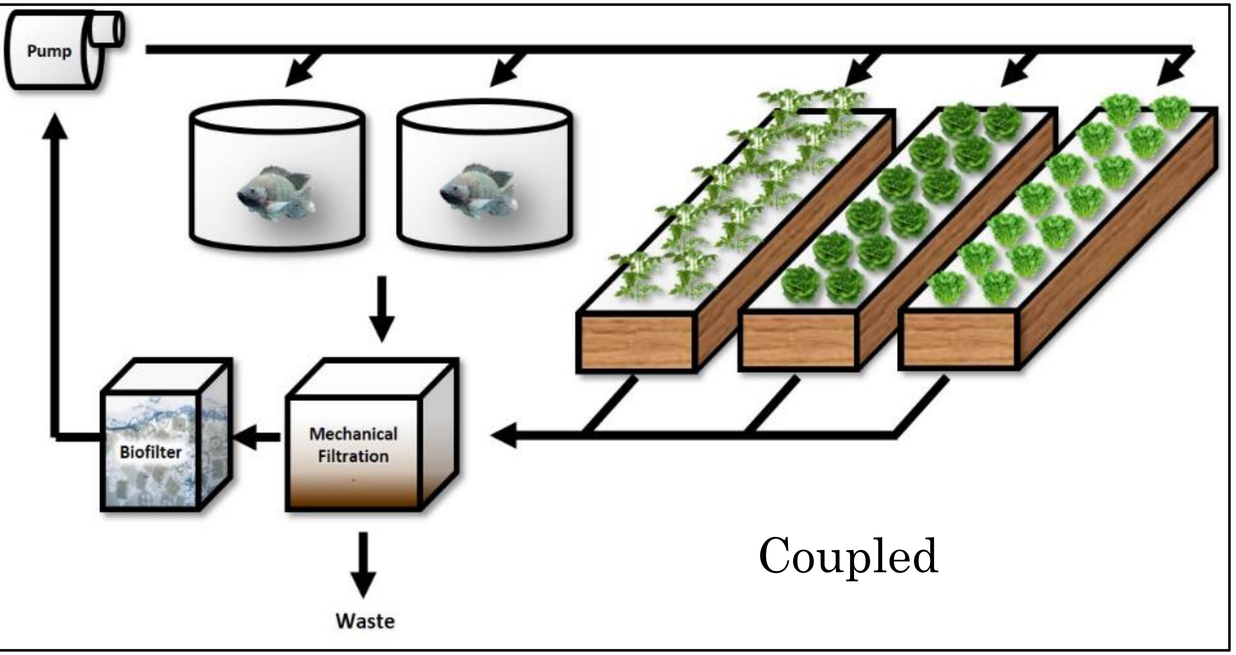
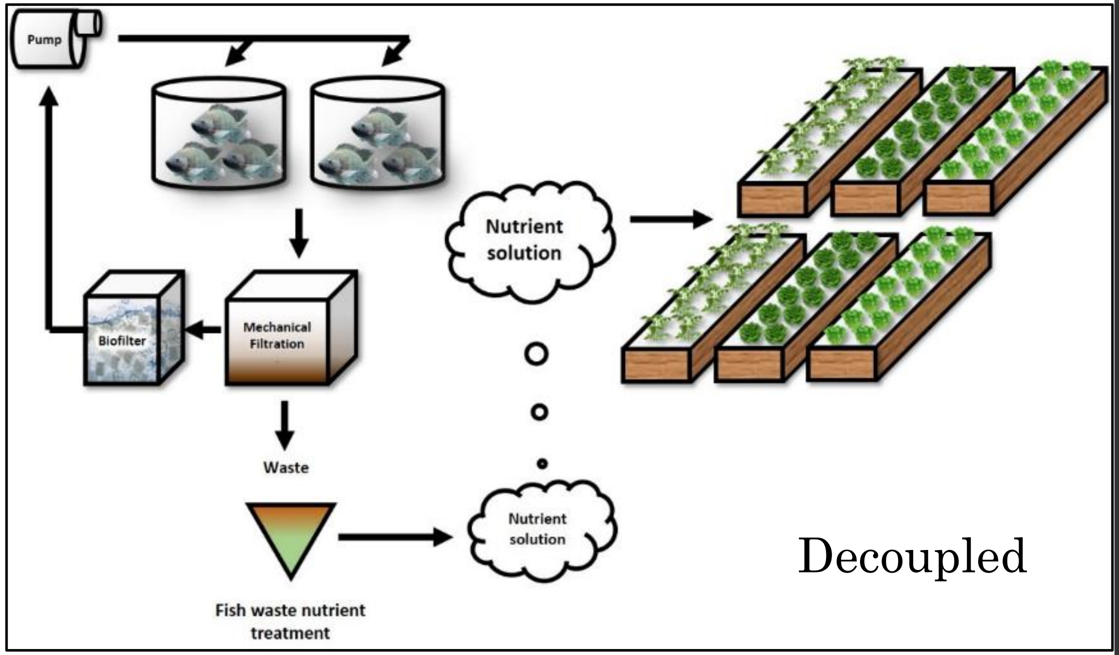
Aquaponic approaches





