PAYMENT FOR ECOSYSTEM SERVICES AND SOIL HEALTH WORKING GROUP FINAL REPORT

Prepared for the Vermont General Assembly in Accordance with

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Senate Committee on Agriculture

House Committee on Agriculture and Forestry

By the

Vermont Agency of Agriculture, Food and Markets

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# Executive summary (TBD after completion of the Report)

Due to the initiative of three farmer-led watershed coalitions, the Vermont Legislature enacted Act No. 83 of 2019, Sec. 3 which was signed into law by Governor Scott on June 20, 2019, which charged the Secretary of Agriculture, Food and Markets to convene a Soil Conservation Practice and Payment for Ecosystem Services Working Group. Act No. 129 of 2020 established fresh charges for the renamed Payment for Ecosystem Services and Soil Health Working Group. This report fulfils the requirements of Act No. 129 (2020) and Act No. 47 (2021) that established the requirement that the Secretary of Agriculture, Food, and Markets submit a report to the Senate Committee on Agriculture and the House Committee on Agriculture and Forestry on behalf of the Working Group by January 15, 2023.

Since submitting the first report to the Legislature on January 15, 2020, the Working Group met twenty-eight times to review approaches to payment for ecosystem services (PES) and soil health management and design a pilot PES program.

# Background and enabling legislation

Due to the initiative of three farmer-led watershed coalitions, the Vermont Legislature enacted Act No. 83 of 2019, Sec. 3, which charged the Secretary of Agriculture to convene a Soil Conservation Practice and Payment for Ecosystem Services Working Group. That legislation charged the Working Group to:

1. identify agricultural standards or practices that farmers can implement that improve soil health, enhance crop resilience, increase carbon storage and stormwater storage capacity, and reduce agricultural runoff to waters;
2. recommend existing financial incentives available to farmers that could be modified or amended to incentivize implementation of the agricultural standards identified under subdivision (1) of this subsection or incentivize the reclamation or preservation of wetlands and floodplains;
3. propose new financial incentives, including a source of revenue, for implementation of the agricultural standards identified under subdivision (1) of this subsection if existing financial incentives are inadequate or if the goal of implementation of the agricultural standards would be better served by a new financial incentive; and
4. recommend legislative changes that may be required to implement any financial incentive recommended or proposed in the report.

Between September 2019 and January 2020, the Working Group met in-person five times and held six webinars with experts and practitioners who provided resources and perspectives to aid in the Working Group’s thinking about tools, metrics, and system design for payment for ecosystem services (PES) programs. The Working Group submitted a Report to the Legislature on January 15, 2020, which satisfied the requirements under Act No. 83 of 2019. This report concluded that more time and expertise was needed for the Working Group to review and recommend an agricultural PES program for the State of Vermont which satisfied the goals of the farmer watershed coalitions which raised the need for a new PES program in Vermont.

Following several recommendations of the Working Group, as laid out in its 2020 Report, Act No. 129 of 2020 amended Act No. 83 of 2019 to rename the group the “Payment for Ecosystem Services and Soil Health Working Group”, (PES WG) establish the Working Group through February 1, 2022, include additional seats on the Working Group, and lay out additional charges for the Working Group.

In Act 129 of 2020, the Legislature specifically instructed the Secretary of Agriculture, Food and Markets to submit a report that shall include the following recommendations and analysis.[[1]](#footnote-1) This Final Report is organized accordingly:

1. a recommended payment for ecosystem services approach the State should pursue that benefits water quality, flood resilience, and climate stability, including ecosystem services to prioritize and capital or funding sources available for payments;
2. a recommended definition of healthy soils, a recommended method or systems for measuring soil health and other indicators of ecosystem health, and a recommended tool for modeling and monitoring soil health;
3. a recommended price, supported by evidence or other justification, for a unit of soil health or other unit of ecosystem service or benefit provided;
4. proposed eligibility criteria for persons participating in the program;
5. proposed methods for incorporating the recommended payment for ecosystem services approach into existing research and funding programs;
6. an estimate of the potential future benefits of the recommended payment for ecosystem services approach, including the projected duration of the program;
7. an estimate of the cost to the State to administer the recommended payment for ecosystem services approach; and
8. proposed funding or sources of funds to implement and operate the recommended payment for ecosystem services approach.

The Working Group met fourteen times in 2021 remotely via the ‘Zoom’ platform to advance work in preparing the findings and recommendations above. On February 2, 2021, The Agency of Agriculture, Food and Markets (VAAFM) retained the consulting and facilitation services of the Consensus Building Institute (CBI) to provide facilitation services for the Working Group. These facilitation services were extended through 2022 with a contract which was amended on February 18, 2022. The Agency of Agriculture, Food, and Markets, at the direction of the Payment for Ecosystem Services Working Group, contracted with a team of technical experts - led by the University of Vermont (UVM) Gund Institute for the Environment - to provide technical research and analysis services to the Working Group. The initial technical contract with UVM was executed on September 29, 2021, and amended on June 30, 2022. The technical contractors produced ten task and subtask reports in collaboration with the Working Group, outlined in the appendices of this report. These UVM reports and topics are listed just below:

1. Measuring ecosystem services for soil health
2. Soil health scenarios for Vermont
3. Farmer PES Survey and Interview results
4. Calculating the full economic costs of selected field management change scenarios for improving soil health on Vermont farms
5. Valuation of ecosystem services from soil health
6. Review of PES programs, including Vermont farmer PES concepts
7. Approaches to quantification of climate regulation ecosystem services at the whole farm scale
8. PES program design issues and recommendations.

Act No. 47 of 2021 extended the Working Group’s charge through February 1, 2023. The Working Group thus submitted an Interim Report to the Legislature on February 1, 2022.

Act 9 of 2021 appropriated $250,000 to the Agency for Agriculture, Food, and Markets (AAFM) for continuation of work in soil conservation practices and payment for ecosystem services which included the costs of the working group initially established by Act 83 of 2019.[[2]](#footnote-2) Add $250K. Act No. 185 of 2022 (the FY 2022 budget) appropriated $1,000,000 to the Agency of Agriculture, Food, and Markets “for the development of an agricultural Payment for Ecosystems Services Program to support the work of the Payment for Ecosystem Services and Soil Health Working Group (PES WG) – as authorized by 2019 Acts and Resolves No. 83, amended by 2020 Acts and Resolves No. 129 and 2021 Acts and Resolves No. 47 – to enable Payment for Ecosystem Services Program development to retain facilitation services, contract identified research needs, fund pilot program development, and deliver payments to farmers for quantified ecosystem services.”

In 2022, the Working Group met fourteen times via Zoom and once in-person, to advance its findings and recommendations under its legislative charges and to explore options and prioritize a specific approach for a pilot program.

