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Ecology

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Project Summary

Complex Integrated Farming System is a design that expands upon a study on Nigerian Fish Farming systems by Gabriel, U.U. Using the successful elements of the farms researched in the journal as a base for the project, works by Earl E. Werner and group, Robert I. Clutter and group, Gillian Malin, and Ulrich Sommer were analyzed to inspire a refinement, and a further expansion of the farm to further maximize efficiency, and also cultivate a greater biodiversity of produce. Initial appeal for this project will be for researchers who are like-minded to those referenced in this summary, and want to begin experimenting at small scale farms in order to see the results of such an expanded integrated farming system. While this project is the conceptualization of a system, the target will consist of researchers who can calculate precise measurements of the scale of each habitat, and the frequency of interactions between each habitat. After researchers have calculated the precisions of the project, small scale farmers who wish to be become a more independent entity in the agricultural industry can begin to implement an expansion into the ***Complex Integrated Farming System***. Since all organisms in this farm is dependent to one another, the amount of outsourced materials will be minimalized. Researchers will also want to analyze the output of these farms, and the interactions of the organisms within the system.

In Gabriel, U.U's ***Economic Benefit and Ecological Efficiency of Integrated Fish Farming in Nigeria*** the farms have a nutrient cycle that flows between livestock, fish ponds, and crops. [1] The Complex integrated farming system builds and expands upon this. In the same research, it was discovered that pigs were the most appropriate for the system because their manure can be used as both fertilizer and feed for the fish. The diagram presents how there is a flow of nutrients going from the pig livestock to 3 different ponds and into the crops lands. Pigs and crops have a complete cycle of nutrients of their own where the manure from the pigs fertilizes the soil and the produce from the crops are used to feed the pigs. However, for the fish, the manure flows into the fish ponds but there is no return. Instead the fish feed on the manure, and then humus from their own manure, or compost become fertilizer for the crops, and then the produce of the crops flow back to the pigs. This is a cycle between three different kinds of produce.

The unique trait about this farm is that there are three different ponds, and each one provides a different kind of habitat. This is inspired by the research done by Earl E. Werner and Donald J. Hall's research, ***Foraging Efficiency and Habitat Switching in Competing Sunfishes***. The research concluded that rather than individual species living with their own separate habitats, individual species co-existing with their natural competitors in the same habitat are much more efficient at foraging for food, and result in larger growth of the species. Werner and

Hall's research used three different species of sunfish that live in the same lake and then put them all in different habitats. In a pond habitat with vegetation, sediment, and open water green sunfish were found to grow the largest and most abundant. In the habitats with sediments and open water, pumpkinseed sunfish grew to be the largest, and in habitats with only open water, bluegill sunfish were found to grow the largest. [2] Using three different ponds with unique habitats, and then cycling the 3 different species of fish within them, optimal cultivation of these three-different kinds of fish can be achieved. When the dominant species in each pond has matured a portion of those fish will be harvested. The unharvested fish species will then be moved to a different pond where they can continue to mature. For example, when a percentage of the green sunfish in the vegetation pond is harvested, the remainder of the fish in the pond will be moved to the open water pond habitat. There, the bluegill sunfish will continue to mature into their optimal growth and abundance, while the green sunfish will now be the sub dominant specie, and the pumpkinseed will continue to be a subdominant species until their next cycle in the sediment pond. An additional trait in the vegetation pond is that crops can also be grown in the vegetated portion of the pond. Whilst the main crop land can grow land based vegetables like tomatoes and cabbages and such, the pond vegetation can grow crops like rice. The research by Werner and Hall, focuses on sunfish species but it is hoped that this project will motivate researchers to explore if the ponds can also harvest 3 other kinds of fish species that also used to co-existing in their original habitats.

