MESM GROUP PROJECT PROPOSAL 2023-2024

Assessment of emission reduction strategies from the application of fertilizer

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Client: Limoneira

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Objectives

The goal of this project is to assess the reuse of biowaste and application of cover crops as means for Limoneira to reach their emission reduction goals, as a large percentage of their emissions are generated from the purchase and use of fertilizers. More specifically, the objectives are to:

1. Review Limoneira's fertilizer use and resulting emission generation.
2. Assess and analyze viability of two fertilizer emission reduction initiatives:
    a. The repurposing of biosolids generated from their on-site wastewater treatment plant (WWTP) and agriculture operations to procure fertilizer and renewable energy fuels.
    b. Cover crop application to increase biological nitrogen fixation and reduce reliance on fertilizer, among other potential benefits (e.g. increase filtering and holding capacity of runoff water quality and quantity; suppress weed growth; decrease need for pesticides, fungicides, and herbicides; increase soil ecosystem health).
3. Recommend one or more management solutions based on the results of the analysis.

Significance

Context:

- The creation of synthetic nitrogen fertilizer through the Haber-Bosch process was one of the most significant inventions of the 19th century, allowing food production to boom and support the rapid growth of the human population. However, the intensification of agriculture has come at a cost, disrupting ecosystems, and generating massive amounts of greenhouse gasses and other harmful emissions.
- The fixation of nitrogen for use as fertilizer through the Haber-Bosch process is an incredibly energy intensive process associated with vast environmental impacts. The process consumes an enormous amount of fossil fuel, and produces an equivalent amount of carbon emissions. Likewise, distribution and mechanical application of fertilizer to fields consume fossil fuels and add to atmospheric CO_2 (Udvardi et. al., 2015).
- Ecological impacts of the use of synthetic N fertilizers are also considerable, including but not limited to: eutrophication of surrounding water bodies, toxic algal blooms that kill marine life, soil nutrient leaching that decreases microbial activity, and more (Johnson and Harrison, 2015).
- On a global scale, perturbation of the nitrogen cycle, as seen significantly through the creation of synthetic fertilizers, poses a growing public health risk. Today, agriculture uses over 100 million metric tons of N fertilizer each year, which has doubled the flux of N through the terrestrial N-cycle (Udvardi et. al., 2015). Excessive air- and water-borne nitrogen are linked to respiratory ailments, cardiac disease, and several cancers. Ecological feedbacks to excess nitrogen can inhibit crop growth, increase allergenic pollen production, and potentially affect the dynamics of several vector-borne diseases, including West Nile virus, malaria, and cholera (Townsend et. al., 2003).

- Implementing better management practices to reduce reliance on synthetic N fertilizer application and increase nitrogen fixation and uptake in the soil has a great potential to reduce adverse impacts on human health (Wang and Lu, 2020) and the surrounding environment.
- "The land sector contributes 22% of annual global emissions but offers up to 30% of the mitigation potential until 2050" (*Forests, Land and Agriculture*, n.d.). Currently, 26% of Limoneira's emissions are from the application of fertilizers and 18% are from the production of fertilizer, totaling 44% of Limoneira's overall emissions.

Others who would benefit besides the target client:

- The assessment would be applicable to much of the agricultural sector. While neither of these approaches are entirely novel, adoption by farmers has been slow. Should Limoneira begin converting solid waste into fertilizer or expand its use of cover crops, the demonstrated success of these principles can serve as a model for others to follow.
- Given agriculture's outsized role in climate change, improving efficiency, and minimizing environmental impact would have a global benefit– especially if the theory and subsequent model prove successful and inspire adoption within the industry. The increased use of cover crops also improves water cycling, which serves to reduce surface water contamination, charge aquifers, and provide direct cooling through evaporation cycles. All of these serve to improve regional and global climate stability.

Background

- Limoneira is a global agribusiness and real estate development company based in Santa Paula, California.
- They manage over 14,500 acres of land, water resources, and other assets and are the largest grower over avocados and one of the largest growers of lemons in the United States.
    - The scope of this project will only contain the land located in Santa Paula, CA.
- Current operations: Limoneira uses nitrogen fertilizers on their lemon and avocado farms. The biosolids/byproduct from the on-site WWTP are sent to Arizona, green waste from their farms is composted on-site, and green waste from their packing house is sent to Agromin (an organic compost, soil, and mulch producer located nearby) for composting. Fertilizers are applied via drip irrigation.
- Experimental test plots are located on the farm in Santa Paula. Plans for cover crop use on these plots are already in the works, and monitoring systems are already in place to track tree trunk growth, water uptake, and soil nutrients, among other parameters. Soil samples and data may be collected in addition to current monitoring as needed to aid in the project.
- Limoneira has partnered with Agromin to build a bioenergy generation / anaerobic digestion facility on-site at Limoneira Santa Paula to repurpose green waste into bioenergy and potentially use the byproduct (nitrogen pellets) as fertilizer. This collaboration project is still in the pipeline in the early stages. The details of the project have not been finalized.
- This project will determine the quantifiable benefits of repurposing biowaste as organic fertilizer and implementing cover crops on Limoneira's farms.

