Swette Center for Sustainable Food Systems

Arizona State University

Considering the Potential Inclusion of Microalgae as a Conservation Practice Standard within the USDA Environmental Quality Incentives Program (EQIP)

Assessing the Compatibility of Conservation Practice Standards with Live Microalgae

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Executive Summary

A growing concern within our food system is the issue of soil nutrient deficiency. With a rising population, it is crucial that our food system pursues sustainable food production methods that regenerate long-depleted croplands. This creates a need for federally funded agricultural practices that prioritize sustainability and conservation. In this context, the use of microalgae emerges as a promising approach to regenerative agriculture by enhancing the health of farmland soils. A comprehensive review of the literature indicates that live microalgae improve the nutritional content, carbon storage, and water-holding capacity of soils, thereby boosting their overall health and fertility. By providing farmers with access to microalgae, we can introduce an innovative and accessible farming strategy with the potential for long-term adoption.

The purpose of this report is to explore the potential for live microalgae to be established as a national Conservation Practice Standard (CPS) through the Natural Resources Conservation Service (NRCS). This analysis focuses on the use of live microalgae as a conservation practice, specifically through the efforts of MyLand, an Arizona-based company that operates in Arizona, California, Washington, and Alberta, Canada. MyLand specializes in cultivating the native microalgae of cropland soil and distributing them as a liquid fertilizer through irrigation systems.

In order to adopt microalgae as a CPS, it was crucial to establish an argument for the science of microalgae to secure NRCS approval of the practice. Therefore, our research was conducted through a thorough literature review of the science of microalgae and interviews with experts in the field. The interviewees included a soil scientist, a hydrological scientist, one current NRCS employee, and one former NRCS employee. It was important to understand the process of establishing a CPS through NRCS in order for farmers to be covered by EQIP. Based on research and insight from the interviews, multiple recommendations for adoption are explored.

One recommendation is to design an entirely new CPS, which has various pathways. One starts with a state implementing an Interim Conservation Practice Standard (ICPS) trial of three years before providing evidence to the NRCS to have it adopted nationwide. This would require going through the Biostimulant Act to define microalgae as a biological input and undergo a trial testing period. Another would be to create a new national practice by going through the head of NRCS, which usually takes four to five years to establish. Finally, a CPS could also be pursued through a state-funded conservation effort from a United States Department of Agriculture (USDA) grant, either the Conservation Innovation Grant (CIG) or the Regional Conservation Partnership Program (RCPP). This process takes between three to five years to establish. The final

recommended pathway is to amend a current CPS to include microalgae fertilization through the Conservation Stewardship Program (CSP). This would have microalgae added as a permanent “enhancement” to an existing conservation practice: Soil Carbon Amendment 336 or Nutrient Management 590. This process can be completed in less than 12 months.

The key findings of this report are that establishing live native microalgae as a federally funded practice provides farmers with an innovative way to regenerate their soils. Federally funded conservation efforts help reduce financial barriers and promote broader adoption of sustainable practices. The environmental and economic benefits of microalgae—particularly its potential to enhance soil fertility, improve water efficiency, and increase carbon storage—reinforce its value as a scalable solution to long-term soil degradation. By formalizing microalgae as a Conservation Practice Standard (CPS), NRCS can provide producers with the technical assistance and financial support necessary to accelerate soil restoration efforts.

Introduction

Maintaining a growing population requires the implementation of sustainable food production techniques. The degradation of agricultural soils, resulting from extractive practices such as excessive tillage and chemical inputs, calls for the adoption of environmentally friendly methods. Microalgae, a group of biologically based microorganisms, play a crucial role in interacting with soil microbes to support a healthy soil ecosystem. Recent research suggests that when used as fertilizer, microalgae can greatly improve soil water-holding capacity, nutrient cycling, microbial activity, and carbon storage. Microalgae offer a pathway toward sustainable agricultural systems and improve the quality of cropland soils.

MyLand, a company based in Phoenix, Arizona, has developed a service that delivers live native microalgae directly into the soil. With funding from the Water Infrastructure Finance Authority of Arizona, MyLand is collaborating with Arizona State University's Swette Center for Sustainable Food Systems and the Center for Hydrologic Innovations to evaluate their live native microalgae delivery system and explore its potential to reduce water consumption for Arizona farmers.

This report examines the various pathways through which the application of live native microalgae in agriculture could gain approval as a Conservation Practice Standard (CPS) under the USDA's Environmental Quality Incentives Program (EQIP). EQIP is an essential program offered by the Natural Resources Conservation Service (NRCS) that provides financial and technical assistance to farmers, ranchers, and forest landowners to incorporate conservation into their operations.

Funding for conservation projects is crucial in promoting the adoption of soil conservation practices, particularly those that may be overlooked or deemed too costly without financial support. Healthy soils are vital for sustaining agricultural productivity because when soil degradation occurs, it can cause long-term damage that is expensive and difficult to reverse. Addressing these problems early can help prevent both environmental harm and economic loss for farmers. In light of these challenges, this report investigates the potential for incorporating microalgae application to farmland as an official Conservation Practice Standard (CPS). Establishing such a standard could enhance accessibility by unlocking federal conservation funding, ultimately assisting more farmers in adopting microalgae technology to restore and maintain soil health across the United States.

MyLand

MyLand is an agricultural service company that uses live microalgae to restore soil health and boost farm productivity while conserving natural resources. Founded in 2015 by Dane Hague, Bob Thompson, and Andy Lax, the company's origins were unexpected: it began with an effort to *eliminate* algae, not promote it. Initially, focused on water systems and removing algae from soil, MyLand developed a method to grow pure algae. In the process, the founders realized that native microalgae could be a powerful tool for soil regeneration.

Today, MyLand operates in Arizona, California, Texas, Washington, and Alberta, Canada, serving farms of all sizes. Their approach is simple but innovative: they begin with on-site soil sampling to isolate as many native algae strains as possible. Their operations team then conducts a detailed soil analysis to identify the most viable and effective microalgae for regenerating that farm's soil.

By 2018–2019, MyLand shifted from selling a product to delivering a service—installing closed-loop systems that cultivate live native microalgae on-site and apply it directly through the farm's irrigation system. This living biology, delivered as a service model, is supported by ongoing monitoring from MyLand's team of agronomists and soil scientists, who track both system performance and soil health.

MyLand's mission focuses on healthy soil, healthy food, healthy people, and a healthy planet. Guided by a deep respect for farmers, who often face rising costs and shifting consumer demands, MyLand's technology focuses on delivering tangible returns. By improving soil health, growers can use less water, reduce chemical inputs, improve yield quality, and increase net income. In short, MyLand's model is designed to provide both ecological restoration and economic resilience.

Why Microalgae?

Microalgae are foundational organisms at the base of the food web, providing the energy that fuels biological systems. In soil science, fungi and bacteria have received more attention, while microalgae remain underexplored despite their ability to feed and stimulate microbial communities, improve soil structure, enhance nutrient cycling, and boost water-holding capacity.

MyLand's approach brings microalgae into the conservation conversation, not as a synthetic input or a shelf-stable amendment, but as a living, ecological catalyst.

A Conservation-Oriented Approach

Although MyLand has been commercial for only four years, its system aligns closely with USDA and NRCS conservation goals:

- Water Conservation: MyLand's system improves soil structure and biology, which allows the soil to retain water more efficiently and results in reduced runoff and lower irrigation demand.

- Input Reduction: As soils become healthier and more biologically active, they require fewer synthetic inputs.

- Yield & Quality: Early adopters have reported not only higher yields but better crop quality, which is a significant economic and nutritional outcome.

What Growers Value and What USDA Needs to See

Growers most often cite improved water efficiency, reduced inputs, and enhanced crop performance as the most significant benefits. For USDA and NRCS, MyLand knows the value lies in data, and they are actively building datasets that measure changes in soil organic matter, microbial biomass, water infiltration, and yield economics over time.

The System Explained

The MyLand process is hands-on, biologically precise, and designed as an ongoing partnership rather than a one-time transaction. It begins with an on-farm visit to conduct what the company refers to as the "algae isolation process." During this phase, soil samples are collected from multiple locations across the grower's field. These samples are analyzed to identify and isolate as many strains of native microalgae as possible. The most promising strains are sent to MyLand's operations and laboratory team for further evaluation, selection, and large-scale cultivation.

Following algae isolation, the team conducts a comprehensive site assessment. This includes reviewing the farm's irrigation system to determine the optimal algae injection point, designing a system tailored to the acreage, crop type, and water infrastructure, and designating treatment and control areas for comparative outcome analysis.

Once the planning is complete, MyLand installs an on-site algae bioreactor to cultivate the selected native strains. These live algae are introduced into the farm's irrigation system, allowing consistent application throughout the active irrigation season. Because algae delivery is tied to irrigation schedules, uninterrupted seasonal operation is essential; once irrigation stops, reentry is not possible, making precise timing and coordination critical.

MyLand's service model emphasizes ongoing support. Each grower is assigned an account management team that oversees implementation and remains engaged throughout the growing season. Soil is monitored three times annually—before application, during the treatment period, and after the season concludes—to track changes in microbial activity, organic matter content, and soil structure. By comparing data from treated and control plots, MyLand can refine application strategies and build the evidence base for the system's agronomic and conservation benefits.