The next extensions to the farm are elements that the Nigerian fish farming system does not consider. One is a mysid shrimp farm based on the research paper ***Ecological Efficiency of a Pelagic Mysid Shrimp; Estimates from Growth, Energy Budget, and Mortality Studies*** by Robert I. Clutter, and Gail H. Theilacker; the other is a DMS (dimethyl sulfide) and DMSP (dimethylsulfoniopropionate) release pond based on ***Elevated Production of Dimethylsulfide resulting from Viral Infection of Culture of Phaeocystis Pouchetii*** by Gillian Malin. These two extensions are not to make produce for food, but instead provide maintenance for the farm, and also help solve some of the world's ecological issues. The mysid shrimp farm is designed to cultivate mysidae and have them spread into specific ponds that may have a deluge of nutrients. Excess nutrients cause algal blooms to form and deoxygenate the pond and create dead zones. In order to prevent this from happening, a self-sufficient farm needs to cultivate mysid shrimps that can flow into the pond and feed on the algal blooms and clean up the ponds. The mysid shrimps were specifically selected for their ecological efficiency of 32%. [3] Since such a high percentage of the energy they consumed can be transferred to their predators (in this case the sunfish), they are a valid selection for cleaning up the ponds. However, they must also be cultivated in separate pond because they can also eat nutrients from manure and crop fodder. Farms do not want them to grow to an abundance that is a hindrance to the growth of the sunfish.

The DMS and DMSP release pond is implemented because of its potential to help lower the earth's temperature. DMS and DMSP are critical in cloud albedo formations. These clouds are low hanging and reflect the suns radiation back into space hence reducing the earth's constantly rising temperature. DMS and DMSP are released from a phytoplankton species called Phaecystic Pouchetti. This specie will be the organic specie growing in an open water pond. When enough of the phytoplankton species have grown, farmers will then flow viral lysis into the pond. Viral lysis will react with the phytoplankton specie to break them down and cause them to release the DMS and DMSP stored within the Phaecystic Pouchetti communities and into the atmosphere. [4] The Phaecystic Pouchetti need to be grown in a separate pond due to its potential to suffocate fish and crop stock. The viral lysis will be sourced from researchers and engineers who will provide this resource in return for access to the farms for research.

Complex Integrated Farming System is a concept to inspire a shift in modern agricultural practices. It has the potential to minimize the use of synthetic fertilizers, increase the independence of individual farmers, and stabilize the rising climate of the earth. It is a design that will call for researchers and engineers to collaborate together to scale the size and abundance of each habitat for an optimal cycle of nutrients in the farm.

Annotated Bibliography

Source 1

Economic Benefit and Ecological Efficiency of Integrated Fish Farming in Nigeria

http://www.academicjournals.org/journal/SRE/article-abstract/5BFC76A13413

Gabriel, U.U., Akinrotimi, O.A., Bekibele, D. O., Anyanwu. P.E. and Onunkwo D.N. 2007. Economic Benefit and Ecological Efficiency of Integrated Fish Farming in Nigeria. *Acadeic Journals, Scientific Research and essay*. 2(8):302-308.

"Economic Benefit and Ecological Efficiency of Integrated Fish Farming in Nigeria" by Gabriel, U. U. is an interesting analysis a new agricultural system that has been implemented in Nigeria in order to meet the needs of its rising population. Fish farming is a combination of mixing fish culture, with livestock, and crop production. This is a revolutionary method that allows various types of food available year-round, self-sufficient farmers, recycling, and maximum use of resources without waste.

An example, is the Pig cum poultry farm. A pig farm is near a pond, and the manure produced by the pig is used to fertilize the soil in the pond. With the fertilized soil, crops can be grown, and the fish can be used to feed the pigs. This method has proven to be 28% more economically advantageous than normal pig farming methods.

This report is important because it provides a successful form of ecological sustainable agriculture that is more economically and ecologically beneficial than standard farm practices elsewhere. Practices like these show evidence that an integrated system of production may be a possible solution to other forms of production that will use the integration within other ecological communities to build an ecologically friendly system of production.

Source 2

Foraging Efficiency and Habitat Switching in Competing Sunfishes

http://www.jstor.org/stable/1937653?seq=1#page_scan_tab_contents

Werner, Earl E., Hall, Donald J. 1979. Foraging Efficiency and Habitat Switching in Competing Sunfishes. *Ecology*. 60(2):256-264.

