Report on the Vermont Ripsower Survey

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Intent of this report

The Vermont Ripsower is a novel agricultural implement that functions as a subsoiler, seeder, and inoculant injector. While the ripsower has been a focal point of excitement among some portions of the farming community in Vermont, there remains a lack of published research on its impacts or best practices for use. The purpose of this report is to summarize the results of a survey conducted in early 2024 exploring farmer perceptions of and experiences with the Vermont Ripsower in order to help those interested in using, studying, or learning more about the ripsower better understand farmer's experiences with this piece of equipment in Vermont.

Background

The Vermont Ripsower, hereafter referred to as a ripsower, is a novel agricultural equipment which functions as a combined subsoiler, seeder, and liquid bio-stimulant injector. The intended functions of the ripsower are to 1) shatter compacted soil; 2) prime seed in-furrow with liquid bio-stimulants and biofertilizers; and 3) interplant diverse blends of forbs, or any seed blends, into pastures. Developers of the ripsower say that, "The Vermont Ripsower is for land stewards working to grow top-quality forages as they minimize inputs, grow topsoil, infiltrate every drop, and heal the land." Ripsower developers recommend using a keyline design.

Ripsowers in Vermont

A community of land managers in Vermont are excited about the potential of using ripsowers to benefit farms and the larger environment. Interest seems to be largely generated through a local organization called the Land Care Cooperative which promotes the ripsower and has held regular workshops on it across the state. There is also a community of land managers and agricultural/conservation practitioners who are skeptical and cautious of the ripsower, and some of the claims made around it.

In response to farmer interest in the ripsower, Vermont's Agency of Agriculture, Food and Markets (VAAFM) helped farmers across the state purchase a total of six ripsowers through the Capital Equipment Assistance Program (CEAP), a water quality program which helps farmers purchase conservation equipment, over the course of a couple years. In 2023, VAAFM suspended the funding of ripsowers for non-research purposes due to lack of peer-reviewed research tying ripsowing to water quality benefits.

Research on Subsoil Compaction & Tillage

There has not been any published or peer reviewed research evaluating the biophysical impacts of using the ripsower. However, there is research which has looked at some functional elements associated with the ripsower including subsoiling — the core (and most physically disruptive) function of the ripsower.

Subsoiling, or subsoil tillage, is meant to alleviate soil compaction below the 6- to 8-inch depth of typical tillage. Subsoil tillage often refers to physical subsoil tillage methods (e.g., with subsoiler or ripper), but can refer to or be paired with biological methods (e.g., through deep rooted plants). Subsoiling is used by some farmers to alleviate subsoil compaction in their fields, particularly in areas with heavy traffic. Subsoil tillage can also be used to ameliorate subsoil compaction in non-agricultural sites, like at construction sites or other areas which experience heavy disturbance.

Soil compaction occurs when soil particles are pressed together. It is associated with decreased soil porosity, aggregate stability, hydraulic conductivity, and nutrient availability. Agricultural soil compaction most commonly results from heavy traffic from machinery or livestock (often in wet soil conditions), and other management practices. Soil compaction primarily impacts topsoil but can also reach down into the subsoil.

Soil compaction has a range of agricultural and environmental impacts. Soil compaction can decrease soil fertility by negatively impacting nutrient storage and accessibility, thus potentially having negative impacts on crop yields. Soil compaction can lead to higher N20 emissions (a potent greenhouse gas) from the soil due to more anaerobic soil conditions (Hernandez-Ramirez, G., et al., 2021). Compaction impacts on contaminant losses from fields (and, subsequently, water quality) are inconsistent and highly dependent on the specific context (Hu et al., 2021). Compaction impacts on soil biota and biological processes are difficult to generalize, though do become consistently negative after a certain bulk density is exceeded (Beylich et al., 2010).

Subsoil tillage can be an effective tool in alleviating subsoil compaction, in appropriate sites and conditions. A 2022 meta-analysis of subsoiling studies (Ning et al., 2022) showed that physical subsoiling in compacted agricultural fields, on average, boosted crop yields by 19%. However, the quality and persistence of the impacts from subsoil tillage are ranging and are shaped by an array of factors including the type of subsoiling equipment used, soil textures, soil conditions, and management practices. Importantly, subsoiling soils does not necessarily lead to better yields or soil moisture levels, especially if there are not acute compaction issues present (Evans, S.D., et. al, 1996). Subsoil tillage can even be damaging, especially if used in heavy, wet soils. Subsoil tillage can also result in tradeoffs, it tends to be less disruptive than conventional tillage (Yang, Y., et al, 2021), but subsoil tillage still does decrease organic carbon content in the topsoil compared to fields under no-till cultivation. (Ning et al., 2022).