Pricing is primarily structured on a per-acre basis, reflecting the operational scale and biological nature of the service. While this model provides a straightforward framework for growers, flexibility is built in through bulk pricing options and custom rating fee structures, particularly for larger or more complex operations. In practice, MyLand's systems are most efficient and cost-effective on farms of at least 180 acres; however, installations have also been implemented on farms as small as 60 acres, depending on site-specific conditions.

System feasibility and cost depend heavily on the farm's irrigation layout and injection point location, which can influence both design and operational logistics. In specific contexts, especially with high-value cropping systems, external cost-share programs, such as those offered by the Water Infrastructure Finance Authority (WIFA), can offset installation and service expenses. These financial partnerships lower barriers to adoption and enhance the model's potential for integration into conservation programs like EQIP, where scalability, return on investment, and measurable environmental benefits are key considerations.

Duration of Use of Live Microalgae

Whether microalgae application can eventually be reduced or discontinued, and at what point soil can sustain its functions without ongoing inputs, remains an open question. Most farms adopting the MyLand system begin with severely degraded soils, the result of long-term conventional management practices that have depleted biological activity, reduced organic matter, and weakened structural integrity. The nature of agriculture itself compounds these challenges through repeated tillage, chemical applications, and crop cycles, all of which can disrupt soil regeneration.

To date, MyLand has not identified a clear threshold at which microalgae application can be reduced or discontinued. However, ecological theory and early observations suggest that, with sustained stewardship and minimal disturbance, soil systems may gradually regain their capacity to support microbial life and nutrient cycling independently. As these biological networks become more established, the intensity of external inputs could be scaled back. Currently, however, the MyLand system is designed for regular application during the irrigation season, when soil biology is most active and responsive. Further longitudinal research will be necessary to determine the duration and conditions under which a farm can transition from an active input-based state to a more self-sustaining, regenerative state.

National Resources Conservation Service (NRCS)

The Natural Resources Conservation Service (NRCS) is an agency within the United States Department of Agriculture (USDA) that has long stood at the forefront of national conservation efforts (Natural Resources Conservation Service, n.d.-g). Established in 1935 as the Soil Conservation Service (SCS) in direct response to the ecological devastation of the Dust Bowl, the agency initially concentrated on combating soil erosion and widespread land degradation (Natural Resources Conservation Service, n.d.-h). Over time, its mission has expanded considerably. Since its reorganization and renaming in 1994, the NRCS has partnered voluntarily with private landowners and agricultural producers to implement scientifically grounded conservation strategies. Today, the agency plays a vital role in protecting soil, water, air, and other natural resources while ensuring agricultural operations remain economically viable. Its efforts encompass a broad range of services, including technical assistance, financial support, and comprehensive conservation planning.

NRCS operations are carried out through regional offices, partnering with conservation districts and various stakeholders at a local level. At the national level, the agency administers flagship conservation initiatives such as the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). It also develops and maintains critical resources like the Field Office Technical Guides (FOTG), which provide regionally adapted recommendations to address site-specific conservation challenges. A cornerstone of NRCS is the development and stewardship of Conservation Practice Standards (CPS). These standards serve as the technical foundation for scientifically rigorous conservation activities nationwide. The NRCS is responsible for reviewing, approving, and updating CPS at the national level, while also incorporating input from state agencies, local partners, and producers to ensure practices remain practical and adaptive to evolving conservation needs.

What is a Conservation Practice Standard (CPS)?

Conservation Practice Standards (CPS) are conservation efforts that have been approved for use in NRCS programs (Natural Resources Conservation Service, n.d.-b). There are currently over 160 established conservation practice standards. A CPS describes why a particular practice is needed, and it sets a minimum criterion that must be met when the practice is implemented by a producer. These standards provide both consistency and scientific rigor at the national level while also serving as a framework for states to develop their own Field Office Technical Guides (FOTG). Different CPSs are adopted and modified for each state. These plans are detailed in FOTG and can be more restrictive than the national criteria. The FOTG includes details that are specific to the environment of each state that way conservation practices are uniquely implemented to best suit that state's soil health needs. Through this structure, CPSs are not applied in a one-size-fits-all manner but are instead tailored to regional needs.

The development of a new CPS is a rigorous multi-year process designed to balance scientific rigor and public accountability. Proposed practices are first evaluated by national experts and undergo internal NRCS technical review before a draft is published in the Federal Register for public comment. Following this revision process, the standard is formally adopted. Then, states are given one year to incorporate additional regional amendments. It's important to stress that CPSs are not static documents, as each is reviewed and updated on a five-year cycle. This allows for changes to be made for advances in conservation science, evolving resource concerns, and feedback from producers in the field. This process ensures that NRCS standards are both scientifically current and practically applicable across the diverse landscapes of American agriculture.

Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program (EQIP) is the NRCS's flagship conservation program, which integrates conservation practice standards (CPSs) into working lands (Natural Resources Conservation Service, n.d.-f). Through EQIP, producers receive financial assistance that offsets a portion of the costs associated with adopting CPSs, thereby reducing barriers to implementation and promoting broader participation. EQIP has no minimum acreage requirement; however, it is a competitive program that awards points based on resource concerns to be addressed and other factors. NRCS will rank applications against other similar eligible applications, with the highest-scoring applications receiving contract offers. The average gross income of the producer needs to be less than $900,000, with the exception of Indian Tribes. By blending financial assistance with rigorous technical standards, EQIP serves as an important mechanism for advancing conservation on private lands.

Conservation Stewardship Program (CSP)

Another program that NRCS offers producers is the Conservation Stewardship Program (CSP), which provides technical and financial assistance to help producers elevate their conservation efforts to the next level (Natural Resources Conservation Service, n.d.-c). Conservation Stewardship Program offers opportunities for producers to expand on existing conservation efforts by applying new conservation practices, enhancements, and bundles. “Enhancements” refer to management activities that exceed the minimum CPS requirements to help producers achieve a higher level of conservation (Natural Resources Conservation Service, n.d.-d). There are approximately 140 enhancements currently available (Natural Resources Conservation Service, n.d.-e).To incentivize participation, CSP offers annual payments that reward both the implementation of new practices and the maintenance of existing conservation measures. Contracts are issued for a five-year term, with the option to renew for an additional five years if conservation goals are being met. While CSP does not impose a minimum acreage requirement, participation differs from EQIP in that the entire agricultural operation, not just an individual field, must be enrolled. Eligibility for CSP requires that all enrolled land comply with USDA’s highly erodible land and wetland conservation provisions. Participants must meet income requirements, with average gross income capped at $900,000, with the exception of Indian Tribes. By rewarding comprehensive, operation-wide stewardship, the Conservation Stewardship Program serves as a tool for scaling conservation practices, trying more advanced practices, and strengthening the long-term resilience of agricultural land.

Literature Review

Introduction

As global food demand continues to rise and the need for environmentally sustainable agricultural systems becomes more urgent, it is essential to transition away from intensive agriculture toward sustainable alternatives that can both preserve and enhance agricultural productivity. Microalgae offer a biologically-based alternative for soil nutrient and water management in crop systems (Alvarez et al., 2021; Li et al., 2024). The NRCS’s Environmental Quality Incentives Program (EQIP) is a USDA program that incentivizes producers to incorporate conservation practices focused on improving soil and water quality (Natural Resources Conservation Service, n.d.-f). This literature review addresses whether the current research surrounding microalgae supports its potential inclusion as a new or modified Conservation Practice Standard (CPS) under EQIP.

Overview of Microalgae in Agriculture

Algae are a diverse group of organisms found in aquatic and terrestrial environments. These creatures are essential to the structure of habitats and the production of ecosystem nutrients (Kholssi, Rajaa ; Lougraimzi, Hanane ; Grina, Fatiha ; Lorentz, Juliana F. ; Silva, Iosody ; Castaño-Sánchez, Omar ; Marks, Evan A. N., 2022). There are two types of algae: macroalgae and microalgae. Both macro- and microalgae carry out many essential functions, including converting CO_2 from the atmosphere and facilitating photosynthesis (De Silva, Agampodi Gihan S.D. ; Hashim, Z. K. ; Solomon, Wogene ; Zhao, Jun Bin ; Kovács, Györgyi ; Kulmány, István M. ; Molnár, Zoltán & BASEL:, n.d.). Macroalgae comprise seaweed and other multicellular organisms that are primarily found in freshwater and marine environments. Microalgae are unicellular organisms that fall into two categories: eukaryotic (e.g., green algae) and prokaryotic (e.g., cyanobacteria) (Kholssi, Rajaa ; Lougraimzi, Hanane ; Grina, Fatiha ; Lorentz, Juliana F. ; Silva, Iosody ; Castaño-Sánchez, Omar ; Marks, Evan A. N., 2022). Microalgae inhabit the topsoil of croplands, accounting for approximately 27% of the total biomass of agricultural land, and have the highest net primary productivity among terrestrial biomes (De Silva, Agampodi Gihan S.D. ; Hashim, Z. K. ; Solomon, Wogene ; Zhao, Jun Bin ; Kovács, Györgyi ; Kulmány, István M. ; Molnár, Zoltán & BASEL:, n.d.). The literature states that microalgae (both eukaryotic and prokaryotic) play a significant role in soil fertility. Due to their capacity to rehabilitate degraded soils, microalgae are the most commonly utilized algae in agricultural activities. Their presence in soil ecosystems contributes substantially to soil health and nutrient density, making them a vital component of agricultural systems.