## Key concepts

### What are ecosystem services?

In the Working Group’s 2021 report to the Legislature, the group defined ecosystem services (ES) as “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life”[[3]](#footnote-3) i.e. “the set of ecosystem functions that are useful to humans.”[[4]](#footnote-4) By adding other forms of capital and investment to alter human management of agricultural systems, people may amplify the benefits provided by ecosystems and may glean additional value from the ES. The perceived or estimated value may be monetized, but can also be measured in other terms, including satisfaction (e.g. recreational enjoyment), public health costs avoided, or other benefits. The Working Group learned that there are disadvantages to a strictly market-based PES approach, mainly the potential for markets to undervalue farmers’ stewardship of natural capital and to ignore value that cannot be easily quantified.

In the context of farming in Vermont, key ecosystem services the Working Group identified to value are provisioning of clean water (i.e., retention of nutrients and soil), flood mitigation, and climate regulation, climate resilience, biodiversity, in addition to the cultivation of food and fiber—the ecosystem services for which farmers are currently paid, but for which many sectors do not set the price they receive for the foodstuffs produced. The Working Group also explored with intensity the importance of biodiversity and how it might be measured and included considered in an agricultural PES program. The Working Group recognized and explored the central role that Vermont’s soil and soil health play in all these ecosystem service.

The Working Group also outlined the concept of *natural capital*. Nature provides (and humans can degrade) natural capital – like healthy soils, functional landscapes such as wetlands, and perennial native vegetation – that sustain both human production and natural systems over generations. Natural capital results in *ecosystem services.* By focusing on natural capital, the Working Group took a more systems-based approach that can yield more interconnected ecosystem services than focusing solely on one or another ecosystem service.

As outlined in our 2021 report, the Working Group chose to focus primarily, but not solely, on healthy soil as an essential part of Vermont’s natural capital to invest in and rebuild. A focus on soil health provides a focal point for action and plausibly addresses several desired ecosystem services and outcomes, including improved farm productivity. Healthy soil – which means soil that has a well-developed, porous structure (‘spongy’), is chemically balanced, supports diverse microbial communities, and has abundant organic matter (derived from 6 V.S.A. § 4802(4) – is central to the sustainable, productive, and climate resilient growing of food and crops in Vermont and provides a host of additional environmental, economic, and social co-benefits. A PES system that rewards farmers for rebuilding healthy soils could potentially improve many ecosystem services simultaneously and provide a framework for a viable, sustainable, and regenerative Vermont agricultural system.

The Working Group identified, and the technical contractors the following ecosystem services as the key ecosystem services which could be feasibly linked as measurable outcomes to farmer improvements in cropland management to improve soil health:

1. Climate regulation (carbon storage and sequestration)
2. Downstream flood risk mitigation
3. Soil conservation
4. Climate resilience
5. Biodiversity

The Working Group has also been very interested in water quality; however, the Working Group’s technical contractors found that soil health is not always directly related to water quality and thus difficult to include in a soil health-focused PES program. While many water quality conservation practices have co-benefits with soil health, there is not a consistent causal link from soil health to water quality. Instead, the technical contractor recommended that the Working Group rely on other tools (like the Vermont Phosphorus Index and USDA’s Agricultural Policy/Environmental eXtender model) to assess water quality outcomes.[[5]](#footnote-5) An example of this non-casual relationship includes the hypothetical scenario where: compost is improved to a crop-field to improve soil health. The application of this compost can lead to improvements in soil organic matter and aggregate stability [the indicators of improvements of soil health], however, if the improvement of these characteristics of a healthy soil were achieved by a farmer through the overapplication of compost beyond what is agronomically required by the crop, water quality outcomes could be negatively affected through increased runoff of nutrients to surface waters. While there is a positive directionality between the adoption of water quality conservation practices (cover crop, no-till, management intensive grazing) and improvements in soil health, how those practices are implemented are key to assessing the attendant impacts to water quality. Therefore, the Working Group decided to investigate the five ecosystem services mentioned above.

It should also be noted that the ecosystem services do not operate in isolation but have co-benefits with one another. Therefore, while it is useful to assess ecosystem services individually to understand their relationship to soil health, the Working Group is interested in understanding the joint value of ecosystem services from agriculture and how ecosystem services can be “stacked” within an area of land to produce multiple co-benefits.

### How does a payment for ecosystem services system work?

We also outlined in our 2021 report that ES often provide public goods, but quantity and quality of the provisioning of these ES are influenced by private decisions. Those who supply the ES (or those whose land provides the service) are not always those who benefit. For example, water quality benefits from nutrient retention measures on farm fields help the entire watershed. Flood mitigation benefits from improved infiltration of soils benefit downstream and downgradient land users. Carbon sequestration has global benefits in the collective effort to mitigate climate change. The commodities market does not account for such ES benefits or costs and so does not provide for nor reward the improvement or harm to the natural capital of the soil that was extracted or enhanced to produce the agricultural commodity in question. Monetizing the benefits of ES and rewarding the farmer through a payment for ecosystem services (PES) is one strategy to ensure that public benefits are stewarded by those whose land can provide them.

A formal definition of PES is: a voluntary transaction where a well-defined service is ‘bought’ by at least one ES buyer from at least one ES provider, if and only if the ES provider secures ES provision.[[6]](#footnote-6) For instance, a public agency might pay a farmer for the quantified reduction in tons of soil erosion below the regulatory standard from their farm following a change in agricultural practices that the farmer considered, chose, and implemented.

the Working Group sought to learn about various PES programs in operation nationally and internationally to learn of best practices, what works, and what to avoid in designing a PES program. The Working Group’s technical contractor surveyed ten PES programs to assist the Working Group’s framing of a Vermont-focused PES program.[[7]](#footnote-7) These included two Vermont-focused programs – the Vermont Pay for Phosphorus Program and the Vermont Forest Carbon Project. The Working Group was also made aware of a regional assessment of over 1,300 ecosystem service programs and policies across the northeastern United States.[[8]](#footnote-8)

In understanding the best approach to program design, the Working Group grappled with the competing concepts of paying for *practices* and paying for *performance.* ‘Pay for practice’ programs identify a set of agricultural practices (such as reducing tillage, planting cover crops, and extending rotations) that have documented conservation benefits. These programs compensate agricultural producers for implementing these practices, often on a per-acre basis of implementation. The advantage of practice payments is that they can be evidenced-based with research done nationally or regionally, they are relatively easy to describe, implement, and monitor to ensure they were implemented to standards. On the other hand, performance-based payment programs identify quantifiable conservation outcomes and associated metrics that can either be measured or monitored. Performance-based programs will then compensate agricultural producers for the units of the metrics conserved, for example, lbs/acre of nutrients retained, or tons/acre of carbon sequestered. Performance-based programs have the advantage of leaving the “how” up to the farmer and focusing on the “what” is produced, focusing on outcomes, not practices that should or may lead to outcomes, and paying for outcomes based on clear market or societal valuations. However, outcome-based programs require more and sometimes prohibitively expensive monitoring and require time for the farmer to show statistically measurable benefit, hence delaying payment. An approach that focuses exclusively on measurement that is cost-effective and scalable will not provide ‘certainty’ for the farmer, that is, farmers may take actions that end up having no appreciable measurable benefit for a year-on-year basis and will thus not get paid, placing risk more on the farmer than a program. For instance, a strictly performance-based PES program that relies on soil health as a proxy for ES provision is that for some soil health indicators (such as soil carbon) it can take as many as five to seven years before changes can be detected.[[9]](#footnote-9) A strictly pay-for-performance soil health PES program could take several years to assess outcomes for producers, which would ultimately mean that producers would have to wait several years before receiving payments. Again, a performance-based approach that relies solely on measurement could place significant risk on the producer over a longer period than a practice-based program generally would.