Subsoil tillage tends to be more effective in coarser-textured (e.g., sandy) soils than finer-textured soils. Some research suggests that subsoil tillage is more effective when paired integration of deep-rooted plants, organic residues, manure, and/or other soil amendments (Ning et al., 2022; Zhang et al., 2020).

Many of the peer-reviewed studies looking at subsoil tillage in pastures have taken place in arid regions (which is where subsoiling seems to be most common) and in soils/climate dissimilar to Vermont. Findings from a very small UVM study (not peer reviewed) noted that farmers liked how the subsoil tillage helped redistribute water flow (slowing and/or speeding up drainage in different parts of the field), but that it had led to bumps/uneven soil surfaces in many of the participating fields (Gorres et al., n.d.). A Canadian study reported that after one pass of subsoiling (follow a keyline design pattern) there were minimal field impacts. They found slight *possible* increases in topsoil moisture holding capacity (but not subsoil), *possible* increases in water infiltration rates during larger summer/fall rainfall events, *possible* decreases in soil penetration resistance, and *possible* increases in rooting depth. It did not appear to have an impact on soil moisture or infiltration rates in the winter/spring though (Duncan & Krawczyk, 2018).

However, there are numerous studies in other contexts which have shown increased pasture production and improved moisture management due to subsoiling (Harrison et al., 1994; Drewry et al., 2000). All this suggests that differences in equipment, climate, weather conditions, crop types, soils, and management practices can lead to very different results in the quality and persistence of the impacts from subsoil tillage. Physical subsoil tillage is not a cure-all, but it can be effective in some contexts. Lessening and preventing soil compactness should always be the priority strategy for limiting the harms of soil compaction. Subsoiled soil can recompact quickly if compaction-inducing management continues.

Methods

This survey was conducted using Qualtrics online survey software available through University of Vermont (UVM). Anonymous survey responses were collected between mid-February and the end of March 2024. Institutional Review Board (IRB) approval for human subjects related research was obtained through the UVM by the Principal Investigator (PI) Juan Alvez prior to the distribution of the survey. Prospective respondents were recruited via emails distributed through UVM listservs. As this was a preliminary research study that was not funded, no compensation was provided to either researchers or respondents for their work or participation. A summary of the results of this survey are provided in the next section.

Survey Results

DEMOGRAPHIC SUMMARY OF RESPONDENTS

A total of 13 responses were collected in this survey from farmers across the state of Vermont (see **TABLE 1**). These respondents represent a wide range of farm sizes and types. In terms of size, farmers that responded managed farms that ranged from 20 acres to 1000 acres with an average farm size of 235 acres. On these farms, soil types also varied significantly from heavy clay to predominantly sand and loam. The most common soil type reported was loam (n=9/13) followed by both sand and clay (n=5/13 each). A number of farms had multiple predominant soil types on their property, the most common being loam/silt (n=3/13).

In terms of farm type, all respondents with the exception of one produced some type of livestock. This includes 5 farms that produce beef cattle, 2 that produce dairy cattle, 4 that produce sheep, 6 that produce pigs, 4 that produce poultry, and 1 that produces goats. Of these farms, 5 produced a single type of livestock while the remaining 8 produced multiple types of livestock. For these farms 10 out of 13 raise at least some portion of their herd as grass fed. In addition to livestock, 11 out of 13 farms produced pasture/hay. A number of other crop types were also represented, including 3 diversified vegetable producers, 2 producers with tree crops and one grain producer. There was also one dedicated diversified vegetable, berry and tree crop producer that raised no livestock.