Earl E. Werner and Donald J. Hall's experiment reports the competitive interactions between 3 congeneric species of sunfishes. When segregated from one another, all three species survive through the same vegetation, and sediments. However, they differ in their efficiency when surviving in different habitats. The experiment focuses on how each specie's use of a habitat will alter the habitat, and also, how each species will behave when the researchers place competitors to change the habitat for the different Sunfishes. The results of the experiment are important because it presents how the inclusion of competitors actually result in a more efficient ecosystem. When the three congeneric species were put together the green sunfish were found to be the most efficient at foraging through the preferred vegetation land. This forced the Bluegill, and pumpkinseed sunfish to forage through the open water and sediment habitats. This is significant because it indicates that instead of 3 congeneric species completely depleting resources from only one type of land, they instead move to other types of habitats and forage through a more diverse range of habitats to consume resources in a more sustainable and manageable method.

Source 3

Ecological Efficiency of a Pelagic Mysid Shrimp, Estimates from Growth, Energy Budget, and Mortality Studies

http://www.vliz.be/en/imis?refid=133119

Clutter, Robert I., Theilacker, Gail H. 1971. Ecological Efficiency of a Pelagic Mysid Shrimp, Estimates From Growth, Energy Budget, and Mortality Studies. *Fishery Bulletin. 69(1)*:93-114.

“Ecological Efficiency of a Pelagic Mysid Shrimp, Estimates From growth, Energy Budget, and Mortality Studies” by Robert I. Clutter and Gail H. Theilacker is a primary source that conveys an experiment conducted to analyze the ecological efficiency of Metamysidopsis Elongata. These are organisms like the Mysid shrimps, Crustacea, and Mysidacea. The experiment analyses the growth, molting, reproduction, respiration, body composition, and energy content in order to get accurate data.

The experiment has proven that while Mysid shrimps are lower in ecological efficiency to Zooplankton (which are organisms proven to be 30% to 50% efficient in their ecologically efficiency) they still prove to be 19% go 29% ecologically efficient, which is still 2 to 3 times higher than the ecological median. These results are important because it proves that there is a diversity of organisms that can play as crucial of a role as the zooplankton in expanding, and maintaining the food web, and ecological community. With the recent discoveries on the efficiency of planktons to process carbon emissions to a much greater quantity than plant organisms, there have been efforts to recover the depleted planktons around the world. By analyzing the efficiency of mysid shrimps, the world can have a much more diverse network of organisms that are extremely efficient at processing the immense carbon emissions the world is facing today.

Source 4

Elevated Production of Dimenthylsulfide Resulting from a Viral Infection of Cultures of Phaeocystis Pouchetii

http://onlinelibrary.wiley.com/doi/10.4319/lo.1998.43.6.1389/full

Malin, Gillian, Wilson, William H., Bratbak, Gunnar, Liss, Peter S., Mann, Nicholas H. 1988. Elevated Production of Dimethylsulfide Resulting From Viral Infection of Cultures of Phaeocystis Pouchetii. *American Society of Limnology and Oceanography*. 43(6):1389-1393.

Gilliam Malin presents a study that establishes the potential impact of a viral infection on dimethyl sulfide (DMS) and dimethylsulfoniopropionate (DMSP) concentrations in phytoplankton communities, more specifically, the Phaeocystis pouchetii. This phytoplankton is a vital element in the geochemical cycle of DMS, because they can be the primary producers for regions in polar and coastal regions. This is significant because they are resilient to human alterations in the region, and are correlated with the increased ultra violet light levels, and eutrophication. When DMS is oxidized into the hydrosphere multiple sulfur compounds are produced, such as, sulfur dioxide, dimethyl sulfoxide, dimethyl sulfone, mathanesulfonic acid, and sulfuric acid. The production of sulfuric acid is a particular interest for it drives the formation of clouds, blocks solar radiation, and reflects radiation back to space. This is significant to climate change, because it indicates a solution to cool the earth, and offset greenhouse warming. With such an important role in global climate change, Malin's results show that an increase in the centration of DMS by 4 times through infecting the Phaecystis Pouchetii with strain-specific viral isolate is crucial information.