The tradeoff between performance and practice-based systems can be understood in terms of risk placement. As the technical contractor’s outline, practice-based programs offer secure payments to agricultural producers who successfully implement practices and place the risk on the ecosystem service buyer that that the practice may not deliver the desired or complete outcomes. In comparison, a performance-based program may place a high level of risk on the producer if their management strategy fails to deliver the desired outcomes.[[10]](#footnote-10) PES programs manage this risk tradeoff in various ways. For example, the Vermont Pay for Phosphorus program (a performance-based program) offers an enrollment payment to farmers regardless of future performance.

It should be noted that there are “hybrid” models that seek to take evidence-based practices that have led to measurable outcomes through using more basic farm-specific data (soil type, slope, etc.) and modeling to arrive at calculated or derived ecosystem outcomes rather than farm-by-farm field-based monitoring. The advantage of these hybrid modeling-supported approaches includes lower monitoring and measurement costs for all, evidence-based practices with inclusion of some specific farm data, and the ability, depending on the model, at looking at multiple ecosystem services and anticipated benefits. The disadvantage of course is that these approaches don’t measure actual outcomes and are constrained by the assumptions and limitations of modeling and the model and can be seen as “black box” to program participants.

## The transactional limitations of PES

Since submitting our report to the Legislature in 2021, the Working Group has had opportunities to further understand PES as a concept and the limitations of that concept for a program in Vermont. PES as a formal concept is a transactional relationship between ecosystem service producers and one or several buyers.

However, there are other ways to value stewardship beyond a strict buyer-seller relationship. The Working Group’s technical contractors surveyed 179 farmers in Vermont and found that 99% of Vermont farmers believe improvements in soil health have benefits for the environment off their farm, 95% of Vermont farmers believe that they should take additional steps beyond required practices to protect soil health, and 90% of Vermont farmers believe they have a responsibility to be part of climate solutions.[[11]](#footnote-11) One could infer from these findings that Vermont farmers have an innate understanding of their responsibility for soil health management and that the value of their management practices extends beyond their farms. The Working Group learned that there can be disadvantages to “commodification” of ecosystem services by incorporating them into a market-based regime. Leimona et al. write that “The monetization and commodification of ES through PES … also raises ethical arguments by obscuring cultural, political and social relationships in environmental service generation …”[[12]](#footnote-12)

These concerns, along with concerns about determining a recommended price which we discuss below, led the Working Group to consider an approach that reduces the emphasis on accurately valuing ecosystem services in a transactional sense. Instead, the Working Group focused on an approach that places more emphasis on recognizing producers for their good stewardship of their agricultural land while encouraging and supporting producers with lower stewardship levels with improving. The survey referenced above provides an important window into the goals and needs of farmers, as the survey reported that 94% of Vermont farmers believe they have the knowledge and technical skill to enhance soil health on their farm, yet only 58% have the financial capacity to do so.

### Original Legislative Charge Tasks

In preparation for developing the recommendations as outlined by the 2020 Legislature, the WG also explored two key charges of the initial 2019 statute. These are both discussed briefly below.

1. *identify agricultural standards or practices that farmers can implement that improve soil health, enhance crop resilience, increase carbon storage and stormwater storage capacity, and reduce agricultural runoff to waters;*

The WG utilized AAFM to identify the existing practices that Vermont farmers can utilize to produce the mentioned ecosystem services. AAFM developed and the provided to the WG an extensive matrix of practices approved by the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS). These practices have been and evaluated nationally to indicate their conservation value. This matrix is attached as Appendix Y. As the WG reviewed these practices, they noted that several agro-forestry practices that might help produce the desired ES were not approved or used in Vermont. In part, this led to a NRCS discussion and action to provide for these additional practices in Vermont. In 2021, NRCS-VT adopted Conservation Practice Standard 381: Silvopasture as an eligible conservation practice for Vermont farmers to implement through the Environmental Quality Incentives Program (EQIP); this now means the full-suite of nationally avaliable agroforestry practices appropriate for Vermont are eligible for Vermont farmers to implement through NRCS; this includes: windbreaks, riparian forest buffers, silvopasture, alley cropping, forest farming.

1. *recommend existing financial incentives available to farmers that could be modified or amended to incentivize implementation of the agricultural standards identified under subdivision (1) of this subsection or incentivize the reclamation or preservation of wetlands and floodplains;*

The WG also received several presentations on existing federal and state programs and their financial incentives to not only reclaim or preserve wetlands and floodplains, but also to incentivize numerous practices and actions from soil health to aquatic and terrestrial biodiversity. Copies of these presentations can be found at \_\_\_\_\_\_. Some members of the Working Group and some public commentors from members of the public raised the concern about the sheer number of programs available to farmers for conservation and the potential inefficiency and confusion that can produce for farmers, technical service providers, and the public. Unfortunately, this is not an uncommon challenge across states. For instance, the Lancaster County Clean Water Partners commissioned an extensive catalogue of existing partners and programs for clean water alone available to the agriculturally rich Pennsylvania County and identified 49 separate funding sources.[[13]](#footnote-13)

Ultimately, all appropriated conservation program funding is obligated to farmers through state water quality and federal USDA NRCS EQIP programs on a year-on-year basis, with many millions of dollars of unfunded applications remaining. In total, between SFY 2016 and SFY 2021, VAAFM has invested $32.4 million dollars in clean water projects in farms, leveraging $18.9 million of federal investment, and $7.2 million of farmer investment.[[14]](#footnote-14) While some members remain concerned about the sheer number of programs, agencies have developed specific targeting of programs and priorities that require a service-delivery model that is not one-size-fits all. Evidence that farmers are successful in applying, contracting, and implementing these conservation programs is evidenced by the over 300,000 acres of annual conservation practices that were implemented between state and federal water quality programs between SFY 2016 and SFY 2020. Taking these concerns from some into consideration regarding existing programs and seeking to build on, rather than create a new program, the PES WG did recommend a pilot building off of a federal existing program (‘CSP’ or Conservation Stewardship Program) and informed by Vermont’s original foray into PES with the recognition only VESP program. This is detailed further below.

While not the explicit charge of the PES WG, the WG also heard public comment from and discussed how farmers could better navigate the plethora of conservation programs available. The PES WG recognizes that almost all state and federal programs have been developed over time, each program with its own unique statutory creation, evolution, constituencies, and complexities. While the State would of course have far more control over consolidating, integrating, or simplifying its programs should the Legislature decide such actions have merit, many state programs are connected to or supplement USDA NRCS programs which are national in nature and hard to influence, shape, or consolidate by a single state. Furthermore, Vermont has a diversity of farm types and farm sizes so one or a few programs cannot easily serve all of these needs.