These microalgae reproduce rapidly when isolated and replicated in cultivation settings (Li et al., 2024). They can be grown in either an open system, where there is direct exposure to the air, or in a closed system where evaporation and temperature are more controlled. The best technique for cultivating microalgae is in an open system, where evaporation and air exposure help regulate temperature. Open systems are also cost-efficient as wastewater is used as the culturing medium; however, it may contain heavy metals (such as lead, nickel, and cadmium) (Nichols, 2025). Once cultivated, microalgae can be applied to croplands as living or dead cells via sprays, liquid injectors, or irrigation systems, targeting the soil, foliar surfaces, or root zones (Nichols, 2020). Applying microalgae to croplands has primarily improved soil health and decreased the cost of fertility inputs, with higher crop yields acting as a secondary benefit (Nichols, 2020).

The application of microalgae is becoming increasingly marketable in the agricultural industry due to its numerous advantages as a soil amendment (Nichols, 2020). Many companies that sell microalgae products use the strain *Chlorella vulgaris.* Some companies amend the microalgae with bacteria, enzymes, and minerals, and they are available in either liquid or dry form. Both dry and liquid microalgae products can be diluted with water and administered as a bare root or transplant drench, spray, or irrigation. They also have a longer shelf life (Nichols, 2020). However, the literature suggests that using live microalgae has more advantages than using dry microalgae, as growing the cropland's native microalgae has significant advantages over dry microalgae. Live microalgae are able to interact with microorganisms already present in the soil, such as mycorrhizal fungi and *Rhizobium* bacteria, enhancing their benefits to plants (Nichols, 2020). Many environmental factors, such as temperature, illumination, pH levels, humidity, and salinity, can alter the growth and efficiency of microalgae. The uniqueness of the application and how it can be tailored to crop and soil conditions must be determined in order to fully reap the benefits of microalgae treatment (Li et al., 2024).

Agronomic Effects of Microalgae on Crops

Plant Growth and Yield Enhancements

Studies have shown that live microalgae offer numerous plant growth-promoting benefits, including increased germination, shoot growth, root growth, and leaf development in various crops. For example, the addition of live N_2-fixing cyanobacteria in tomato production increased plant N, P, and germination (Alvarez et al., 2021). When applied to corn, a combination of microalgae and cow manure resulted in increased germination and growth performance. (Golubkina, 2022). These biostimulatory effects are attributed to the phytohormones and micronutrients produced and released through the application of live microalgae (Alvarez et al., 2021). The application of microalgae to various crop types has resulted in increased yields and elevated nutritional value. Chickpeas, for example, experienced a 50% yield increase when treated with an *Anabaena laxa* microalgae formulation (Golubkina, 2022). Additionally, the application of microalgae shows promising results for plant growth and turgor. When applied to potted tomato plants in various treatment amounts, microalgae increased plant height and stem thickness in all trials, with the most promising results from the combination of microalgae and chemical fertilizers (Li et al., 2024).

Nutritional and Quality Improvements

The biostimulatory characteristics of microalgae are effective in increasing total plant nutritional value, increasing protein content, enhancing antioxidant activity, and optimizing mineral composition (Golubkina, 2022). Although there is limited data surrounding microalgae’s impact on protein content in specific crops, certain trials have indicated that the protein increase induced by microalgae application depends on the species applied, the application dose, and the genetics of the specific crop. The application of cyanobacterial consortia, including *Anabaena doliolum*, *Cylindrospermum sphaerica*, and *Nostoc calcicola*, resulted in increased protein content in the grain and leaves of wheat crops (Golubkina, 2022). Furthermore, the plant antioxidant content and enzyme activity increased significantly as a result of the combined application of mycorrhizal fungi and microalgae, resulting in increased ascorbic acid and carotenoids, and a reduced sugar content in crops (Golubkina, 2022). When compared to the application of chemical fertilizers on potted tomato plants, microalgae fertilizer treatments could increase the levels of soluble sugars (by 19.19~26.74%), soluble proteins (by 99.99~383.33%), Vitamin C (by 21.43~39.29%), and lycopene (by 69.49~158.31%) (Li et al., 2024). Microalgae-based liquid fertilizers applied at appropriate concentrations, particularly around 20%, significantly enhanced plant nutritional content by increasing protein, lipid, carbohydrate, and phenol levels compared to control groups (Deepika & MubarakAli, 2020). The improved mineral composition can be attributed to increased plant accessibility to soil macro- and microelements resulting from the application of microalgae (Golubkina, 2022). Additionally, studies have found that microalgae applications also increase the post-harvest quality and shelf life of certain crops. Eggplants, for example, experienced more stable pulp firmness and storability when applied with specific concentrations of *Spirulina platensis* (Dias et al., 2016).

Soil Health and Fertility Improvements

Nutrient Cycling and Availability

Cropland is deficient in vital nutrients as a result of intensive farming methods, including frequent tillage and extensive chemical fertilizer use. Microalgae promote soil health and fertility while reducing nutrient loss by gradually releasing nitrogen, phosphorus, and potassium (Li et al., 2024). Nitrogen fixation, the process of converting atmospheric nitrogen into a form usable by plants, is a crucial component of a healthy soil system. (Li et al., 2024). Cyanobacteria, a type of microalgae, are key agents of nitrogen fixation, capable of fixing atmospheric nitrogen at rates ranging from 10 to 60 kg N/ha per year (Ramakrishnan et al., 2023). This nitrogen-fixing ability of cyanobacteria is crucial in reviving cropland soils that have been degraded by synthetic chemical fertilizers commonly used in agricultural practices. Microalgae also offers a solution to soil organic carbon (SOC) depletion. Extractive tillage practices have depleted the soil carbon storage of cropland soils (Ramakrishnan et al., 2023). Microalgae fix carbon at rates 10 to 50 times greater than terrestrial plants by absorbing carbon dioxide through photosynthesis and sequestering it into the soil (Li et al., 2024). Additionally, the application of microalgae has been shown to increase SOC levels by approximately

15-30%, highlighting their importance as a strategy for soil conservation and the rehabilitation of degraded croplands (Ramakrishnan et al., 2023).

As microalgae fix carbon and nitrogen from the atmosphere, these microorganisms also contribute to the availability of potassium and phosphorus within the soil. The increase in phosphorus availability is attributed to the mineralization of organic phosphorus by microalgae, which releases available phosphate ions (Li et al., 2024). Microalgae increase potassium availability by releasing bioactive substances such as polysaccharides and polyphenols that promote the release of potassium ions (Li et al., 2024). In a study on potted tomato plants, those fed a 100% microalgae fertilizer concentration showed an increase in potassium of 167.2% and an increase in phosphorus of 232.8% (Li et al., 2024).

The same study found that applying microalgae fertilizer improved soil pH levels. Elevated pH can negatively impact crop growth and yield by disrupting plant photosynthesis.. The application of microalgae fertilizer has been shown to lower soil pH, with one study demonstrating that it can neutralize pH levels within 60 days (Zhang et al., 2024). While high pH levels are harmful, low pH levels, such as those found in saline soils, also negatively impact crop growth.. Soil salinity is a major abiotic stressor that degrades soil quality, as excessive Na^+ and Cl^- ions can cause irreversible damage to the photosynthetic process of plants (Zhang et al., 2024). Microalgae help remediate saline soils by restoring pH levels to neutral. Overall, the presence of microalgae inoculants increases soil nutrient density, aiding in the restoration of degraded croplands and enhancing plant productivity.

Soil Physical and Biological Enhancements

Cyanobacteria microalgae enhance soil health both chemically and physically through interactions with other microorganisms and by forming symbiotic relationships with plants (Ramakrishnan et al., 2023). Their contributions include increasing soil water-holding capacity by forming soil aggregates, controlling soil erosion, fostering beneficial microbial communities, and supporting the long-term productivity of biofilms that live among biocrusts on soil surfaces. The biomass of microalgae contains primary and secondary nutrients, organic matter, and trace elements, which improve soil structure by creating and stabilizing aggregates through the attachment of organic matter to sand, silt, and clay particles (Kolman et al., 2024).

Microorganisms, primarily fungi and bacteria, play a central role in the formation of microaggregates (20-250 μm in diameter) and macroaggregates (larger than 250 μm in diameter). Alongside microorganisms, green algae and cyanobacteria contribute significantly to soil aggregation and the formation of biological soil crusts, particularly in arid, semi-arid, and coastal dune ecosystems. Their importance to soil aggregation in agricultural soils has been well documented (De Silva, Agampodi Gihan S.D. ; Hashim, Z. K. ; Solomon, Wogene ; Zhao, Jun Bin ; Kovács, Györgyi ; Kulmány, István M. ; Molnár, Zoltán & BASEL:, n.d.). This restructuring of soil by microalgae enhances water-holding capacity, aeration, and drainage, creating optimal agricultural soil characterized by roughly 50% solids (45% minerals and 5% organic matter), 25% air, and 25% water–conditions closely linked to biodiversity and productivity (Ramakrishnan et al., 2023). Soil structures and water-holding capacity increase while influencing erosion control from wind and water. For example, it has been shown that cyanobacterial inoculations reduce soil loss by 36% following natural rainfall on abandoned agricultural lands (Alvarez et al., 2021).