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The UNH Fish Barn

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Macfarlane Research Greenhouses

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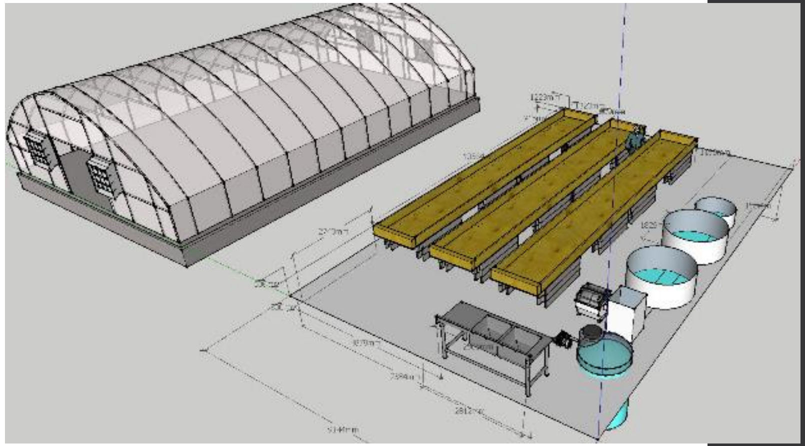
New Hampshire Agricultural Experiment Station

Recirculating Farm Greenhouses:
UNH Kingman Farm





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Opportunities in Aquaponics

- Improving sustainability of agricultural systems through treatment of aquaculture wastewater
- Economic and environmental
- Implementing hydroponics and aquaponics in both small and large scale farm operations in Northeast
- Naturally-derived nutrient solutions
- Opportunity to expand strawberry production through the use of CEA

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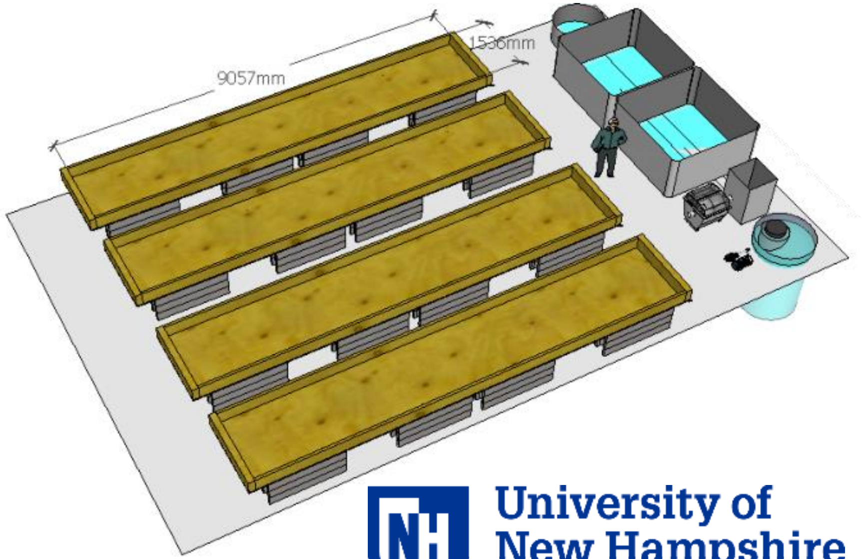
Recirculating Farm Greenhouses: UNH Kingman Farm

- Engineering scalable designs for year-round production
  - Integrated agricultural systems in high tunnels
- Nutrient mass balance: Capture and Reuse
  - Effluent (Waste) capture → treatment → reuse
- Food safety
  - Study microbial community profiles in unit processes
  - Validate product handling protocols (e.g. GAPs)
- Integrated Pest Management
  - Study disease progression, use of biocontrols
- Economics of integration (How much is too much?)