TABLE 1. SUMMARY OF SURVEY RESPONDENTS

	Livestock	Crops	Size	Grass/ Grain fed?	Soil type(s)	Main goals as farm	Has used subsoiler?	Subsoiler results	Has used ripsower?
1	Beef, Pigs	Pasture/hay	400	Grass	Clay	Implement regenerative practices, High-quality products	Yes	Positive	Yes
2	Dairy	Pasture/hay	125	Grass	Clay, Loam	Grow business, Reduce inputs	No	N/A	Yes
3	Sheep	Pasture/hay	25	Grass	Sand	Implement regenerative practices, Animal well-being	Yes	Negative	Yes
4	Pigs, Goats	Pasture/hay	150	Both	Loam	Implement regenerative practices, High-quality products	No	N/A	Yes
5	Dairy, Pigs, Poultry	Pasture/hay	500	Grass	Loam, Silt	Keep land in ag., Animal well-being	Yes	Positive	Yes
6	Sheep, Pigs, Poultry	Div.Veg.,Tree crop, Pasture/hay	94	Grass	Loam, Sand	Implement regenerative practices, Diversify	Yes	Positive	Yes
7	Beef	Div. Veg., Pasture/hay	180	Grass	Loam	Keep land in ag., Support community/food system	Yes	Mixed	No
8	Beef, Pigs, Poultry	Pasture/hay	100	Grass	Loam, Sand	Reduce inputs, Implement regenerative practices	Yes	Negative	No
9	Sheep	Pasture/hay	1000	Grass	Clay	Grow Business, Reduce inputs	Yes	Negative	No
10	Beef, Sheep, Pigs	Pasture/hay	155	Grass	Loam	Grow Business, Reduce inputs	No	N/A	No
11	None	Div.Veg., Tree crop, Berries	60	N/A	Loam, Silt	Implement regenerative practices, Reduce inputs	No	N/A	No
12	Poultry	Div. Veg., Grains	20	Both	Loam, Sand	High-quality products, Implement regenerative practices	Yes	Positive	No
13	Beef	Pasture/hay	162	Grass	Clay	Grow business, Reduce inputs	No	N/A	No

Among these farms, farmer priorities also varied significantly. The most frequently reported priority was to “implement sustainable/regenerative practices” (n=7/13) followed by “reduce inputs” (n=6/13) followed by “grow your business” (n=5/13). Other notable priorities reported include “produce high-quality products (n=3/13), “keep land in agriculture” (n=2/13), and “animal well-being” (n=2/13).

For subsoiling, 8 out of 13 farmers reported having previous experience with it, while 5 out of 13 did not. For those who have subsoiled in the past, half reported positive experiences with it, and 1 reported a mixed experience and 3 reported negative experiences. Of these, 6 out of the 8 farmers with subsoiling experience reported prior experiences using the Vermont Ripsower. Lastly, while only 4 out of these 13 farmers reported flooding issues from the 2023 season, 9 of them reported significant ponding issues during the 2023 season and 6 of these farms suffered damage as a result.

FARMER PERSPECTIVES ON THE VERMONT RIPSOWER

To better understand farmer perspectives on the Vermont Ripsower, several survey questions were asked to gauge questions or uncertainties, sources of information, and anticipated impacts of implementing the ripsower on their fields. **TABLE 2,** below, shows a summary of farmer responses to the question, "What questions, if any, do you have in terms of the impact that ripsowing will have on your fields?"

This list includes a number of important observations regarding the current state of knowledge around the Vermont ripsower. These questions can be generally organized into two main categories: 1) questions around the technical implementation of the ripsower and 2) questions around the economic feasibility and broader impacts of the ripsower. Technical questions included questions around the soil types and conditions for optimal ripsower use as well as questions about seeding varieties and nutrient requirements for supplementing improved production through ripsower application. Economic feasibility questions included questions not only on the cost/benefit analysis of ripsower use, but also about how farms in Vermont might be able to cost share, rent, or otherwise access a ripsower without having to outright purchase one.

TABLE 2. FARMER QUESTIONS REGARDING VERMONT RUPSOWER IMPLEMENTATION

What questions do you have about the impact that ripsowing on your fields?

- What soil types and soil conditions is the ripsower most suitable for?
  - How does one determine when a ripsower is most appropriate to apply?
  - What is the impact on soil when implementing a ripsower in a wet year?
- What is the carbon footprint of using the ripsower?
- What kind of tractor/equipment is needed to pull the implement?
- How well do different seed varieties germinate and establish when sown via the ripsower?
  - Are perennial or annual grasses preferable for application via ripsower?
- What are the economics of implementing a ripsower (i.e., cost of machine, diesel, labor, etc. when compared with benefits)?
- Will implementing the ripsower damage already existing deep-rooted plants?
- How much fertility will be needed to support new growth after the implementation of the ripsower?
- How do farms in Vermont obtain access to a ripsower without having to purchase one outright?