Equity

- Limoneira owns residential communities where only Limoneira workers and their families can live. Many of these workers are on work visas. The drinking water for these residential communities comes from wells that pull from shallow aquifers. Some of the communities rely solely on well water as they do not have hookups to city water. By adding cover crops, the filtering and buffering capacity of nutrients in the soil system will increase, providing cleaner water to the wells that supply water to this community.
- A portion of this project investigates the use of cover crops as a regenerative farming practice, and although newer to modern industrial agriculture, this is a practice that has been used by Indigenous

communities for centuries. We aim to incorporate and accredit Indigenous knowledge in our study of the use and benefits of cover cropping.
    - "Long before the arrival of Europeans, Indigenous populations protected local ecosystems and preserved biodiversity through land management and farming practices… As we rethink American history, we can thank Indigenous Americans for advancing practices that define sustainable agriculture and land stewardship"(*The Indigenous Origins of Regenerative Agriculture*, 2020).
- The Santa Clara River is located near the Limoneira farms in Santa Paula. The Santa Clara River flows directly into the Pacific Ocean. Decreasing surface water runoff from Limoneria's farms to the Santa Clara River will decrease the excess nutrients dumped into the river and the ocean and help decrease eutrophication, which can have outsized impacts on lower socio-economic communities.
- Impacts of climate change are anticipated to disproportionately impact the global south. As Limoneira is a large company within the land-intensive sector, they have the ability to reduce their impact on climate change through the reduction of fertilizer purchase and use.

Available Data

All data currently available at Limoneira can be shared with students. The following is a list of data that may be needed, and is available, for this project. This list is not exhaustive.

- Data from Client:
    - Amount of fertilizer (N) currently being applied
    - Emissions data (including emissions from removal of biowaste from WWTP and fertilizer production and use)
    - Current costs to remove the biowaste from WWTP
    - Contaminant test results of biowaste
    - Data from pilot plots of cover crops (e.g. costs, seeds, application)
    - Soil characteristics data
    - Wastewater quality analysis
- Data from Literature:
    - Costs of anaerobic digestion of biowaste from 1 ton of water

Possible Approaches

- Setting Science-based targets (*Ambitious Corporate Climate Action*, n.d.)
    - Using SBTi Forest, Land and Agriculture Guidance (*Forests, Land and Agriculture*, n.d.) for land based emissions reductions. Also utilizing the FLAG pathways
- Comparative LCA (current process compared to those proposed above)
- Cost-Benefit-Analysis of cover crop implementation and use of biowaste fertilizer pellets

Deliverables

In addition to the required Bren School deliverables, this project will produce one or more of the following:

- Viability assessment of the maximum reduction potential of both initiatives
    - Comparative LCA
    - Cost-Benefit-Analysis

Internships

Limoneira can provide 1 internship for a Bren student during summer 2023. Interns will be compensated $18/hr for 10-12 weeks of work.

APPENDIX

Citations

Ambitious corporate climate action. (n.d.). Science Based Targets. Retrieved January 27, 2023, from https://sciencebasedtargets.org/

Forests, Land and Agriculture. (n.d.). Science Based Targets. Retrieved January 27, 2023, from https://sciencebasedtargets.org/sectors/forest-land-and-agriculture#:~:text=The%2520SBTi%25E2%2580%2599s%2520FLAG%2520Guidance%2520provides%2520the%2520world%25E2%2580%2599s%2520first,emissions%2520from%2520agriculture%252C%2520forestry%2520and%2520other%2520land%2520use

The Indigenous Origins of Regenerative Agriculture. (2020, October 12). National Farmers Union.https://nfu.org/2020/10/12/the-indigenous-origins-of-regenerative-agriculture/#:~:text=Indigenous%20Americans%20practiced%20agroforestry%2C%20or%20the%20management%20of,and%20to%20foster%20wildlife%20populations%20and%20improve%20hunting

Johnson, A., & Harrison, M. (2015). The increasing problem of nutrient runoff on the coast: as development increases along coastlines worldwide, water quality--and everything that depends on it--degrades. *American Scientist*, *103*(2), 98-102.

Townsend, A. R., Howarth, R. W., Bazzaz, F. A., Booth, M. S., Cleveland, C. C., Collinge, S. K., ... & Wolfe, A. H. (2003). Human health effects of a changing global nitrogen cycle. *Frontiers in Ecology and the Environment*, *1*(5), 240-246.

Udvardi, M., Brodie, E. L., Riley, W., Kaeppler, S., & Lynch, J. (2015). Impacts of agricultural nitrogen on the environment and strategies to reduce these impacts. *Procedia Environmental Sciences*, *29*, 303.

Wang, Y., & Lu, Y. (2020). Evaluating the potential health and economic effects of nitrogen fertilizer application in grain production systems of China. *Journal of Cleaner Production*, *264*, 121635.

Budget

It is not anticipated that the proposed project will require additional funding beyond the $1,000 (and $300 for printing) contributed by the Bren School.

Client Letter of Support

Client Letter of Support is attached.

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This letter is to serve as a statement of intent between Limoneira Co. and the University of California – Santa Barbara Bren School of Environmental Science and Management, for the proposed group project coordinated between the two. In relation to this project, Limoneira will provide one internship opportunity at a pay rate of $18/hour for a duration of approximately 10-12 weeks. Additional funding may be provided for relevant expenses, to be evaluated on a case-by-case basis, and not to exceed a total of $1,000 after the initial $1,000 provided by the school for such expenses. Data for the project will be made available to the students, including but not limited to relevant costs and volumes for fertilizers, seeds, applications, and waste management. Requests for data shall be made to Evan Hazlett. As a publicly traded company, Limoneira must require students to sign and comply with a non-disclosure agreement in order to prevent the release of proprietary information, and final results of the project must be approved by Limoneira in order to ensure security prior to publication. This agreement is not intended to interfere with the students' or intern's access to or publication of relevant information.

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