NH Agricultural Experiment Station

USDA

NIFA

Sea Grant New Hampshire

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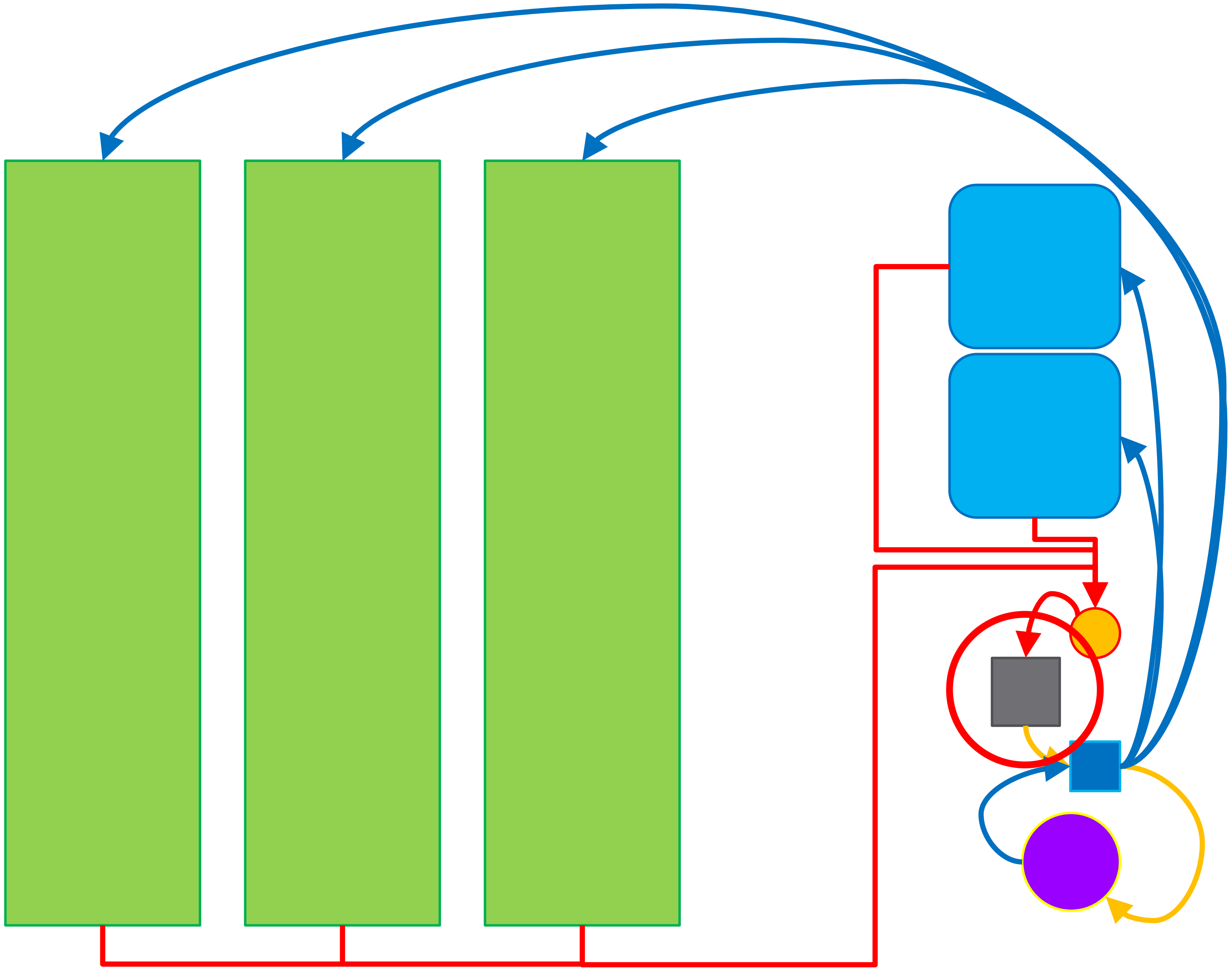
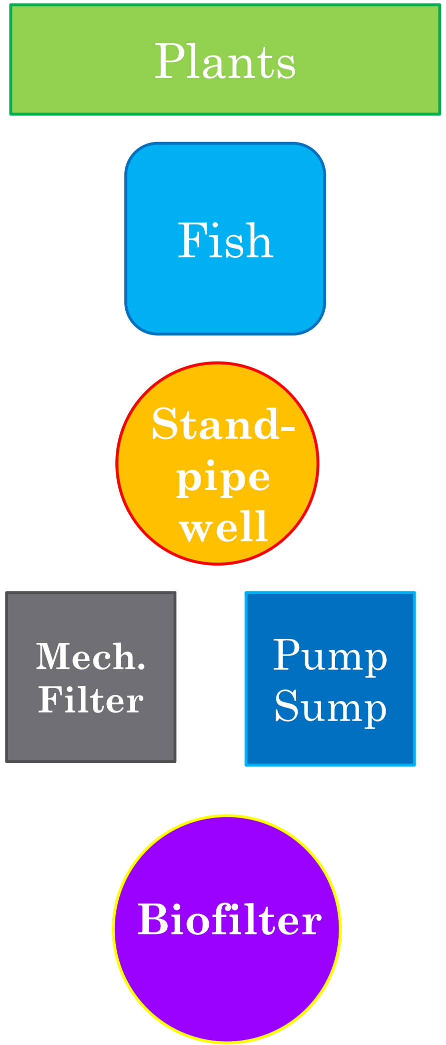
Aquaculture IS Agriculture