The PES WG did explore several ideas in addition to its specific charge on tools or approaches that might aid and simplify farmer navigation of multiple programs and funding sources. Please see *Additional Considerations* below for further commentary.

# Recommended payment for ecosystem services approach

The Working Group explored several approaches for a payment for ecosystem services program, including several operational or proposed by Vermonters. In collaboration with our technical contractors, the Working Group explored three PES program proposals developed by three farmers, one of whom is a Working Group member, and two existing programs developed by the AAFM and the Vermont Agricultural Water Quality Partnership (VAWQP)[[15]](#footnote-15). The proposals were:

1. CSP+, presented by Guy Choiniere
2. VT PES Observed Metrics Approach, presented by Scott Magnan
3. VT Healthy Soil Protection & Restoration Act, presented by Stephen Leslie
4. The Vermont Environmental Stewardship Program (VESP) by AAFM
5. The Vermont Pay for Phosphorus Program by AAFM

These three farmer proposals are outlined in the ‘Farmer PES Program Proposals’ report and the two Vermont AAFM programs are outlined in{XXXX].[[16]](#footnote-16)

After receiving the $1 million appropriation from the Legislature in the FY 2022 budget, the Working Group began to focus on designing a pilot program that would utilize the appropriated funds for the enumerated uses. The pilot program would be an initial program focused on demonstrating proof-of-concept and providing the ability to learn key operational lessons to advance a potential future program.

Based on the objectives outlined in the Working Group’s Program Goals they developed by June of 2022, staff from the Agency of Agriculture, Food, and Markets developed five pilot program options during the summer of 2022 in collaboration with a Working Group Subtaskgroup for the Working Group to consider. The five options developed and presented were:

1. Soil health testing via Cornell Comprehensive Assessment of Soil Health (CASH)
2. Soil carbon testing via soil bulk density tests
3. Soil carbon modeling via a process-based model
4. In-field observation with modeling assessment and payment
5. In-field observation with rubric-based scoring

Though the Agency developed the five options distinctly, the intention was that a pilot program could combine and hybridize them. Copies of these proposals are avaliable in appendix x.

Given concerns with each of the pilot options for various reasons, the Working Group members decided to consider an alternative option to use the pilot appropriation to supplement payments to farmers in Vermont who enroll in the USDA Natural Resource Conservation Service’s Conservation Stewardship Program (CSP). CSP is the country’s largest conservation program by acreage but has historically seen low uptake among Vermont farmers. The program’s objective is to provide technical and financial assistance to farmers and ranchers to recognize their ongoing management efforts and incentivize additional conservation enhancements.[[17]](#footnote-17) The CSP program meets the definition of a threshold-based PES program, assessing, documenting, and requiring stewardship enhancements across cropland, pasture, associated agricultural land, and the headquarters area of a farm for fourteen resource concern areas,

In order to enroll in the program, farmers work one-on-one with NRCS or contracted third-party planners to evaluate their farms’ stewardship threshold eligibility using NRCS’ Conservation Assessment Ranking Tool. If their farms score sufficiently high, farmers can work with planners to select conservation activity enhancements in line with the farmers’ objectives. Farmers that do not meet initial planning thresholds can either develop a plan to meet standards or enroll in EQIP to address baseline resource concerns. After successful planning and ranking, a farmer can then sign a 5-year contract with NRCS and receive annual payments for implementing practices on their farms and maintaining existing conservation levels.

Clients who enroll in CSP are eligible for payment from four different program elements:

1. Stewardship Threshold Payments for meeting Resource Concern Categories for each landuse assessed
2. Landuse Payments
3. Enhancement Practice Payments
4. Base Payments [Optional]

Producers who meet the standards and successfully enroll in CSP would receive a minimum annual payment of $1,500 regardless of acreage.

The Working Group’s USDA-NRCS Conservation Stewardship Program with Vermont State Enhancement pilot approach would supplement CSP payments to farmers from NRCS with lump sum payments at specific points in the CSP planning and contract process:

1. A **Planning Completion Payment (PCP)** upon completion of conservation planning with a CSP planner;
2. A **Contract Incentive Payment (CIP)** upon signing of a 5-year agricultural CSP contract; and
3. Annual **Implementation Incentive Payments (IIP)** for implementation of the CSP contract for 5 years.

The Working Group’s approach would also devote some of the pilot funds toward one full-time equivalent conservation technical assistance staff to supplement existing NRCS and third-party planners with enrolling additional clients, given the anticipated increase in applications from the Working Group’s approach.

There are several advantages to this approach from the Working Group’s perspective. The CSP with Vermont State Enhancement approach leverages an existing program that focuses on incentivizing environmental stewardship and the provision of ecosystem services. CSP includes the opportunity for one-on-one support and technical assistance from planners for clients and potential clients. The Working Group heard from several producers with farms of diverse sizes and crop types who are currently enrolled in CSP that the program is valuable to them, but that the low base payment is a barrier to enrollment. The Working Group’s pilot approach would provide higher payments for new clients and supplement the payments to existing clients already under 5-year contracts.

# Definition of healthy soils, method for measuring soil health, and recommended tool

6 VSA chapter 215 defines “healthy soil” as “soil that has a well-developed, porous structure, is chemically balanced, supports diverse microbial communities, and has abundant organic matter.” Healthy soil is central to the sustainable, productive, and climate resilient growing of food and crops in Vermont and provides a host of additional environmental, economic, and societal co-benefits. The Working Group discussed the concept of the “soil sponge” as a related concept, which is defined as the structural and functional integrity of soils, which in turn is dependent on the biological integrity of the land, both above and below ground. The concept of the “soil sponge” can be helpful for understanding that soil health has both structural and functional aspects and highlights the role of biodiversity for soil health and related ecosystem services.

There is no single measure of soil health – many biological, physical, and chemical characteristics of soil that relate to ecological function can be measured as indicators of soil health. The Working Group identified a list of five measurable characteristics that could be used as indicators for five ecosystem services of interest for a PES program. The Working Group’s five indicators of soil health are as follows[[18]](#footnote-18):

1. Organic matter (the portion of soil that consists of decomposed plant and animal tissue);
2. Aggregate stability (the ability of soil aggregates to resist disintegration when disruptive forces are applied);
3. Bulk density (a measure of soil mass per volume and an indicator of soil compaction);
4. Greenhouse gas (N2O and CO2) emissions; and
5. Soil biodiversity (the mix of living organisms in soil).

The technical contractors studied the above indicators and found that four of the five metrics are feasibly measurable for a PES program: organic matter, aggregate stability, bulk density, bulk density, and soil biodiversity.[[19]](#footnote-19) The technical team found that the cost and time required to measure greenhouse gas flux from soil surface would be cost-prohibitive. Models for greenhouse gas flux exist (varying from weak to moderate accuracy), though they may not capture all management practices for Vermont. However, measuring of soil carbon is feasible and requires multi-year monitoring and collection of bulk density cores.