The literature states that microalgae play a significant role in building microbial communities that are essential to forming biofilms within cropland biocrusts. (Alvarez et al., 2021). Intensive agricultural practices, particularly the use of chemical fertilizers, have disrupted native microbial communities in croplands, making the diversification of these communities essential for restoring soil health. When applied, microbial inoculants increase soil organic matter, enhancing fertility by improving plant drought resistance/tolerance, alleviating growth stresses, and promoting nutrient uptake through increased nutrient bioavailability. This positions microalgae as a highly effective tool for restoring agricultural fields and mitigating adverse soil conditions that limit crop productivity (De Silva, Agampodi Gihan S.D. ; Hashim, Z. K. ; Solomon, Wogene ; Zhao, Jun Bin ; Kovács, Györgyi ; Kulmány, István M. ; Molnár, Zoltán & BASEL:, n.d.). However, restoration of the microbial consortium must be regionally tailored, as inoculated cyanobacteria don't become dominant in soils where indigenous cyanobacteria are already abundant (Alvarez et al., 2021).

Environmental Benefits

The use of microalgae offers substantial environmental benefits that go beyond the productivity of croplands. Agricultural lands cover approximately 38% of the global land surface but generally have low soil organic carbon (SOC) levels, positioning them as significant potential sinks for carbon sequestration (De Silva, Agampodi Gihan S.D. ; Hashim, Z. K. ; Solomon, Wogene ; Zhao, Jun Bin ; Kovács, Györgyi ; Kulmány, István M. ; Molnár, Zoltán & BASEL:, n.d.). Microalgae can fix up to 1.8 kg of CO_2 per kg of biomass (Ramakrishnan et al., 2023), indicating that application on arable soils could offset anthropogenic emissions and play a critical role in climate change mitigation (De Silva, Agampodi Gihan S.D. ; Hashim, Z. K. ; Solomon, Wogene ; Zhao, Jun Bin ; Kovács, Györgyi ; Kulmány, István M. ; Molnár, Zoltán & BASEL:, n.d.). Beyond carbon sequestration, microalgae also mitigate nutrient runoff contamination. By enhancing soil water-holding capacity and stability, they promote nutrient recycling within the soil rather than nutrient loss through leaching. This is achieved through multiple processes, including symbiotic relationships between plant roots and soil microorganisms, nitrogen fixation, phosphorus solubilization, greenhouse gas mitigation, CO_2 sequestration via organic carbon inputs, and the progressive release of nutrients for plant uptake (De Silva, Agampodi Gihan S.D. ; Hashim, Z. K. ; Solomon, Wogene ; Zhao, Jun Bin ; Kovács, Györgyi ; Kulmány, István M. ; Molnár, Zoltán & BASEL:, n.d.). Microalgae also remove potential pollutants from the soil, reducing the risk of water contamination from agricultural runoff entering groundwater and other water systems. Microalgae can increase soil water holding capacity, reduce wastewater runoff, and act as a buffer against agrochemical runoff, as they can thrive in high concentrations of agrochemicals. (Kolman et al., 2024). The capability of mitigating runoff makes microalgae a valuable tool in environmental conservation (Kolman et al., 2024).

The use of chemical pesticides and fertilizers on agricultural lands contributes to significant environmental challenges. Microalgae biofertilizers offer a sustainable, regenerative alternative by harnessing the capabilities of microorganisms to replace or reduce synthetic inputs (De Silva, Agampodi Gihan S.D.; Hashim, Z. K.; Solomon, Wogene; Zhao, Jun Bin; Kovács, Györgyi; Kulmány, István M.; Molnár, Zoltán & BASEL, n.d.). These biofertilizers promote plant growth by modulating metabolism, enhancing nutrient uptake, and improving stress tolerance (Kolman et al., 2024). Cyanobacteria, a type of microalgae, can also reduce reliance on chemical pesticides by producing bioactive compounds that inhibit fungi, nematodes, and other plant pathogens through mechanisms such as enzyme inactivation, disruption of cytoplasmic membranes, and inhibition of protein synthesis in soils (De Silva, Agampodi Gihan S.D. ; Hashim, Z. K. ; Solomon, Wogene ; Zhao, Jun Bin ; Kovács, Györgyi ; Kulmány, István M. ; Molnár, Zoltán & BASEL:, n.d.). Additionally, microalgae contribute to the decomposition of organic matter and play a direct role in the biogeochemical cycle of nutrients, improving their availability in the soil. Consequently, nutrient use efficiency can surpass that of many chemical fertilizers, leading to reduced environmental pollution (Kholssi, Rajaa ; Lougraimzi, Hanane ; Grina, Fatiha ; Lorentz, Juliana F. ; Silva, Iosody ; Castaño-Sánchez, Omar ; Marks, Evan A. N., 2022)

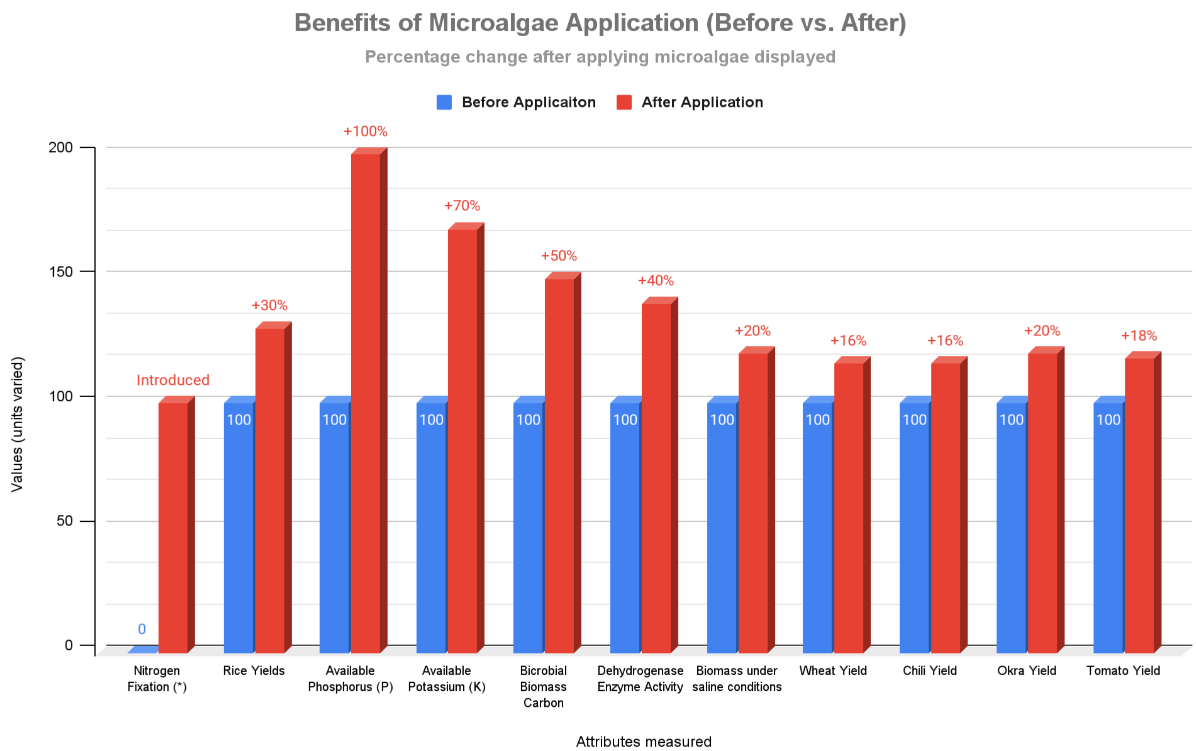

Figure 1.

Bar graph showing soil organic carbon level before and after microalgae application (Deepika, et al., 2020; Nichols K, 2020; Ramakrishnan et al., 2023).

Application Methods

The literature identifies several application methods for microalgae in agriculture. One common approach is fertigation, in which liquid microalgae are delivered through irrigation systems (Alvarez et al., 2021). Microalgal liquid fertilizers are also commonly applied via foliar sprays, soil spraying, and seed coating (Deepika & MubarakAli, 2020, Alvarez et al., 2021). Additionally, microalgae can be supplied as either living or non-living biomass and used directly as a soil amendment and fertilizer (Alvarez et al., 2021). Both forms of microalgae, live and dried, have been shown to positively impact crop production (Kolman et al., 2024). However, several studies suggest locally-sourced, live microalgae may produce better results than dried alternatives due to greater compatibility with soil conditions (Kolman et al., 2024). The microalgae concentration levels utilized within each study range from .2% to 100% based on the algae type, crop type, and application method. Furthermore, a broad range of crops has been studied, including legumes (soybeans, chickpeas), vegetables (tomatoes, cucumbers, peppers), and cereal grains (maize, rice, wheat) (Kolman et al.,2024, Deepika & MubarakAli, 2020, Li et al., 2024).

Gaps in Knowledge

Research on the effects of microlagae on soil health and plant productivity remains ongoing, and the literature suggests that further development is needed before widespread adoption in agricultural systems is feasible. Some studies suggest that due to limited knowledge of microalgae on varying crops, the true effectiveness of the fertilization is unknown. Most existing studies have focused on rice (27%), wheat (19%), maize (16%), tomato (11%), and legumes (6%), with relatively little research on leafy vegetables (3%) and cucumbers (2%) (Golubkina, 2022). The literature also recommends two more advances for developing research on the use of microalgae on different crops: the creation and use of microalgae fertilization. More research is needed in each application method to determine which crops benefit most from a particular technique and how best to prepare and apply microalgae fertilization.