Production Unit Process Flow





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Nutrient Mass Balance in Recirculating Aquaculture

- Characterize nutrient flow
  - Inputs (Feed, well water)
  - Outputs (Fish, wastewater)
  - Sources/Sinks
- Predict nutrient mass flow from recirculating aquaculture systems
  - Scheduling plant production expectations
  - Structuring future treatment needs
  - Enabling improved nutrient (and water!) utilization efficiency

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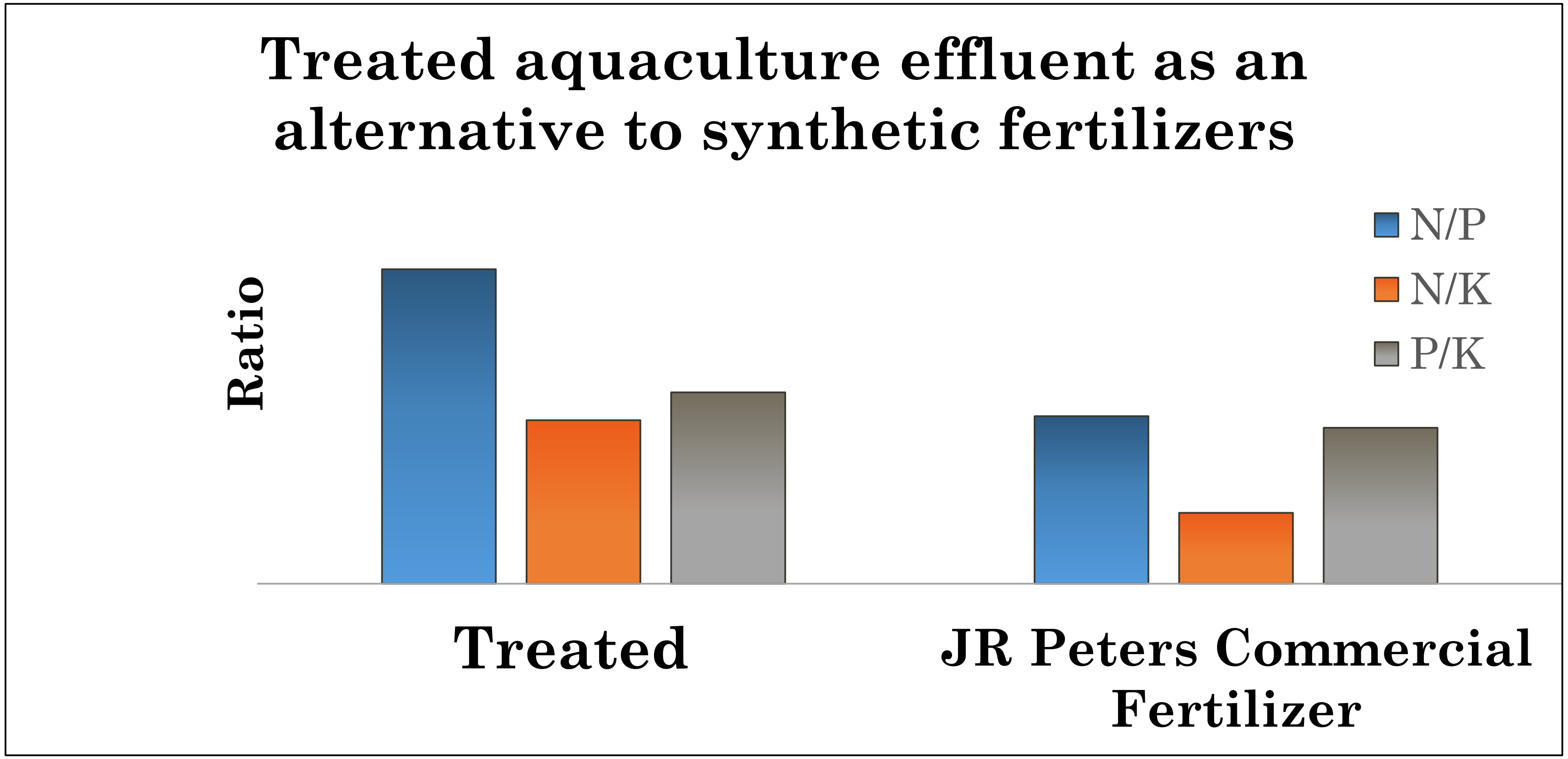
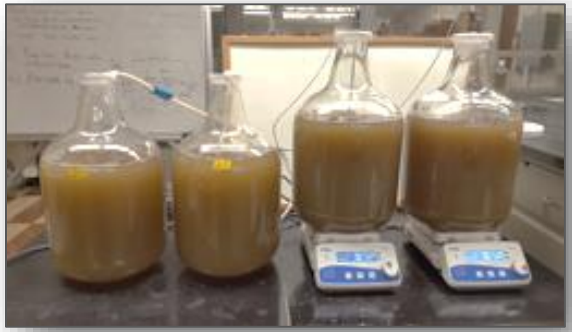
Relative Nutrient Availability