Additionally, the technical contractors studied and illustrated how changes in management practices on Vermont farms can influence the five soil health indicators at the field scale.[[20]](#footnote-20)

A “Vermont soil health index” would combine the various indicators of interest to the Working Group into a single score to represent soil health in Vermont. Creating such an index would need to follow a facilitated process to determine how heavily each indicator weighs in the overall score. Such a process would also require ample time, resources, and technical expertise.

Similarly, the Cornell Comprehensive Assessment of Soil Health (CASH) test assesses scores for several attributes against regional baselines renders an overall score. The CASH test attributes overlap with the Working Group’s priority indicators to some degree and would allow for comparisons with data from across the region.

A modeling-based approach to monitoring soil health indicators would reduce operational costs (due to labor, shipping, and other costs for sample-collection and testing). While it is not currently feasible to measure greenhouse gas emissions from soil surface, models like USDA’s COMET-FARM model are able to estimate CO2 and N2O flux based on farm management practices. However, COMET-FARM does not assess the other four indicators of interest.

One approach would be to develop a new model or modify existing models to estimate all five indicators. Such an approach would reduce the costs of direct measurement for a PES program. Nonetheless, there would still be the need to collect field data to develop models and provide inputs into the models to estimate additional soil health parameters.

*\*I think we should say something here about CSP’s approach to soil health and cross-walk with WG’s understanding.*

# Recommended price for a unit of soil health or other ecosystem service

The Working Group’s approach to determining a price was focused on understanding two components of a market price: 1) the amount that society would be willing to pay for a unit of soil health based on the ecosystem services generated and 2) the amount that farmers would be willing to accept for providing ecosystem services through the management of their farms. By understanding these two payment rates on a per-acre basis, one could in principle determine a price that society could pay that would compensate farmers adequately for their provision of ecosystem services.

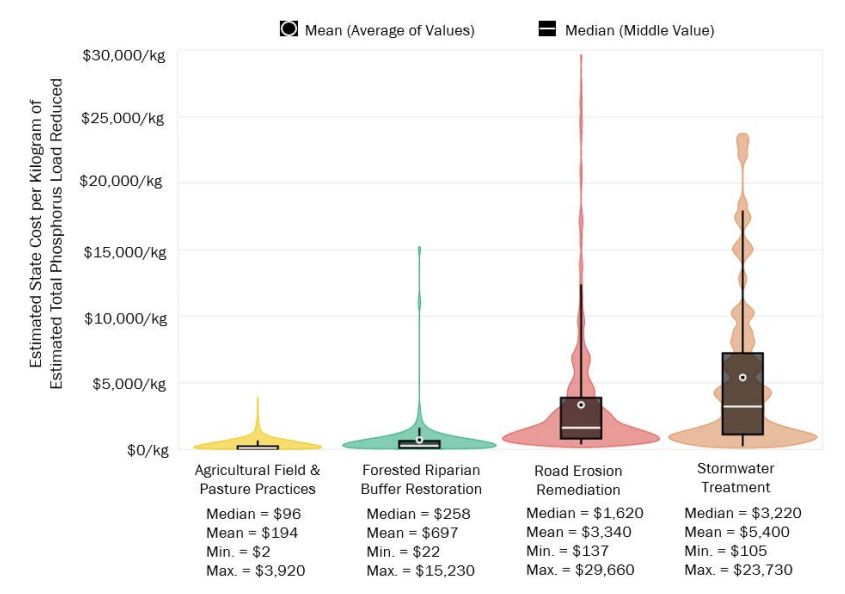
In order to better understand the cost – or value – of ecosystem services provided by agricultural land management changes, the technical contractors investigated preliminary valuation estimates for four ecosystem services generated by improvements in soil health – climate regulation (carbon storage), nutrient retention (phosphorus loading reduction), soil erosion control, and flood runoff mitigation.[[21]](#footnote-21) (The technical contractors also investigated potential options for valuing for soil biodiversity but found that none were feasible within the scope of their study.) The technical team assessed benefits from two scenarios for soil health improvements: ambitious (“best”) improvements and “good” improvements. The “best” scenario is defined as a 50% increase in soil organic matter and 20% decrease in soil bulk density compared to the reference condition. Similarly, the “good” scenario is defined as a 25% increase in soil organic matter and 10% decrease in soil bulk density.

“Best” improvements in soil health on Vermont farms could yield benefits worth $34 per acre per year across the suite of four ecosystem services combined. Similarly, the technical team found that “good” improvements could yield benefits worth $17 per acre per year. It is worth noting that while these are estimates of the value of these ecosystem services to society, they are not exactly estimates of what society would be willing to pay for these services.

The technical contractors also investigated the minimum payment levels that farmers would be willing to accept for provision of ecosystem services through their management of soil health. They surveyed 179 farmers in Vermont and found that the mean per acre compensation rate for meeting soil health threshold goals under a program was $206.[[22]](#footnote-22) The technical contractors further investigated the payment rate by interviewing 35 Vermont farmers to explore their perspectives on compensation associated with a payment for ecosystem services and soil health program. That follow-up study found that mean minimum and preferred per-acre payment rates required by farmers for *maintaining* soil health were $40 and $186 respectively. Furthermore, the mean minimum and preferred per-acre payment rates required by farmers for *enhancing* soil health were $269 and $843 respectively.[[23]](#footnote-23)

There is a clear difference between the valuations of ecosystem services from soil health and the amount that would be meaningful for producers to maintain or enhance soil health on their farms. Structuring a PES program around the economic valuations of the ecosystem services identified risks paying producers less than would be meaningful for them. Structuring payments around a “recommended price” would also raise concerns about whether producers would voluntarily enroll in such a program that pays them less than they would accept.

It is important to note that farmer’s willingness to accept (the cost to them to implement soil health practices) and the technical contractor’s review of value of ecosystem service function improvement cost diverge from the actual costs of conservation practice implementation to meet environmental goals in Vermont as reported by the Vermont Clean Water Investment Report. [[24]](#footnote-24) Whereas ecosystem service valuations from the technical contractor utilized WWTF figures that calculated an abatement cost of $100 per pound of phosphorus, actual median costs to the State of Vermont to reduce phosphorus have far exceeded $100 per pound for every sector but agriculture. Reassessing eco-system service valuation with actual costs to the State of Vermont would greatly increase the value of Phosphorus, on an annual basis. Median prices for phosphorus abatement for stormwater treatment practices are over $3,000 more per kilogram than compared to agriculture.



It should also be noted that any payment levels for the pilot approach would have been determined based on the funding already appropriated by the Legislature. This is different from a strictly market-based price.

The discrepancy in these results led the Working Group to reconsider structuring payments around a recommended price for a unit of soil health or ecosystem services. Instead, the Working Group’s CSP with Vermont State Enhancement pilot approach seeks to pay farmers for maintaining a stewardship *threshold* defined in their CSP contract*.* This approach allows for greater flexibility in providing standards for farms to meet conservation goals while still paying farmers for meaningful contributions to conservation stewardship.