Although varying concentration levels of microalgae have been shown to benefit plants, little is known about why different concentrations yield different effects. Several studies include post-application nutrient analyses, but findings, particularly regarding protein content, are inconsistent (Golubkina, 2022). Furthermore, post-harvest quality has rarely been addressed, despite its relevance given the time lag between harvest and consumption. There is also a notable gap in longitudinal studies that investigate the long-term impacts of using microalgae in agriculture.

Alignment with EQIP Goals and CPS Criteria

The application of microalgae and its benefits align directly with the environmental and resource conservation goals set out by the NRCS's Environmental Quality Incentives Program (EQIP). The EQIP program focuses on environmental priorities, including improved water and air quality, enhanced soil health, conserved ground/surface water, reduced soil erosion and sedimentation, and increased climate resiliency (Natural Resources Conservation Service, n.d.-f). Based on various studies and trials, the use and application of microalgae, both live and dried, contribute to many of these objectives set out by EQIP. For example, microalgae applications improve nutrient levels in soil and increase water retention, allowing for enhanced crop growth (Gurau et al., 2025). Furthermore, the biofertilizing and biostimulatory properties of microalgae allow for improved chemical and biological properties of the soil, restored soil fertility, and a reduced reliance on synthetic nutrients (Golubkina, 2022). Additionally, microalgae contain large amounts of organic matter, which enables the formation of soil aggregates, thereby increasing soil porosity and water-holding capacity (Li et al., 2024).

Due to these benefits, the use of microalgae as a soil amendment may be considered applicable under current Conservation Practice Standards (CPS) such as Nutrient Management (CPS 590) and Soil Carbon Amendment (CPS 336). Nutrient Management 590 outlines conservation practice standards designed to enhance crop productivity and soil organic matter while minimizing environmental impacts (Natural Resources Conservation Service, n.d.-i). Research has shown that microalgae applications can enhance nutrient cycling and soil biological activity, thereby improving their compatibility with current practices and standards under 590 (Alvarez et al., 2021). Soil Carbon Amendment 336 encompasses the use of biochar, compost, and other organic matter to improve soil health, sequester carbon, and enhance biodiversity (Natural Resources Conservation Service, n.d.-k). Microalgae applications have shown positive results for carbon sequestration and increased biodiversity in soil microbial communities, enhancing alignment with 336 practice standards (Alvarez et al., 2021, De Silva, Agampodi Gihan S.D. ; Hashim, Z. K. ; Solomon, Wogene ; Zhao, Jun Bin ; Kovács, Györgyi ; Kulmány, István M. ; Molnár, Zoltán & BASEL:, n.d.). Ultimately, microalgae offer a sustainable solution that addresses EQIP priorities and aligns with existing Conservation Practice Standards.

Conclusion

Microalgae are biologically based microorganisms that play a vital role in soil health by interacting with other soil organisms to create a microbiome that enhances the longevity and fertility of croplands. Cultivating live microalgae offers a sustainable alternative to synthetic fertilizers and pesticides, which have contributed to the degradation of cropland soil health. The application of microalgae has demonstrated significant potential to enhance plant growth, yield, and nutritional quality across diverse crops, largely due to the phytohormones and micronutrients they produce (Alvarez et al., 2021, Golubkina, 2022, Li et al., 2024). Microalgae improve soil fertility by increasing nitrogen levels through the nitrogen-fixing capabilities of cyanobacteria, raising soil organic carbon (SOC) content, stabilizing pH, and enhancing the availability of phosphorus and potassium. Existing research is broad and diverse, encompassing various application methods, microalgae forms, concentration levels, and crop types. However, additional research and development are needed to fully understand the various abilities that microalgae fertilization has on cropland soil improvement before this practice can be widely adopted. Overall, the use of microalgae aligns with the conservation goals of EQIP and offers strong potential as a sustainable soil amendment compatible with existing conservation practice standards (Natural Resources Conservation Service, n.d.-f).

Methodology

The objective of this study was to identify existing Conservation Practice Standards relevant to the application of microalgae and to assess the NRCS process for approving a CPS for inclusion in the Environmental Quality Incentives Program (EQIP). Additionally, the study explored different pathways for the adoption of live microalgae as a CPS, aiming to integrate it as a part of EQIP. Given that CPS are adapted at a state level, our research also examined which states are most likely to adopt a CPS related to live microalgae. Our research utilized qualitative data methods and included interviews with various experts from NRCS, as well as soil and water specialists.

Interview Method

Interviews were conducted with a diverse group of former and current NRCS employees, as well as soil scientists and hydrologic specialists. The initial pool consisted of 12 experts, selected with guidance from Arizona State University's Swette Center for Sustainable Food Systems. Researchers reached out to a group of nine experts and subsequently interviewed five individuals. All participants signed IRB consent forms, with one interviewee requesting anonymity to be maintained in the study. The interviews were conducted via Zoom and followed a semi-structured format, allowing for prepared questions along with the flexibility for follow-up questions. Among the interviewees, two had prior experience with the USDA, specifically within NRCS, while one was currently employed by the NRCS. The soil scientist and hydrologic specialist were not affiliated with NRCS or the USDA.

The interview questions were tailored to align with each person's professional role. Staff from NRCS were asked questions focused on the EQIP process, while the soil scientist and laboratory researcher were asked questions surrounding soil health and the role of microalgae. Initial interviews involved former NRCS employees, who provided valuable insight into the Conservation Practice Standard (CPS) process. The questions formulated for current NRCS staff were adapted from insights gained during the interviews with former NRCS employees. To enhance our understanding of microalgae, we also interviewed a soil scientist specializing in Biostimulants. Furthermore, we engaged with the Lab Manager responsible for data collection in a study examining MyLand's irrigation technology and services, which is currently being investigated by Arizona State University's Center for Hydrologic Innovations.

The analysis of the interviews involved recording and the utilization of Zoom's transcription feature. The data were examined for common themes, particularly focused on pathways for microalgae to be recognized by the USDA as a conservation practice standard. These themes were analyzed to identify potential avenues for the recognition of microalgae. It is noteworthy that all Interviewees granted permission for the inclusion of direct quotations in the analysis.

Interview Findings

NRCS Experience

Ferd Hoefner, Former National Lead of NRCS:

Ferd was a former policy director at the National Sustainable Agriculture Coalition whose role over multiple decades involved, among many other things, proposing changes to USDA/NRCS Conservation Practice Standards (CPS) to make them more consistent with sustainable and organic agriculture science and practice. Based on our interview, Ferd mentioned that the process of creating a new CPS can be lengthy, taking approximately 4-5 years. Revising an existing CPS is only slightly faster, as CPSs get reviewed on a 5-year rotating basis with a limited, but formal opportunity for public comment, often only at the very end of the process. CPS codes 590 and 336 are highly relevant to this project and are not currently in the queue for revision. Practices that involve animal waste or endangered species are subject to greater scrutiny by regulators. Every CPS must undergo a scoring process based on 42 so-called micro resource concerns, on a minus 5 to positive 5 scale; the higher the positive ratings, the greater the environmental benefit, which can sometimes result in greater the payments producers receive from EQIP or the other working lands conservation programs. Microalgae would require peer-reviewed support for consideration into CPS. Literature reviews can be quite helpful. Integrating microalgae into an existing CPS means that the USDA must provide an internal review for approval.

States are allowed to propose interim Conservation Practice Standards (ICPS), which are temporary, state-level conservation standards. The ICPS is somewhat easier to initiate than national standards. The ICPS could be a precursor to a national CPS; it has been proven effective and adopted by farmers. ICPS are generally adopted for 3 years and then evaluated. If successful, they become national CPSs. If not, they are dropped. A single state NRCS office can propose an ICPS, though sometimes a handful of states develop them together. Once approved at the national level, any other state office that wishes to can offer that interim conservation practice. In some cases that might be just a couple of states and in other cases there have been some with 20 or more states making the offering to their farmers and ranchers.

The conservation enhancements (CE) that together with CPs make up the backbone of the Conservation Stewardship Program (CSP) offers a faster pathway that can be accomplished more quickly than CPS changes, often within just a twelve month timeframe. The process for adopting or revising CEs is less formal than for CPSs, with no set timeline and no formal public comment period. In essence, it is a more internal, and frequently quicker process. CSP requires conservation across all land for a producer, including specific CEs on particular acres. Both EQIP and CSP pay for CPs, but only CSP pays for CEs. EQIP does not cover CSP enhancements. Microalgae could be introduced as an enhancement, providing a quicker pathway than CPS development. There may also be a potential opportunity for a CSP CE and ICPS to be developed simultaneously. Financially, EQIP provides higher payments per CP than CSP, but CSP also pays for CEs as well as the active management of previously adopted conservation. EQIP can offer funds if microalgae are part of an already approved CPS or potentially an ICPS. Ferd also mentioned the new National Environmental Policy Act (NEPA) revisions were adopted with a view toward accelerating USDA decision-making, speeding up the process and implementation of conservation practices. The implications of the new NEPA regulations could be another avenue to explore.

Anonymous, Former NRCS Employee:

The CPS 590 standard has equipment constraints and focuses on nitrogen and phosphorus, whereas CPS 336 may be a more suitable pathway given its emphasis on carbon capture. A strategic insight was brought up for a general amendment to CPS that consolidates materials such as microalgae, which could streamline future amendments under a single umbrella.

A state-level ICPS is developed locally and typically piloted for about three years. The ICPS pilot programs, if successful, can be adopted and advanced into the CPS framework. This process is a collaborative effort, requiring metrics that demonstrate the effectiveness of the microalgae, agreement and sponsorship from the state, participation from the state agronomist, and submission of a document to NRCS after the fact. The interviewee noted that neighboring states integrate and adopt ICPS into their local programs, highlighting the collective nature of this initiative.