Treatment strategy analysis
Anna DeVitto

Treatment ***must*** address nutrient ratios required for plant growth – **Stoichiometry!**

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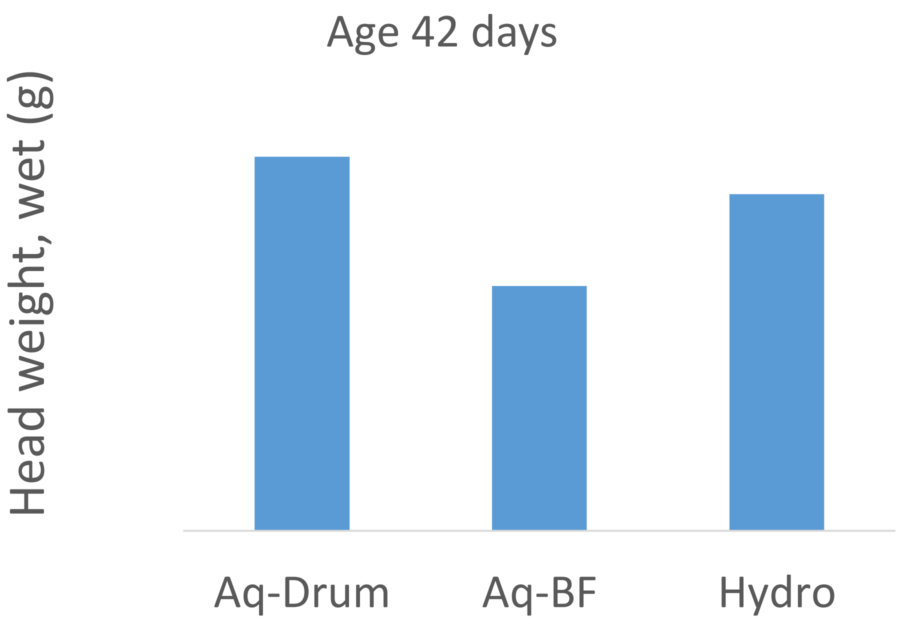
Is plant nutrient uptake affected?
{How much?!}

- Opposing optimal operating conditions
  - pH, temp (?), alkalinity (?), environmental (light)
  - Chemical/molecular ‘speciation’

  {Fe → DTPA}
- Relative plant-availability of nutrients
  - Based on different effluent handling strategies
  - Drum → Removal of solids < 15 mins
  - BF → Solids retained aerobically for 7 days