# Proposed eligibility criteria

In its Program Objectives, Elements, and Assumptions, the Working Group agreed that all farmers should be eligible to participate if they are in good standing with the Secretary of Agriculture, Food, and Markets (as defined under 6 VSA chapter 215). However, only those farmers who meet the standards and requirements set by the program will receive payments.

It should also be noted that NRCS Vermont applies a ranking system for CSP once applications reach the available funding levels. However, this has not historically been the case in Vermont, and so the Working Group does not anticipate that ranking will factor into eligibility for this program.

# Methods for incorporating the recommended approach into existing research and funding programs

The Working Group learned about a range of research and funding programs at the state and federal levels that the program could be incorporated with. The pilot approach would directly build the USDA-NRCS Conservation Stewardship Program (CSP) by providing funds to farmers and increasing enrollment in the state. The pilot also builds on lessons learned from the Vermont Environmental Stewardship Program (VESP). VESP was a pilot voluntary program that encourages agricultural producers to achieve high environmental standards through responsible land stewardship. Participants in the program are eligible for additional technical and financial assistance to meet their stewardship goals.

VAAFM’s Agricultural Clean Water Initiative Program (Ag-CWIP) education, outreach, and technical assistance funding program to support partners who work with farms to improve water quality across the state of Vermont through education and outreach, technical assistance, organizational capacity development, and conservation practice surveys. Ag-CWIP already supports several initiatives of interest related to the Working Group’s goals, such as grant opportunities for farmers and other stakeholders to investigate metrics related to water quality and ecosystem services.

While the Working Group’s pilot approach is a collaboration between USDA-NRCS and the State, there is the potential that the pilot could inform an application for USDA NRCS’ Regional Conservation Partnership Program (RCPP). RCPP provides funding for partnerships between NRCS and other entities that seek to develop solutions to natural resource challenges on agricultural land. The Working Group’s CSP with Vermont State Enhancement pilot approach could lead to a future RCPP application for a version of CSP tailored to the specific needs of Vermont farmers.

The Working Group learned from several of its members and other stakeholders that navigating the range and variety of state and federal funding programs can be seen as a challenge for farmers who seek to leverage these opportunities. Although many funding programs exist, farmers are often unaware the range of options available, which ones might be best suited to their needs, and how to apply for them. Other state-level initiatives have raised the concern about navigation – the Governor’s Commission on the Future of Vermont Agriculture recommended in its 2021 Action Plan that the state “Establish a new full-time permitting, regulation, and funding ‘navigator’ position at VAAFM to assist a range of farm and food businesses streamline their experience of government programs and resources.” Working Group members put forward the idea of creating an online portal where farmers can access information about the various programs as they decide which to apply to. Another idea was to use “farm teams” to provide technical assistance and shared learning opportunities to multiple farmers.

# Potential future benefits

The Working Group’s program approach would yield several benefits to farmers and the state more broadly. Firstly, the program would yield improvements in conservation in Vermont agriculture. The program would incentivize and pay for improvements in soil health outcomes on Vermont farms that would provide the ecosystem services identified by the Working Group. The program would also yield improvements in water quality and data for tracking progress in the state’s water quality efforts.

Secondly, the program would yield tangible benefits to Vermont farmers. The program would also provide direct funding to farmers – a key desire of farmers within the Working Group and beyond. In addition to funding, the program would provide direct technical assistance to farmers from NRCS or third-party planners to support them in conservation planning and addressing resource concerns on their farms. Critically, farms of diverse sizes, types, and land tenure arrangements would be able to access the program.

Thirdly, the program would set the state up to leverage increased incoming federal funding for USDA and NRCS under the Inflation Reduction Act, including funding increases for CSP and other programs like EQIP and RCPP.

The projected duration of the pilot program would be three years (2023-2025) with the potential for a larger subsequent to be developed based on lessons learned during pilot implementation.

# Estimate of the cost to the state

[From pilot development subgroup]

# Proposed funding or source of funds

The funding for the pilot would come from the FY 2022 budget appropriation for the Working Group’s pilot program, along with resources from USDA NRCS-Vermont.

Should the state pursue an RCPP grant in the future, the funding for that program would come from NRCS with matching monetary or in-kind contributions from the state. These funding requirements would become clearer as more is learned from implementation and operation of the pilot.

# Other considerations

## Biodiversity

The Working Group identified biodiversity is a key ecosystem service provided by farms in Vermont. Microorganisms and fauna in soil participate in several ecosystem functions, including the formation of soil structure, carbon and nutrient cycling, decomposition of plant and animal matter.[[25]](#footnote-25) For these reasons, biodiversity is generally regarded as a supporting ecosystem that regulates other ecosystem functions. As an ecosystem service, it provides benefits both locally (to the farm operation) and even more broadly by providing a foundation for other ecosystem functions and conserving genetic resources. The Working Group included soil biodiversity as a measurable indicator of soil health and biodiversity as an ecosystem service. The Technical contractors found that it would be feasible for a payment for ecosystem services program to include soil biodiversity as a measurement. The CSP program currently includes terrestrial biodiversity in the form of assessment and ranking against terrestrial habitat considerations.

There are two general approaches for measuring soil biodiversity. One approach is to measure *functional* diversity, which “refers to those components of biodiversity that influence how an ecosystem operates or functions.”[[26]](#footnote-26) This approach seeks to capture the range of ecosystem functions carried out by the organisms present. The other approach is to measure the *amount* of biological diversity, which is often inferred as an indicator of diversity though not a direct measurement. Such approaches include measuring microbial biomass and respiration.

Soil biodiversity can also be measured at the *microbial* scale and/or by monitoring soil invertebrates (ranging from microscopic mites to earthworms to dung beetles) which play significant roles in the delivery of ecosystem services.

The technical contractors pointed out that, while there are methods of measuring soil biodiversity, it can be difficult to interpret results. Ideally, a locally relevant reference point should be selected from an optimal undisturbed or otherwise desired site.[[27]](#footnote-27) Furthermore, the FAO recommends that soil biodiversity measurements should be “sensitive enough to reflect the influence of management and climate on long-term changes in soil quality but not be so sensitive as to be influenced by short-term weather patterns and robust enough not to give false alarms.” Furthermore, “Such measurements must be robust and not subject to rapid (and unstable) rates of change, related to the basic methodological problem that soil biodiversity is highly dynamical.”[[28]](#footnote-28)

Working Group members explored methods for measuring soil biodiversity and interpreting metrics. One such method was submitted by one Working Group member organization titled a draft “Biodiversity Matrix” that seeks to assess indicators of biodiversity across the farm and assign scores that can then be compiled into a final measurement (see appendix). The advantage of such an approach is that it would be simple to understand for farmers and could empower them to make specific changes in their farm management. The disadvantage, however, is that a payment for ecosystem services program would need to be able to make these qualitative assessments in a standardized way and any methodology would require peer-review to ensure that weightings are meaningful and relevant to conditions in Vermont.