The CSP enhancement was mentioned as being a faster pathway. However, these enhancements are often initiated at the national level, though states and individuals can propose them. The process for submitting an enhancement involves writing it up and then submitting it through the state agronomist, a key figure in the proposal process. Once the proposal is submitted, it will be considered for the national level. An external champion or the state agronomist must advocate for the proposal. The state agronomist holds the key entry point for both CPS and CSP proposals.

The recommended documentation, which includes all changes in soil properties supported by peer-reviewed evidence, is required for inclusion in ICPS or CPS. The interviewee recommends that we emphasize the importance of the native state of microalgae, as NRCS's focus is on native plants. It was also recommended not to use trade names in technical documents and to use generic descriptors.

Finally, it was also recommended to consider budgeting timelines. The payment schedule is structured in quarters, which could be critical for rolling out practices. All the conservation practices must have associated payment structures, which require planning for producers. An emerging development is also the biological input standard that is being anticipated for release on October 1st, 2025. The new amendment could create a new direct pathway for microalgae inclusion. The new undersecretary of the USDA is expected to oversee this new standard.

Soil Scientist

Dr. Pam Marrone, Senior Fellow, Swette Center

Dr. Marrone is a scientist and entrepreneur with experience with Biostimulants and shared insights into the science of microalgae. The research team asked questions regarding the benefits of microalgae and soil health. Dr. Marrone repeated the term ‘regenerative’, noting that the pace of soil regeneration is a good measurement of the use of microlagae. She highlighted the comparison between typical biostimulants and native microalgae, asking, “In season, but do those microbes then hang around and colonize for the next season?” Dr. Marrone emphasized the importance of crop yields and crop uniformity, something producers would want to see from microalgae. Dr. Marrone confirmed fertigation as the best application method.

The biostimulant industry’s new standard crop yield rate for a product is 7-10%, while in the past, 5-7% was good enough. But the bar is higher now due to the number of companies in biostimulants. Return on investment was a recurring term in questions about microalgae data collection. The research team inquired about the measurements NRCS would consider for microalgae. Dr. Marrone answered with metrics such as an increase in carbon sequestration, nitrogen fixation, phosphate-solubilization, and overall nutrient uptake enhancement. Dr. Marrone also mentioned that trials need to have “an 80% win rate.” When asked about the potential risks of live/native microalgae, Dr. Marrone explained that testing for non-target organisms, human pathogens, and quality control procedures would need evaluation.

Dr. Marrone shed light on the biostimulant industry, giving examples of what other countries are doing. Brazil is number one in biostimulant use, Pam explained, "Farmers in Brazil are 10 years younger on average. That's a big deal. They're adopting tech and biologicals at a much faster rate. And also, being in a tropical climate, they have a real serious problem with pest resistance.” Questions were asked about Pest Management as a possible pathway for microalgae. Dr. Marrone shared that it would be a long and expensive process, involving the Environmental Protection Agency. When asked about the Make America Healthy Again movement's influence on pesticide use in Agriculture, their response was mixed, acknowledging that lobbying groups for chemicals are strong.

Throughout the interview, it was suggested that biostimulants in general be included as a conservation practice. Dr. Marrone also suggested the Biostimulant Bill would help shape the use of biologicals like microalgae and help producers. Biostimulants are a separate category and not covered in the EQIP program. Dr. Marrone shared, “USDA absolutely needs to step up, and instead of having individual companies doing their own thing on this.” The biostimulant industry currently pays farmers to use their products, usually with a third-party verifier. The Biostimulant Bill will require the USDA to assemble, fund, and conduct research to get the data for biostimulants to be an additional practice for which farmers get payments for adopting.

Hydrologic Specialist

Efrain Vizuete, Lab Manager - Center for Hydrologic Innovations

Efrain Vizuete is working on the data collection of the MyLand study through ASU and WIFA. Data collection is happening at six sites. The Center for Hydrologic Innovations compiled and recorded complex data towers, including soil moisture sensors, soil heat plates, and a gas analyzer for water and carbon influxes. Efrain informed the research team that the data collection is in real-time with remote access. Some sites act as the control group and are not treated with microalgae. The study began collecting data in February 2025 and is scheduled to finish in June 2026.

Efrain disclosed some of the crops being monitored: alfalfa, cotton, date palm trees, and rosemary. When asked about the challenges of measuring or verifying soil health improvements like water capacity, Efrain explained, “We need to know the amount of water that farmers are using in the field.” The Center for Hydrologic Innovations doesn’t currently know the amount of water farmers are using; farmers could be using too much. The research team asks about different soil types in other states, which would yield different results. Efrain's response was yes, and he elaborated with varying types of soil, “they can change the rates of water infiltration, the porosity, the solid organic matter, the pH, all these parameters can help to infiltrate the water, can, you know, retain the water in the surface.” There is another team at ASU that is analyzing the data collected by Efrain and his team.

Recommendations

The purpose of this report was to examine existing Conservation Practice Standards (CPS) related to microalgae applications and to understand the NRCS process for developing a new CPS. Based on the information gathered, we outline potential pathways for live microalgae to be established as a CPS, enabling producers to adopt this practice through EQIP.

We interviewed current and former NRCS employees whose knowledge and experience with the CPS development process helped identify realistic pathways for consideration. Additionally, interviews with experts in soil and hydrology provided valuable insight into current research and emerging trends that could influence the potential for live microalgae to become an approved CPS.

Following group discussions, our team developed recommendations outlining potential pathways for live microalgae to become a CPS. The process of establishing a CPS relies not only on scientific evidence but also on the support of NRCS staff at both the national and state levels. These recommendations are designed to inform stakeholders about viable approaches for integrating f live microalgae as a recognized conservation practice.

Different Methods	Initiation Point	Goal	Approver	Practice Type	Approximate Timeline for approval	Notes
CSP Enhancement	NRCS State Agronomist and State Conservationist	Add Conservation benefits. Create a CSP enhancement to an existing CPS.	CSP Program Lead	Enhancement	~1 year	Enhancements are national but originate with the State Agronomist. One of the fastest routes. The disadvantage is that it is not part of EQIP. Less financially beneficial for producers.
ICPS	State level	Test emerging practices	State Conservationist	Trial Practice	3 years + 1-2 for national CPS	If proven effective after 3 years, it can become a full national CPS.
New CPS	States and partner advocates	Create a new national practice.	Head NRCS Chief	New Practice	4-5 years	Requires public comments and review of technical standards. The document goes to the Federal Register for public comment before finalizing.
Create a New CPS (Encompassing Recommendation)	State and partner advocates	New CPS is using multiple avenues	State Conservationist initially sponsors. NRCS chief for finalization	Integrated Pathway	3-5 years	Three linked mechanisms: ICPS for entry at the state level. CIG provides a pilot demonstrating effectiveness. RCPP supports large-scale operations with multiple stakeholders.

Establish a New Conservation Practice Standard

Establishing a new CPS is a lengthy process; however, it represents the most substantial pathway for live microalgae to become eligible for EQIP. Currently, live native microalgae has only one service provider, which poses a challenge because the NRCS prioritizes evidence-based practices rather than single products. To make this practice viable for implementation, substantial quantitative evidence must be presented to the NRCS.

Accordingly, we recommend pursuing the creation of a new CPS focused on biostimulants—a broad category of microorganisms that enhance plant nutrient uptake This broader scope is necessary to encourage participation from multiple states, a key requirement for the establishment of a new CPS. A CPS for biostimulants would also provide a formal pathway for live microalgae to qualify under the EQIP program.

The timing is advantageous, given the recently introduced Plant Biostimulant Act (S.1907). This bill proposes amending the Federal Insecticide, Fungicide, and Rodenticide Act to include a federally recognized definition of biostimulants, to be approved by the EPA. This legislation is significant because it would provide both a clear regulatory framework and federal recognition for biostimulants—potentially including live microalgae. Moreover, it will stimulate research on the soil health benefits of biosimulants, increasing the availability of quantitative evidence to support their conservation value. More importantly, further research should come not only from private companies but also from independent and academic institutions.

Creating a new CPS would make live microalgae directly eligible for EQIP, which offers higher cost-sharing compared to CSP. EQIP is also designed to support new producers or producers who have not yet implemented conservation practices. This presents an opportunity for MyLand to broaden its producer base while helping more producers improve soil health.

We recommend two options for establishing a new CPS. The first is to leverage USDA grants to expand research, and the second is to create a new CSP through the ICPS process.

USDA Grants: Conservation Innovation Grant or the Regional Conservation Partnership Program

To establish a new CPS, substantial published research and on-farm evidence are required. Currently, there is not enough scientific or practical evidence to justify a CPS dedicated solely to live microalgae.. For this reason,we recommend aligning with broader efforts to develop a CPS for biostimulants, a category under which live microalgae would be included.