*Fall season, no supplemental lighting

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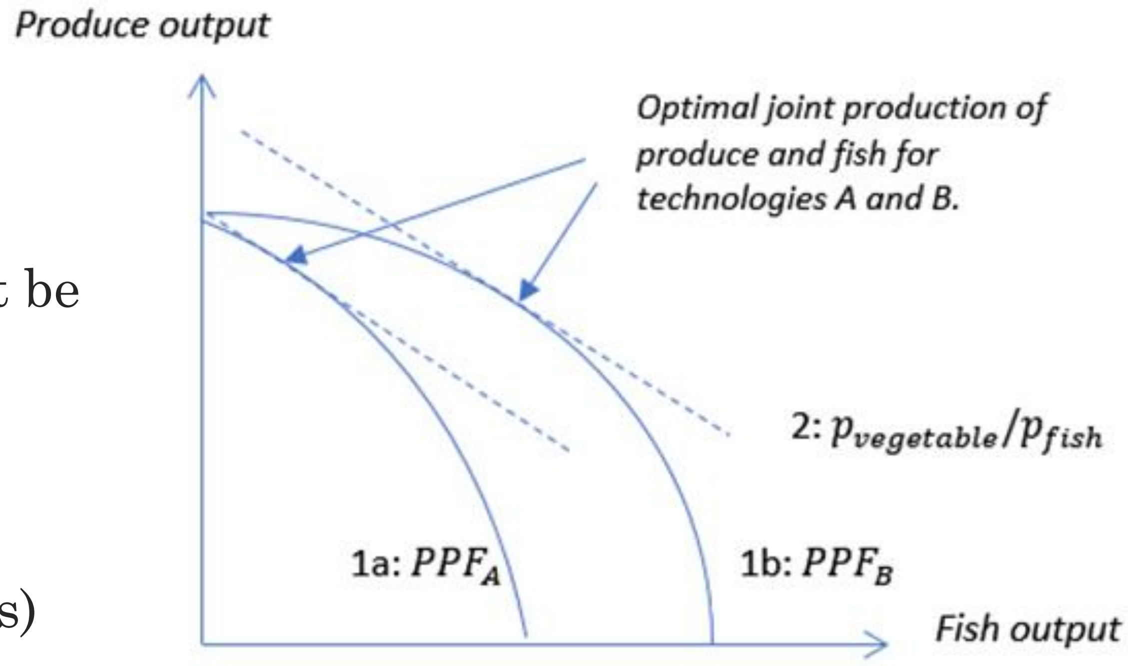
Economic Impact of Integration

- Economies of Scale vs. Scope
  - Margins increase with farm size
  - Balance of 'integrated-ness' must be achieved
- Cumulative Energy Demand
  - Proportional with system size
  - Integrated < ∑ (Separate systems)
- Potential reduction in:
  - Land use
  - Water footprint
  - Synthetic fertilizer



Courtesy of Dr. Shadi Atallah

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Strawberries in the Northeast

-USDA organic certification of hydroponics and aquaponics

-Climactic concerns (drought and flood stress, unpredictable weather)

-Expansion of market for Northeast strawberry production

Day-Neutral Cultivars

- Also known as indeterminate
- Ability to initiate flower buds under various day lengths
  - -(Insensitive to photoperiod)
- Require temperatures between 2°C and 29°C (36-84F)
- Year-round production using cyclical harvest model

Strawberry Nutrient Requirements

Hydroponic recipe	NO3-N	NH4-N	PO4-P	K	Ca	Mg	SO4-S
Yamazaki-strawberry (full strength)	70	7	15	117	40	12	16
Jensen-tomato (HALF strength)	95	0	24	175	100	30	58

Mg/L or ppm

-Significantly lower nutrient concentrations than most other greenhouse crops

-Target EC range varies greatly in research/commercial operations

-how will this translate to aquaponic growing conditions?

-minimal ammonia

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Characterizing nutrient inputs through analysis of synthetic and naturally derived solution and plant tissue

Cultivar x Substrate

- Similar yield results
- Quality (color, shape, firmness)
- Substrate (ability to effect pH- important for strawberries)
- Heat stress

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Effects of inorganic vs organic nutrient solutions on strawberry yields: 3 treatments

- Synthetically derived nutrient solution (targeting precise nutrient requirements for strawberries)
- Aquaponic effluent (average pH: 7.0-7.5)
- Aquaponic effluent (supplemented with phosphoric acid to reduce pH and increase phosphorus levels)

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Research Implications

- Improving the economics of ***year-round strawberry*** production in New England
- Premium prices for aquaponic growers
- Nutrient standardization for aquaponics
- Possibility of waste treatment designs in aquaponic systems to reduce waste and capture/reuse nutrients
- Improved yields of day-neutral strawberries