Complex Integrated Farming System

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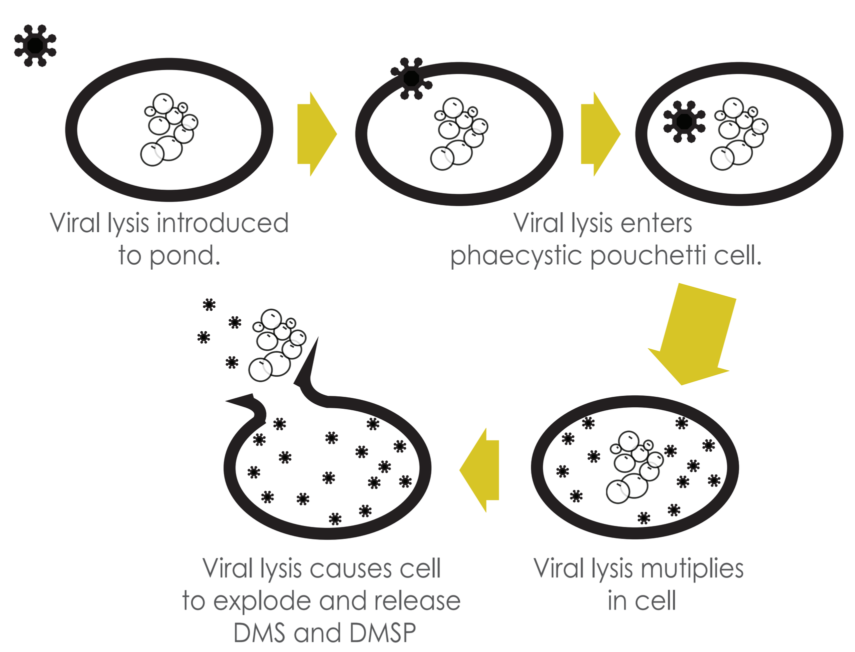
Production of DMS and DMSP