Given the clear interest in biodiversity from the Working Group and the absence of consensus on metrics and interpretation for payment for ecosystem services program in Vermont, the Working Group believes that resources should be committed toward researching approaches to measuring biodiversity and interpreting metrics, particularly around translating qualitative observations into robust quantitative metrics. This research would inform a broader PES program in the future.

## Encouraging farmer participation

Working Group members have been interested in exploring opportunities to encourage farmers to participate in the pilot program. Farmer watershed groups have been involved as members and have contributed to program design, outreach, and feedback. The continued involvement and support of farmer watershed groups will be important for successful rollout and take-up of the pilot program. These groups have also expressed interest in exploring innovative practices and approaches to measurement that could be incorporated in a future program. Grants from programs like the Agricultural Clean Water Investment Program could support projects to pilot metrics for ecosystem services of interest to the Working Group.

## Easing Navigation of Existing Programs

[TO BE DONE} 1) farm team concept; 2) navigator idea as Jon Winston developed; 3) suggested portal or web tool for multiple programs.

# Appendices

## List of Working Group Members

Pursuant to Act No. 129 of 2020, Section 24, the Working Group shall include the following members:

1. the Secretary of Agriculture, Food and Markets or designee;
   1. *Deputy Secretary Alyson Eastman (Co-Chair)*
2. the Secretary of Natural Resources or designee;
   1. *Marli Rupe – Department of Environmental Conservation*
3. a representative of the Vermont Housing and Conservation Board;
   1. *Stacy Cibula (Co-Chair)*
4. a member of the former Dairy Water Collaborative*;*
   1. *Brian Kemp – Champlain Valley Farmer Coalition*
5. two persons representing farmer’s watershed alliances in the State;
   1. *Paul Doton – Connecticut River Watershed Farmers Alliance*
   2. *Scott Magnan – Franklin Grand Isle Farmer’s Watershed Alliance*
6. a representative of the Natural Resources Conservation Council;
   1. *Jill Arace – Vermont Association of Conservation Districts*
7. a representative of the Gund Institute for Environment of the University of Vermont;
   1. *Alissa White*
8. a representative of the University of Vermont (UVM) Extension;
   1. *Joshua Faulkner*
9. two members of the Agricultural Water Quality Partnership;
   1. *Matt Vaughan – Lake Champlain Basin Program*
   2. *Travis Thomason – NRCS Vermont*
10. a representative of small-scale, diversified farming;
    1. *Maddie Kempner – Northeast Organic Farming Association of Vermont*
11. a member of the Vermont Healthy Soils Coalition;
    1. *Cat Buxton or Didi Pershouse*
12. a person engaged in farming other than dairy farming;
    1. *Ed Pitcavage – Philo Ridge Farm*
13. a representative of an environmental organization with a statewide membership that has technical expertise or fundraising experience;
    1. *Heather Furman – The Nature Conservancy in Vermont*
14. an agricultural economist from a university or other relevant organization within the State;
    1. *David Conner – University of Vermont [now vacant]*
15. an ecosystem services specialist from UVM Extension;
    1. *Juan Alvez*
16. a soil scientist*;*
    1. *Meredith Albers – NRCS Vermont*

## Table of meetings, dates, and agenda topics (since 2021)

|  |  |
| --- | --- |
| Meeting Date | Key Agenda topics |
| March 16, 2021 | * Review of legislative charge and rules of the road * Conservation Innovation Grant PES Effort * National Conservation Innovation Grant with Vermont Land Trust and UVM Extension * Agency of Agriculture, Food, and Markets updates * Soil Health Network update |
| April 15, 2021 | * Proposed work plan and creation of workstreams to advance tasks * Workstreams kick-off in small groups |
| April 28, 2021 | * Review of Working Group protocols * Initiation of work plans in task groups |
| May 12, 2021 | * Task group report outs and Working Group requests * Small group discussions to advance task group work plans |
| May 26, 2021 | * Questions to the full Working Group from task groups * Small group discussions to advance task group work plans * Report outs from task groups |
| June 9, 2021 | * Questions to the full Working Group from task groups * Small group discussions to advance task group work plans * Report outs from task groups and outlines of next steps |
| June 23, 2021 | * Programmatic questions for consideration * Review of components of soil health to be measured and related ecosystem services * Discussion of soil unit and pricing issues * Planning for summer activities * Next steps: structure and goals for fall Working Group activities |
| September 21, 2021 | * Review of summer work and progress * Vermont Climate Council and Future of Agriculture Commission: connecting and integrating with parallel efforts * Work Plan for the remainder of 2021 |
| October 5, 2021 | * Scope of work for technical consultant support – oversight by and interaction with the Working Group * Discussion on engaging farmers in the Working Group’s development of options * NSF grant update (University of Vermont) |
| October 19, 2021 | * Discussion on CSP and CSP+ proposal * Program structure development considerations * Update and request for input from technical services team – 1) soil health draft matrix and scenarios and 2) program types and examples to explore |
| November 16, 2021 | * Update from technical consultant on research tasks * Soil health and its connections to other benefits, including biodiversity (VAAFM and Northeast Organic Farming Association of Vermont) |
| December 7, 2021 | * Brief updates from technical consultant on research tasks * Review of PES programs * Program ideas (Scott Magnan & Stephen Leslie) * Ideas for measurement and quantification |
| December 21, 2021 | * Farmer survey development * Valuation of ecosystem services from soil health * Review of PES programs * Measurement, quantification, and program design |
| January 4, 2022 | * Discussion of valuation of ecosystem services from soil health * Detailed discussion on program design * Technical consultant activities for the first quarter of 2022 * Edge of field and whole farm approaches |
| January 18, 2022 | * California Healthy Soils Program: lessons for program design * Discussion on measurement and assessment for program design * Technical consultant updates |
| February 1, 2022 | * Review of approaches to valuation of ecosystem services from soil health * Program design updates * Debrief of California Healthy Soils Program presentation * Technical consultant updates |
| February 15, 2022 | * Technical consultant updates * Brief review of existing “whole farm” programs * Presentation on a whole farm approach (Tony Fleming, Wild Farm Alliance) * Discussion on taking the ideas forward |
| March 15, 2022 | * Valuation of reducing phosphorus loss and erosion and carbon storage * Small group discussions on “whole farm”, “biodiversity”, and “tiering” * Technical consultant updates * Update on PES funding proposals before the Legislature |
| April 5, 2022 | * Net-zero farm operations with regards to greenhouse gas emissions * Farmer payment level survey & stakeholder engagement * Program design updates * Moving forward to detailed program design |
| April 19, 2022 | * Farmer payment level survey & stakeholder engagement * Overview and discussion of draft program goals and objectives * Review of ground rules and decision-making |
| May 3, 2022 | * Overview and discussion of draft program goals and objectives * Review of potential biodiversity metrics |
| May 17, 2022 | * Update on farmer survey and interviews * Threshold and baseline payment options * Review and discussion of draft program vision, goals, and objectives |
| June 7, 2022 | * Final review of program goals and objectives * Summer pilot development |
| September 20, 2022 | * Stage-setting for fall 2022 * Review of draft pilot design options * Fall 2022 timeline and activities |
| October 4, 2022 | * Debrief of pilot program options * October constituency outreach |
| November 1, 2022 | * Overview of funding opportunities around technical assistance, navigation, and coordination * Overview of CSP with Vermont State Enhancement pilot program option * Questions, discussions, and refinements to the pilot option * Decision on a final pilot recommendation from the Working Group * Planning for the Working Group’s 2023 report |
| November 29, 2022 | * Review of draft report outline * Update on pilot development |