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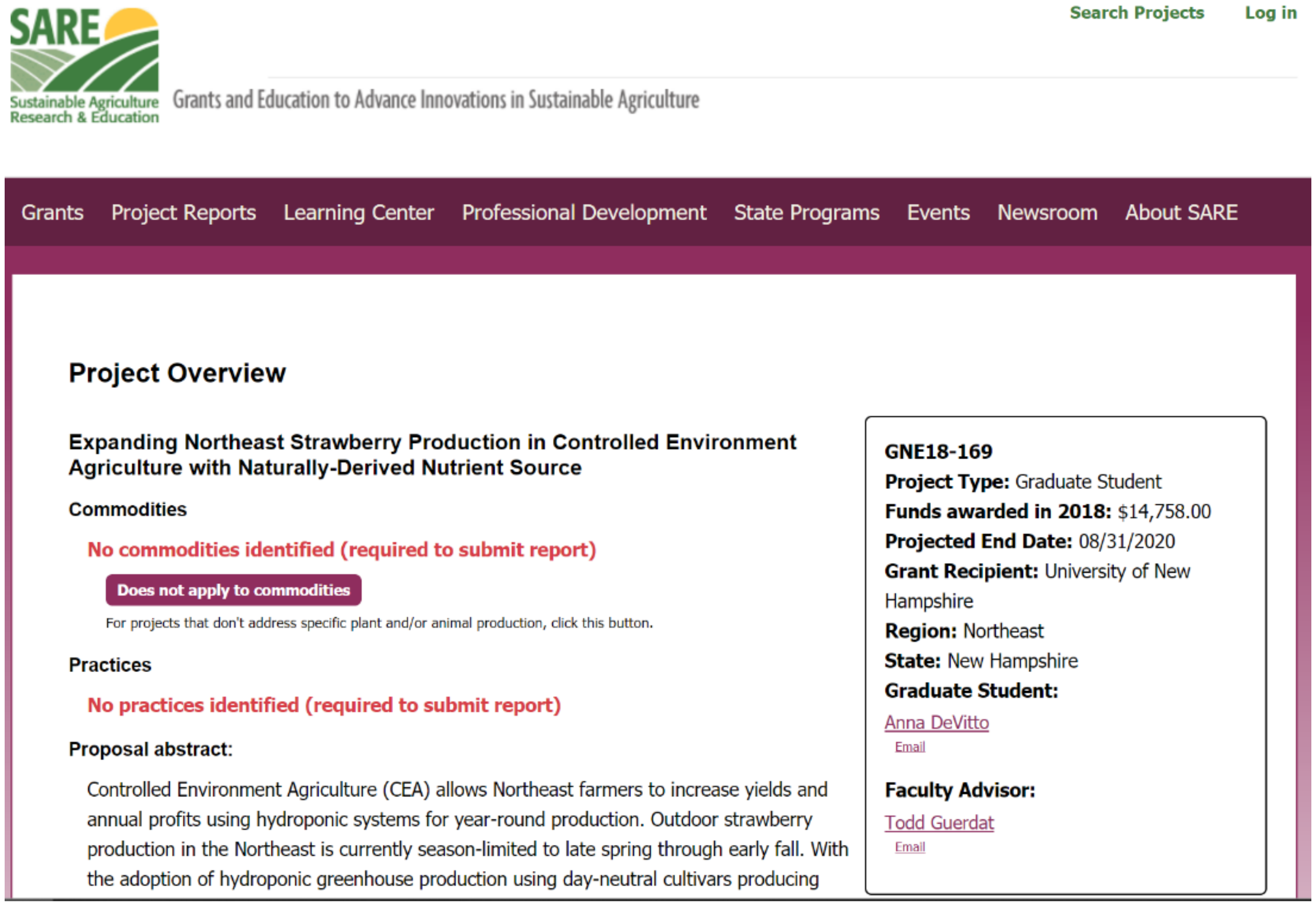
SARE Award- Research looking at light requirements for day-neutral strawberry cultivars

- Light levels (DLI) between 12-25 moles/m^2/d for greenhouse strawberry production
  - Mark Kroggel, Ohio State University
- May vary between cultivar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Project Overview

Expanding Northeast Strawberry Production in Controlled Environment Agriculture with Naturally-Derived Nutrient Source

Commodities

No commodities identified (required to submit report)

Does not apply to commodities

For projects that don't address specific plant and/or animal production, click this button.

Practices

No practices identified (required to submit report)

Proposal abstract:

Controlled Environment Agriculture (CEA) allows Northeast farmers to increase yields and annual profits using hydroponic systems for year-round production. Outdoor strawberry production in the Northeast is currently season-limited to late spring through early fall. With the adoption of hydroponic greenhouse production using day-neutral cultivars producing

GNE18-169
Project Type: Graduate Student
Funds awarded in 2018: $14,758.00
Projected End Date: 08/31/2020
Grant Recipient: University of New Hampshire
Region: Northeast
State: New Hampshire
Graduate Student:
Anna DeVitto
Email

Faculty Advisor:
Todd Guerdat
Email

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Integrating Production Research and Community Engagement

UNH Helps Feed Hungry With Generous Donation to NH Food Bank

SHARE

Thursday, November 30, 2017

DURHAM, N.H. – 'Tis the season for giving, and in that spirit, the University of New Hampshire donated 1000+ pounds of fresh fish to the New Hampshire Food Bank, a program of Catholic Charities NH. The 600 tilapia, which were grown through a sophisticated integrated aquaculture farming project, will be used to prepare meals for several of the Food Bank's feeding programs.