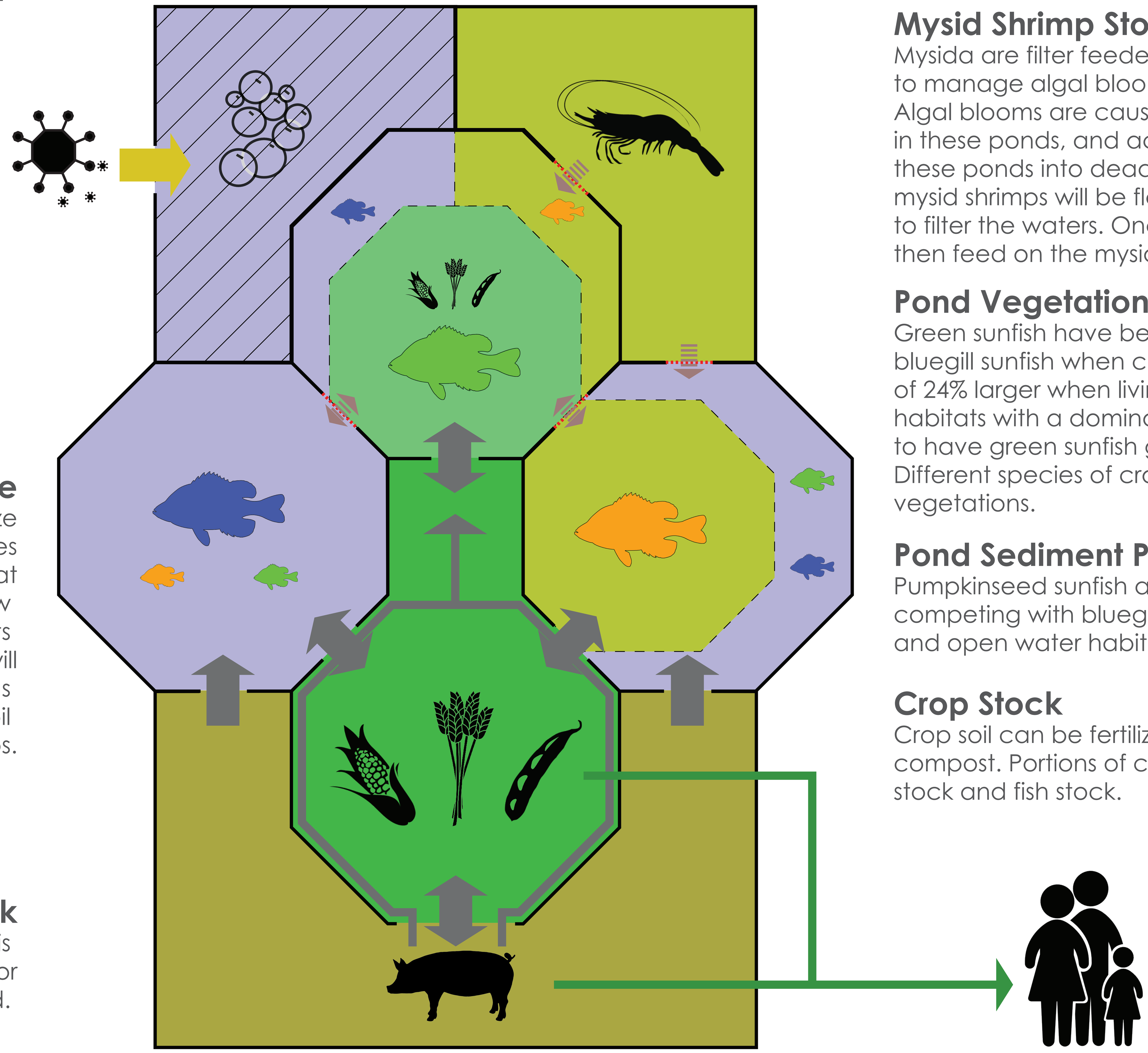


Open Water Produce

Bluegill Sunfish grow to their maximum size cultivated in compitition with its similar species in open water. Due to greater efficiency at foraging in open water it will outgrow all other species. Nutrients from pig's manure and and crops will flow into the pond to act as feed for fish , whilst fertilized soil from fish compost will be fed to the crops.

Pig Stock

Pig livestock are specifically selected for this farm because their manure can be used for both soil fertilizer and fish feed.



Mysid Shrimp Stock

Mysida are filter feeders. They are cultivated in order to manage algal blooms in the different fish ponds. Algal blooms are caused by the excessive load of nutrients in these ponds, and act as deoxygenaters that can turn these ponds into deadzones. In order to prevent this mysid shrimps will be flowed into the ponds in controlled quanities to filter the waters. Once the waters are cleared, the fish can then feed on the mysid shrimps for more nutrients.

Pond Vegetation Produce

Green sunfish have been found to grow 44% larger than a bluegill sunfish when coexisting with its rival species, instead of 24% larger when living by itself. This pond will have all 3 habitats with a dominant habitat being vegetation in order to have green sunfish grow to its maximum size. Different species of crops like rice can also be grown in pond vegetations.