To strengthen the scientific foundation supporting live microalgae and biostimulants, we recommend pursuing opportunities to fund additional research. The USDA offers several programs that provide financial support for conservation-related research, including the Conservation Innovation Grant (CIG) and the Regional Conservation

Partnership Program (RCPP). The CIG focuses on resource conservation efforts and offers grants through three annual competitions, including state-level pilot initiatives as well as national-level pilot and adoption initiatives. CIG projects support the growth of farm productivity through improvements in water quality, soil health, and wildlife habitat. They are accessible to individuals, non-governmental organizations, and state and local governments in all 50 states (Natural Resources Conservation Service, n.d.-a). The RCPP takes a collaborative, landscape-scale approach to conservation and offers two models for implementation: Classic, led through NRCS contracts, and Alternative Funding Arrangements (AFAs), led by partner organizations. RCPP supports conservation strategies that enhance land health on both agricultural and non-industrial lands (Natural Resources Conservation Service, n.d.-j).

We recommend pursuing one of these programs to increase both the visibility and the body of evidence supporting live microalgae. Because RCPP emphasizes area-wide projects and multi-stakeholder partnerships, MyLand could serve as a collaborating organization within a regional initiative. Expanding research beyond Arizona would strengthen the case for live microalgae as a conservation practice by generating data across diverse climates and soil types. Interviewees identified Texas A&M University as an influential institution in NRCS-related efforts. Therefore, we recommend partnering with Texas A&M University in addition to Arizona State University to maximize research credibility and impact.

Interim Conservation Practice Standard

The most effective pathway for developing a new CPS is through an Interim Conservation Practice Standard (ICPS). IICPS are temporary standards used by the Natural Resources Conservation Service (NRCS) to evaluate new or unproven conservation practices. They provide a framework for testing, data collection, and performance evaluation before a practice is considered for permanent adoption. ICPS originates from various sources, including university researchers, vendors, the Agricultural Research Service, or recommendations from state technical leads and field office staff.

The State Technical Guide Committee reviews the ICPS. If approved, it advances to the national subject matter expert, who ensures alignment with NRCS objectives and priorities. There is a three-year trial period for the evaluation of ICPS, to collect data on the efficacy. Following this evaluation, a report is submitted recommending one of three outcomes: national adoption, integration into an existing standard, or discontinuation of the practice.

While the ICPS process can be lengthy, it offers significant advantages. It is directly tied to EQIP, meaning that if the interim standard is successful, it can transition into a permanent CPS with national implementation Additionally, EQIP participation can be more financially beneficial for producers compared to other programs.

Another consideration with an ICPS is producer participation. Interviews revealed that there were times when producers were not using the interim practice, which can impact the outcome of becoming an official CPS. Logistically, For MyLand, producer engagement represents both a challenge and an opportunity. The company currently operates in four states–Arizona, Texas, California, and Washington–which offers a strong foundation for multi-state participation. Subject matter experts emphasized that broader geographic adoption across multiple states can significantly improve the likelihood of national approval. In one case, an expert reported participation from more than twenty states before national adoption was achieved. The ICPS approach is also more diplomatic and allows all biostimulants to be included. Local-level guidance from vendors, field staff, universities, and other stakeholders is essential to develop an interim practice. Providing a prescription can move the interim practice from an idea to a reality.

Amending a CPS through a CSP Enhancement

Amending an existing Conservation Practice Standard (CPS) represents the most time-efficient pathway for live microalgae application to become an approved conservation method eligible for federal cost-share programs. The Natural Resources Conservation Service (NRCS) offers a mechanism for such amendments through the Conservation Stewardship Program (CSP) Enhancements. While CPS establish the minimum requirements for conservation practices, CSP Enhancements enable producers to go beyond those standards, achieving higher levels of conservation outcomes while accessing additional funding opportunities (U.S. Department of Agriculture, n.d.-c). Because enhancements are considered incremental improvements, their approval is typically less scientifically rigorous than that of a new CPS. There is growing evidence suggesting that sufficient research may already exist to support the soil health benefits of live microalgae for inclusion as a CSP Enhancement. Moreover, CSP primarily targets producers who have already implemented basic CPS practices, making it a particularly suitable entry point for advancing innovative soil amendments such as live microalgae.

Each CSP Enhancement must be linked to an existing CPS. Based on our review, the most relevant standards are Soil Carbon Amendment (CPS 336) and Nutrient

Management (CPS 590). Both standards are currently adopted in the states where MyLand operates (Arizona, California, Texas, and Washington). Soil Carbon Amendment 336 encompasses practices such as applying biochar, compost, and other organic materials to improve soil health, sequester carbon, and enhance biodiversity (Natural Resources Conservation Service, n.d.-k). NRCS guidance explicitly allows for “other carbon amendments,” a category under which live microalgae could be incorporated, given their ability to increase soil organic matter and stimulate microbial activity. Similarly, Nutrient Management 590 outlines strategies for optimizing the rate, source, timing, and placement of nutrient applications to improve plant health while minimizing environmental impacts (Natural Resources Conservation Service, n.d.-i). The standard emphasizes maintaining soil organic matter and reducing nutrient losses–objectives that directly align with the demonstrated benefits of live microalgae in promoting nutrient cycling and soil fertility.

Advancing a new CSP Enhancement requires engagement with NRCS decision-makers at the state or national level. Producers or stakeholders can initiate the process by presenting proposals through state technical committees, working directly with state agronomists, or elevating requests to national program leads for CSP and discipline specialists responsible for the relevant CPS. The route to official approval can happen in 12 months or less. While this pathway offers a relatively quick route to eligibility, it is important to note several programmatic distinctions. CSP funding requires producers to enroll their entire agricultural operation, whereas the Environmental Quality Incentives Program (EQIP) allows for financing on a portion of land. Additionally, EQIP historically allocates about 2.5 times more funding than CSP, which may influence the scale and speed of adoption for new conservation practices such as the application of live microalgae.

Conclusion

The long-term viability of U.S. agriculture depends on rebuilding soil health through innovative and sustainable approaches. Conventional practices that have depleted soils are no longer sufficient to meet the needs of a growing population or withstand increasing environmental pressures. This research explored the potential of live native microalgae as a promising conservation tool that can enhance soil structure, support microbial communities, increase soil water holding capacity, improve nutrient efficiency, and increase carbon storage.

Findings suggest that positioning microalgae within federal conservation programs, specifically through the creation or amendment of a Conservation Practice Standard (CPS), would provide farmers with both resources and incentives to adopt this emerging practice. Lowering financial barriers and integrating microalgae into recognized conservation frameworks accelerate the potential for adoption as improved soil function and water use efficiency provide environmental benefits and economic gains for producers.

The advancement of microalgae as a conservation method, however, depends on establishing credibility through rigorous evidence. Lessons from the development of the recently adopted biochar standard CPS 590 highlight that success requires measurable outcomes, including increases in soil organic carbon, improved nutrient efficiency, and enhanced water-holding capacity. More performance benchmarks that resonate with producers, the scientific community, and the biostimulant industry are needed. A critical eighty percent success rate in field trials alongside yield improvements must be demonstrated for NRCS-approved conservation practices. Independent validation by land-grant universities, the Agricultural Research Service, and other evaluators will be essential to build trust, ensure feasible adoption, and justify payments. Importantly, the USDA accepts evidence-based research not only from U.S. studies but also from international peer-reviewed research, providing a strong precedent for the recognition of global scientific findings.

This study is not without limitations. The analysis draws on existing research and comparative examples. Still, it does not yet include longitudinal field trials or economic modeling of adoption at scale in U.S. states that trial the use of microalgae. Future research should evaluate the application of live microalgae across diverse production systems, assess their long-term ecological and economic impacts, and investigate policy mechanisms that could facilitate widespread farmer adoption. Ultimately, advancing live microalgae as a recognized conservation practice represents more than just a technical solution. It is an opportunity to strengthen the resilience of U.S. agriculture, protect soil and water resources, and contribute to a more sustainable and food-secure future.

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Appendix

Glossary of Terms:

Agrochemical runoff: Water that has flowed over agricultural land, picking up chemical substances used in farming, such as herbicides, pesticides, and fertilizers.

Antioxidant: A substance that slows cell damage by neutralizing free radicals.

Biochar: A type of charcoal, at times modified for organic use, as in soil.

Biocrust: Living layers of microorganisms, including cyanobacteria, lichens, mosses, fungi, and algae, forming on the soil surface in arid ecosystems.

Biofilm: Communities of microorganisms, such as bacteria, fungi, or algae, that stick together and form a surface, creating a slimy exterior on objects.

Biostimulant: Microorganisms, when applied to plants, can enhance nutrient uptake. These microorganisms can improve tolerance to environmental stress and boost crop quality and yield.

Carbon sequestration: Carbon dioxide is removed from the atmosphere and held in solid or liquid form. This process can be natural or artificial.

Conservation Innovation Grant: Funding for the development and adoption of innovative conservation approaches and technologies in agriculture.

CPS: Conservation Practice Standard (CPS) contains information on why and where the practice is applied, and it sets forth the minimum planning criteria that must be met during the implementation of that practice for it to achieve its intended purpose(s).

CPS 336 – Soil Carbon Amendment: Link
Soil Carbon Amendments (SCA) are materials derived from plant materials or treated animal byproducts. These amendments may be applied to the soil to improve or maintain soil organic matter, sequester carbon and enhance soil carbon stocks, improve soil aggregate stability, and/or improve habitat for soil organisms. Examples are biochar, compost, and various organic amendments.

CPS 590 – Nutrient Management: Link

Manage rate, source, placement, and timing of plant nutrients and soil amendments while reducing environmental impacts.

CSP: Conservation Stewardship Program (CSP) is an NRCS program designed to compensate agricultural and forest producers who agree to increase their level of conservation by adopting additional conservation activities and maintaining their baseline level of conservation.