Todd Guerdat, assistant professor of agricultural engineering in the Agriculture, Nutrition and Food Systems Department at UNH, helps harvest tilapia to be donated to the New Hampshire Food Bank.

"We're really excited to see these locally-grown fish make a difference in solving the problem of hunger through the good work being done at the New Hampshire Food Bank," said Todd Guerdat, assistant professor of agricultural engineering in the Agriculture, Nutrition and Food Systems Department at UNH. "Over half of the world's seafood is produced from aquaculture yet eighty percent of the seafood we eat here in the United States is imported. It's nice to be able to contribute fresh food while working toward developing a sustainable U.S.-based aquaculture food production system."

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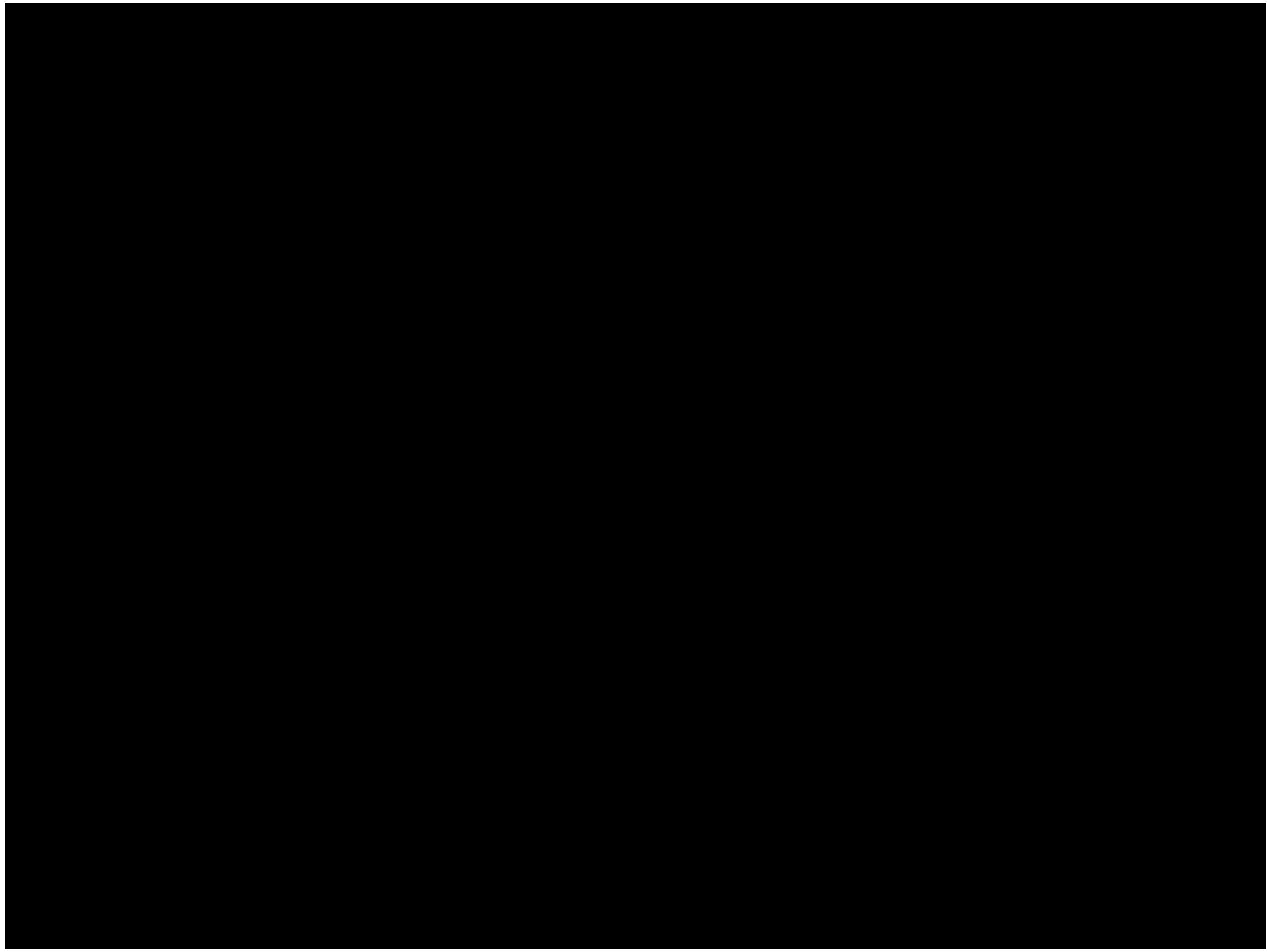
UNH Donates Food to NH Food Banks



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Questions?

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