Pond Sediment Produce

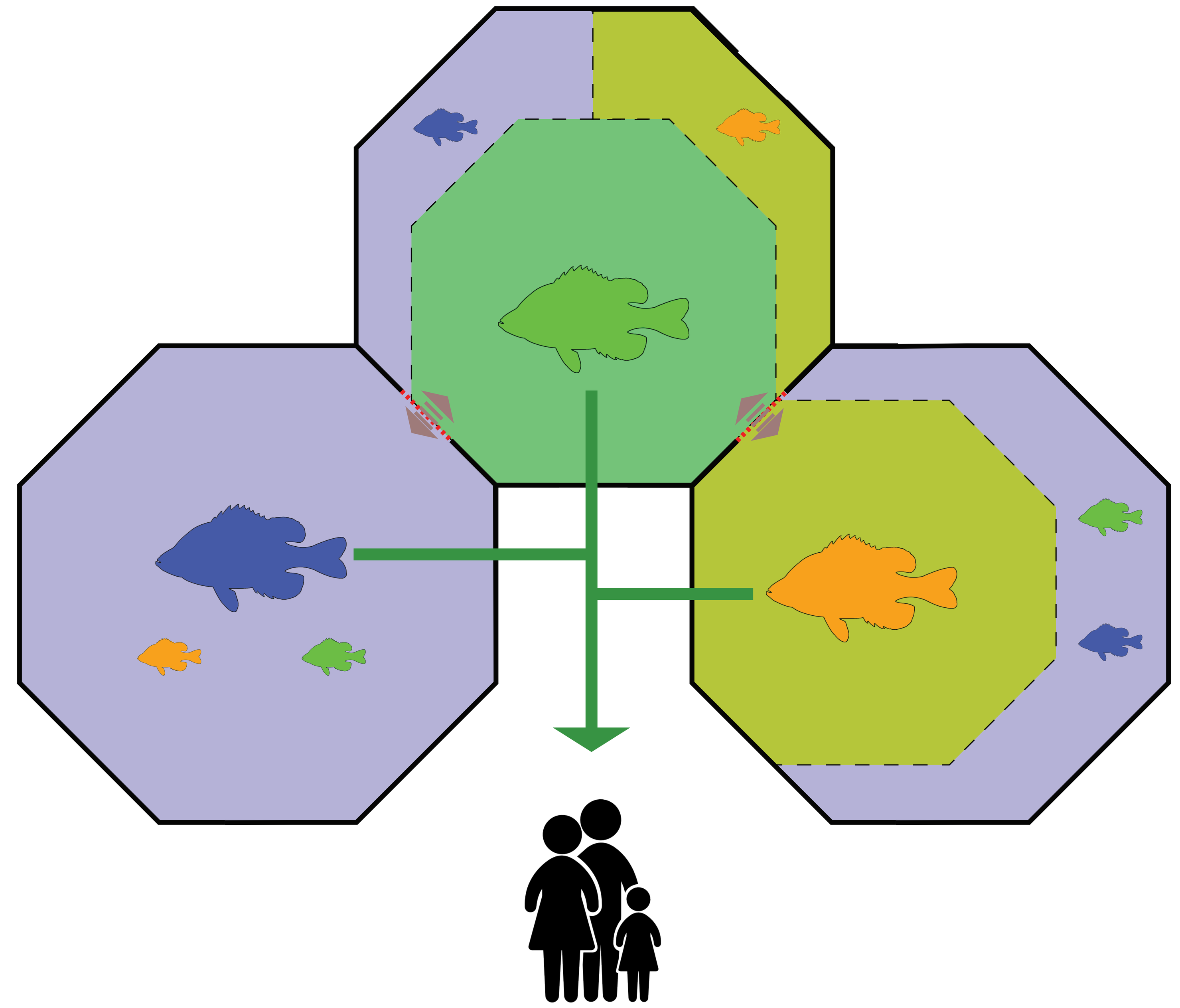
Pumpkinseed sunfish are known to grow largest when competing with bluegill and green sunfish in sediment and open water habitats.

Crop Stock

Crop soil can be fertilized through pig manure and fish compost. Portions of cropstock can be used to feed pig stock and fish stock.

Harvest

Crops and pig live stock will be harvested for humans.



Cycling of Fish Stock

Every couple of months the largest of the dominant species in each pond will be harvested. The other species that have not grown to their full potential yet will be cycled to a different pond to contrinue their maturity to their maximum size in their dominant habitat.

Key Chart:

- Farm Border
- Habitat Border
- Live Stock Habitat
- Crop Land
- Pond Vegetation Habitat
- Pond Sediment Habitat
- Pond Open Water Habitat
- Controled Movement of live stock
- Healthy Flow of Nutrients Flowing Back and Forth
- Healthy Flow of Nutrients Flowing in
- Viral Lysis Flow
- Outflow of harvest to humans
- Vegetation Dominant FIsh Specie (Ex. Green SunFish)
- Sediment Dominant FIsh Specie (Ex. Pumpkinseed SunFish)
- Open Water Dominant FIsh Specie (Ex. Bluegill SunFish)
- Scale of fish indicates size of specie and abundance.
- Pig Livestock
- Crop Stock
- Mysid Shrimp Stock
- Dimethylsulfide (DMS) & Dimethylsulfoniopropionate (DMSP) Production
- Phaeocystis Pouchetti Cultivation
- Phaeocystis Pouchetti storing DMS & DMSP