## June 2022 WG Program Design Objectives

## CSP w/ VSE pilot design materials

## Biodiversity matrix

## UVM task reports

1. (2020 Acts and Resolves No. 129, Sec 24 §§(d)(1) – (8)) [↑](#footnote-ref-1)
2. 2019 Acts and Resolves No.9 Sec. 22 § (b)(3) [↑](#footnote-ref-2)
3. Gretchen C. Daily, ‘Introduction: What Are Ecosystem Services?’, in *Nature’s Services: Societal Dependence on Natural Ecosystems* (Washington, DC: Island Press, 1997), 4. [↑](#footnote-ref-3)
4. Claire Kremen, ‘Managing Ecosystem Services: What Do We Need to Know about Their Ecology?’, *Ecology Letters* 8, no. 5 (May 2005): 468–79, https://doi.org/10.1111/j.1461-0248.2005.00751.x. [↑](#footnote-ref-4)
5. Alissa White et al., ‘Measuring Ecosystem Services from Soil Health’, Vermont Payment for Ecosystem Services Technical Research Report #1 (University of Vermont, December 2021), 3. [↑](#footnote-ref-5)
6. Sven Wunder, ‘Payment for Environmental Services: Some Nuts and Bolts’, Occasional Paper No. 42 (Bogor: Center for International Forestry Research, 2005), https://www.cifor.org/publications/pdf\_files/OccPapers/OP-42.pdf. [↑](#footnote-ref-6)
7. Christopher Bonasia, Lindsay Ruhl, and Nour El-Naboulsi, ‘Review of PES Programs’, Vermont Payment for Ecosystem Services Technical Research Report #6 (University of Vermont, February 2022). [↑](#footnote-ref-7)
8. Alicia F. Coleman and Mario Reinaldo Machado, ‘Ecosystem Services in Working Lands Practice and Policy in the U.S. Northeast: Successes, Challenges, and Opportunities for Producers and Extension’ (Kansas City: Extension Foundation, 15 April 2022), https://online.flippingbook.com/view/749315583/2/. [↑](#footnote-ref-8)
9. Alissa White et al., ‘Field Scale Soil Health Scenarios’, Vermont Payment for Ecosystem Services Technical Research Report #2 (University of Vermont, May 2022), 5. [↑](#footnote-ref-9)
10. Bonasia, Ruhl, and El-Naboulsi, ‘Review of PES Programs’, 12–13. [↑](#footnote-ref-10)
11. Alissa White, ‘Results of the 2022 Vermont Farmer Conservation & Payment for Ecosystem Services Survey’, Vermont Payment for Ecosystem Services Technical Research Report #3a (University of Vermont, June 2022), 6. [↑](#footnote-ref-11)
12. Beria Leimona et al., ‘Fairly Efficient, Efficiently Fair: Lessons from Designing and Testing Payment Schemes for Ecosystem Services in Asia’, *Ecosystem Services* 12 (April 2015): 22, https://doi.org/10.1016/j.ecoser.2014.12.012. [↑](#footnote-ref-12)
13. https://lancastercleanwaterpartners.com/wp-content/uploads/2021/04/Lancaster-Clean-Water-Partners-and-Resources-Inventory-March-2021.pdf [↑](#footnote-ref-13)
14. https://legislature.vermont.gov/assets/Legislative-Reports/AAFMFY21ReportonFinancialandTechncialAssistance.pdf [↑](#footnote-ref-14)
15. http://vtagcleanwater.org/ [↑](#footnote-ref-15)
16. Christopher Bonasia et al., ‘Farmer PES Program Proposals’, Vermont Payment for Ecosystem Services Technical Research Report #6B (University of Vermont, December 2021). [↑](#footnote-ref-16)
17. ‘Farmer’s Guide to the Conservation Stewardship Program’ (National Sustainable Agriculture Coalition, November 2020), 6, https://sustainableagriculture.net/wp-content/uploads/2020/11/CSP-2020-draft3-interactive-1-1.pdf. [↑](#footnote-ref-17)
18. Vermont Payment for Ecosystem Services Technical Research Report #1 [↑](#footnote-ref-18)
19. White et al., ‘Measuring Ecosystem Services from Soil Health’, 2. [↑](#footnote-ref-19)
20. White et al., ‘Field Scale Soil Health Scenarios’. [↑](#footnote-ref-20)
21. Benjamin Dube et al., ‘Valuation of Soil Health Ecosystem Services (Version 2)’, Vermont Payment for Ecosystem Services Technical Research Report #5 (University of Vermont, July 2022). [↑](#footnote-ref-21)
22. White, ‘Results of the 2022 Vermont Farmer Conservation & Payment for Ecosystem Services Survey’, 31. [↑](#footnote-ref-22)
23. Ellen Friedrich et al., ‘Farmer Perspectives on Administrative Burdens & Potential Compensation Structures’, Vermont Payment for Ecosystem Services Technical Research Report #3c (University of Vermont, August 2022), 8. [↑](#footnote-ref-23)
24. <https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/Reports/2021CleanWaterInitiativePerformanceReport_FINAL_updated%201-20-2022.pdf> [↑](#footnote-ref-24)
25. Ramesh Chandra, ‘Soil Biodiversity and Community Composition for Ecosystem Services’, in *Soil Science: Fundamentals to Recent Advances*, ed. Amitava Rakshit et al. (Singapore: Springer, 2021), 69, https://doi.org/10.1007/978-981-16-0917-6\_5. [↑](#footnote-ref-25)
26. David Tilman, ‘Functional Diversity’, in *Encyclopedia of Biodiversity (Second Edition)*, ed. Simon A Levin (Waltham: Academic Press, 2001), 587, https://doi.org/10.1016/B978-0-12-384719-5.00061-7. [↑](#footnote-ref-26)
27. White et al., ‘Measuring Ecosystem Services from Soil Health’, 12. [↑](#footnote-ref-27)
28. Anton M. Breure, ‘Soil Biodiversity: Measurements, Indicators, Threats and Soil Functions’ (I International Conference on Soil and Compost Eco-biology, León, Spain, 2004), 90, https://www.fao.org/fileadmin/templates/soilbiodiversity/Downloadable\_files/8.Breure.pdf. [↑](#footnote-ref-28)