Cyanobacteria: Known as blue-green algae, are prokaryotic bacteria that are photosynthetic organisms, containing chlorophyll and various pigments, such as phycoerythrin, which facilitate photosynthesis.

Erosion control: A practice minimizing or preventing the removal of soil and rock from landscapes by water, wind, or other natural forces.

EQIP: Environmental Quality Incentives Program (EQIP) is an NRCS program that provides financial and technical assistance to agricultural producers and non-industrial forest managers

Fertigation: A process that applies fertilizer through an irrigation system.

Fertilizer: Substances, whether organic or synthetic, added to soil for fertility, providing essential nutrients for plant growth.

Foliar spray: Application of nutrients, pesticides, or other substances to plants by spraying directly onto the leaves and stems.

FOTG: Field Office Technical Guides (FOTG) are the primary scientific references for NRCS. They contain technical information about the conservation practices.

Germination: The process in which a plant embryo starts growing from a seed or spore, eventually developing into a seedling.

ICPS: Interim Conservation Practice Standard. ICPS are to be developed by the States to address resource concerns not covered by existing conservation practice standards, or to create and test new conservation practices.

Live microalgae: Single-celled organisms, primarily eukaryotic, using photosynthesis to convert light energy to chemical energy, propelling their growth, and producing organic compounds.

Microbial consortium: Groups of different microorganisms such as archaea, bacteria, and fungi. These microorganisms live and interact within the same environment.

Mycorrhizal fungi: A fungus that forms a symbiotic relationship with plant roots, enhancing a plant's ability to absorb water and nutrients from soil.

Microalgae: Microscopic, single-celled organisms that are photosynthetic, thrive in aquatic environments, both prokaryotic and eukaryotic.

Native microalgae: Microalgae species naturally occurring in specific geographic locations or environments. The microorganisms are adapted to the conditions of particular areas, including climate, water sources, and soil composition.

Nitrogen fixation: The process of converting N2 (atmospheric nitrogen) to NH3 (ammonia), or other nitrogen compounds that plants can use.

NRCS: Natural Resources Conservation Service is an agency of the United States Department of Agriculture (USDA) that provides technical assistance to farmers and other private landowners and managers.

Nutrient cycling: A natural process that recycles essential plant nutrients within an agricultural ecosystem, providing a steady supply for plant growth and minimizing the need for external inputs such as fertilizer.

pH (as a soil condition): Measurement to determine how acidic or alkaline the soil is.

Phosphorus mineralization: Microorganisms that convert organic phosphorus in soil to inorganic forms. This process makes phosphorus available for plants for use.

Phosphorus solubilization: The process that converts insoluble forms of phosphorus into soluble forms available for plants. The process maximizes the utilization of existing phosphorus soil reserves and reduces the reliance on synthetic fertilizers.

Phytohormones: Chemical messengers regulating various aspects of plant development and responding to environmental stimuli.

Polyphenols: A type of micronutrient found in plant-based foods that act as antioxidants, potentially offering health benefits.

Polysaccharides: Large molecules composed of multiple smaller sugar molecules that are linked together.

Regional Conservation Partnership Program: Partner-driven approach to funding solutions to a natural resource challenge on agricultural land.

Rhizobium bacteria: Gram-negative soil bacteria that can form a symbiotic relationship with legume plants - see nitrogen fixation.

Runoff: Water that flows over land surfaces, typically after rainfall and snowmelt, that does not infiltrate into the ground.

Soil organic carbon (SOC): The carbon component of soil that includes all living and dead organic matter within soil.

Turgor: The inflation of a cell through fluid absorption, resulting in a rigid cell or tissue.

USDA: United States Department of Agriculture (USDA) is an executive department of the United States federal government.

Water contamination: Harmful substances known as contaminants are introduced into water, making it unsafe for drinking, recreation, and other uses.

About the Authors

Valerie Bednarski

Valerie Bednarski is a data-driven professional specializing in water resource management and sustainable agriculture. Valerie began her career in research after earning a B.A. from UC Berkeley, then transitioned into agricultural technology sales and marketing, where she spent five years working directly with hundreds of specialty crop growers across California. She now works as a graduate student researcher with Dr. Jay Famiglietti, focusing on water accounting and governance. Her current research explores how Taiwan responded to a historic drought by balancing the water demands of people, agriculture, and the semiconductor industry—offering insights relevant to Arizona's rapidly expanding tech sector. Valerie was recently awarded the Federal Boren Fellowship to learn Mandarin in Taiwan. She is particularly interested in the intersection of water security, food systems, and national resilience.

Lisa Castrichini

Lisa Castrichini earned her degree in Nutrition from Arizona State University. There, she learned about the veil around our food system and the social injustices that plague it. Her newfound knowledge led her to the field of community health, with an emphasis on child health and food access. Lisa is a Certified Health Education Specialist and dedicated Yoga Teacher, passionate about mindfulness. She spent time working for Arizona's SNAP-Ed program and Southwest Human Development's Head Start program. Lisa also has clinical experience as a Health Coach for Bayless Integrated Healthcare. Currently, she serves as the Manager of Healthy Food Initiatives at Local First Arizona, where she leads their food access and nutrition education programs at their Community Kitchens. Having grown up near farmland, Lisa has witnessed its decline over the years, which motivated her to pursue a master's degree to advocate for food policy changes.

Madelyn Downing

Madelyn Downing is an agribusiness instructor at a non-profit university in Ohio. Madelyn received her bachelor's degree in agribusiness marketing and management from The University of Northwestern Ohio. She grew up as the eighth generation on a 200-acre fruit and vegetable farm in Ohio, learning the ins and outs of the operations and the struggles that produce farmers can endure in America. She is passionate about changing the current scope of American Agriculture and fostering change among the next generation of leaders. Madelyn's current role as an educator provides the opportunity to work directly with the future of the agriculture industry. She is involved as the Lima community Farmer's market manager alongside the students in her newly developed 'Ag Club' at the university. The club offers an inclusive opportunity for students from diverse backgrounds to work directly with local farmers, food producers, and business owners, providing the community with much-needed access to fresh and local food. The lifelong access to homegrown fruits and vegetables from her family's farm drives Madelyn's passion for educating the public and providing them with access to these products.

Alexandra Greenwald

Alexandra Greenwald graduated from Portland State University with a degree in Environmental Studies and Geography. After graduating, Alexandra served her first year with AmeriCorps through a San Francisco, CA-based nonprofit called Education Outside, which brought garden-based science education to public elementary schools. She found her year of teaching to be exceptionally rewarding because of the curiosity she witnessed from her students, and found that cooking with her students in the garden was the best part of the year. A few years later, Alexandra began a two-year service with FoodCorps - AmeriCorps through the San Francisco Unified School District, working within the Student Nutrition Services Department. Her other duties included district-wide taste tests, promoting the Harvest of the Month program, assisting school cafeterias, school garden programming, and supporting the implementation of district-wide cafeteria projects.

Since her time with AmeriCorps - FoodCorps, Alexandra has been working with a local nonprofit organization that runs various farmers' markets throughout the Bay Area. Her main role is working with the Rollin' Root, a mobile farmers market program that delivers and sells farmers' market produce out of a food truck. The mission of the program is to deliver farm-fresh produce to those who would otherwise not be able to make it to the farmers' market. Through all these experiences, Alexandra has found a passion for food accessibility and food sustainability, and feels proud to be a part of her local food system.

Kellie Henwood

Kellie Henwood is a Sustainable Agriculture and Local Food Systems Extension Educator and Specialist with a long-standing career dedicated to strengthening regional food systems. Since 2013, she has led Washington State University Extension's Regional Small Farms Program, delivering experiential education, evidence-based research, policy guidance, and resources to farmers, with a strong focus on community development. At the core of her work is collaboration with local farmers, researchers, and community organizations to advance equitable land access, create culturally relevant agricultural learning opportunities, support farm viability and business planning, and develop programs for new and beginning farmers. She is also an active member of the WSU Statewide Food Systems Team. Kellie holds an undergraduate degree in Sustainable Agriculture from The Evergreen State College in Washington. Prior to joining WSU Extension, she built extensive hands-on experience through years of work on diversified organic farms and in the commercial fishing industry. Her commitment to farmland protection and farmer advocacy has also included board service for Jefferson Land Trust and Tilth Alliance—two organizations dedicated to supporting farmers and preserving working lands.

Gustavo Zaragoza

Gustavo Zaragoza has had close to a decade of experience in the food and healthcare industries. Starting from a humble beginning in the hospital as a "food runner" during his undergraduate studies at ASU. Gustavo completed his undergraduate studies and eventually earned his degree in Nutrition and Dietetics. During his career, he participated in an internship at the Paradise Valley School District, where he helped manage elementary school kitchens and fed children. Gustavo assisted in upholding federal standards for school lunch programs. Afterwards, there was also a stint at the Arizona Department of Education, starting as an auditor for the Child and Adult Care Program and eventually becoming the supervisor for the daycare homes section of that program. Following this, he spent five years at NSF International, where he eventually became a head auditor and area trainer for the Southwest region, overseeing private health inspections that are partially based on the federal food code and retail company standards. Currently, Gustavo is a staff member at ASU working for Learning Enterprise. The pursuit in Sustainable Food Systems (MS) aims to provide a gateway to addressing the water crisis in Arizona, reducing overall food waste in the state and the USA, and combining this with a certificate in Data Analytics.

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