The next set of survey questions asked farmers to reflect on the sources of information through which they have heard of or received information regarding the Vermont ripsower (see **FIGURE 1**). A majority of farmers (n=9/13) reported the Land Care Cooperative as their source of information on the ripsower in Vermont. A slightly smaller number (n=5/13) reported that they had heard of the ripsower through neighbors or other farmers in the state. Others (n=2/13) reported their main sources of ripsower related information as being the White River Junction Conservation District, the Vermont Agency of Agriculture, Food and Markets, and NOFA-VT (Northeast Organic Farming Association of Vermont).

The next set of questions asks farmers to reflect on the anticipated benefits of ripsower implementation on their fields. As the responses in **FIGURE 2** show, the number of anticipated impacts is wide ranging. The most commonly reported anticipated impacts include soil compaction (n=11/13), water infiltration/retention (n=10/13), soil health (n=10/13), and biodiversity improvements (n=9/13). Beyond these, however, there were seven other potential impacts to which at least half of the farmers listed. These include fertility, production, topsoil availability, farm resilience, farm sustainability, animal health/welfare, and farm viability.

FIGURE 1. SOURCES OF INFORMATION ABOUT THE VERMONT RIPSOWER

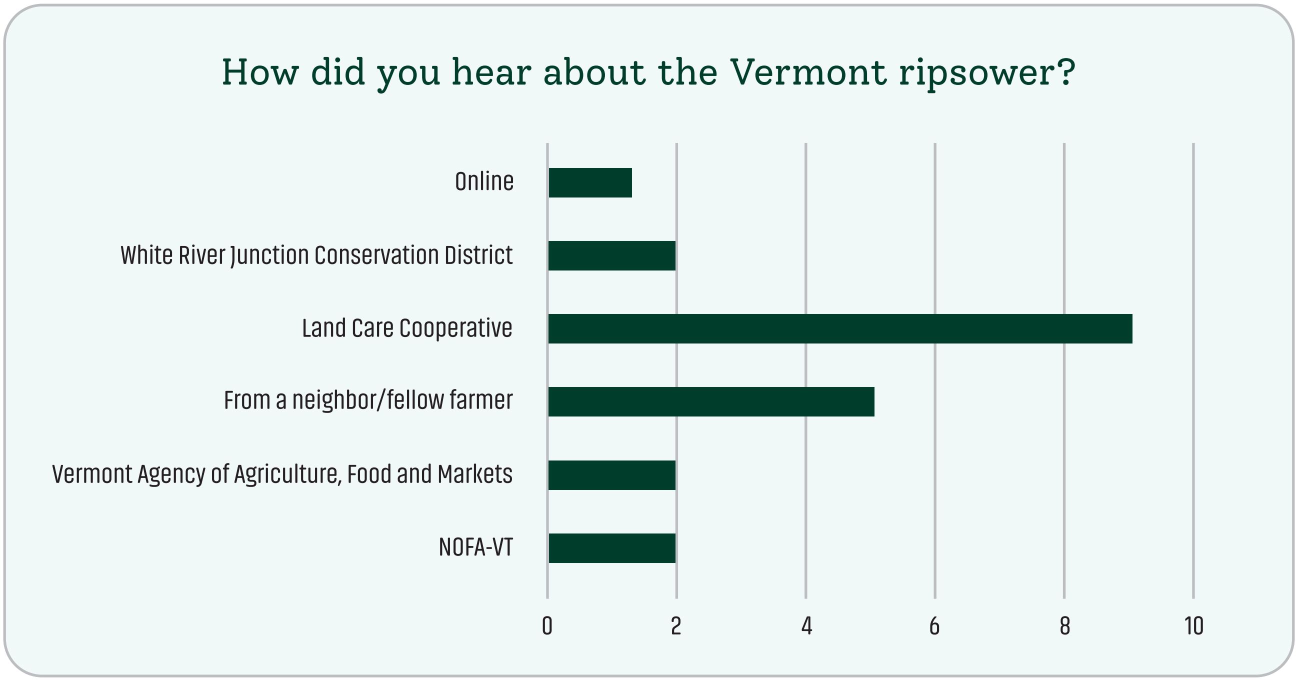
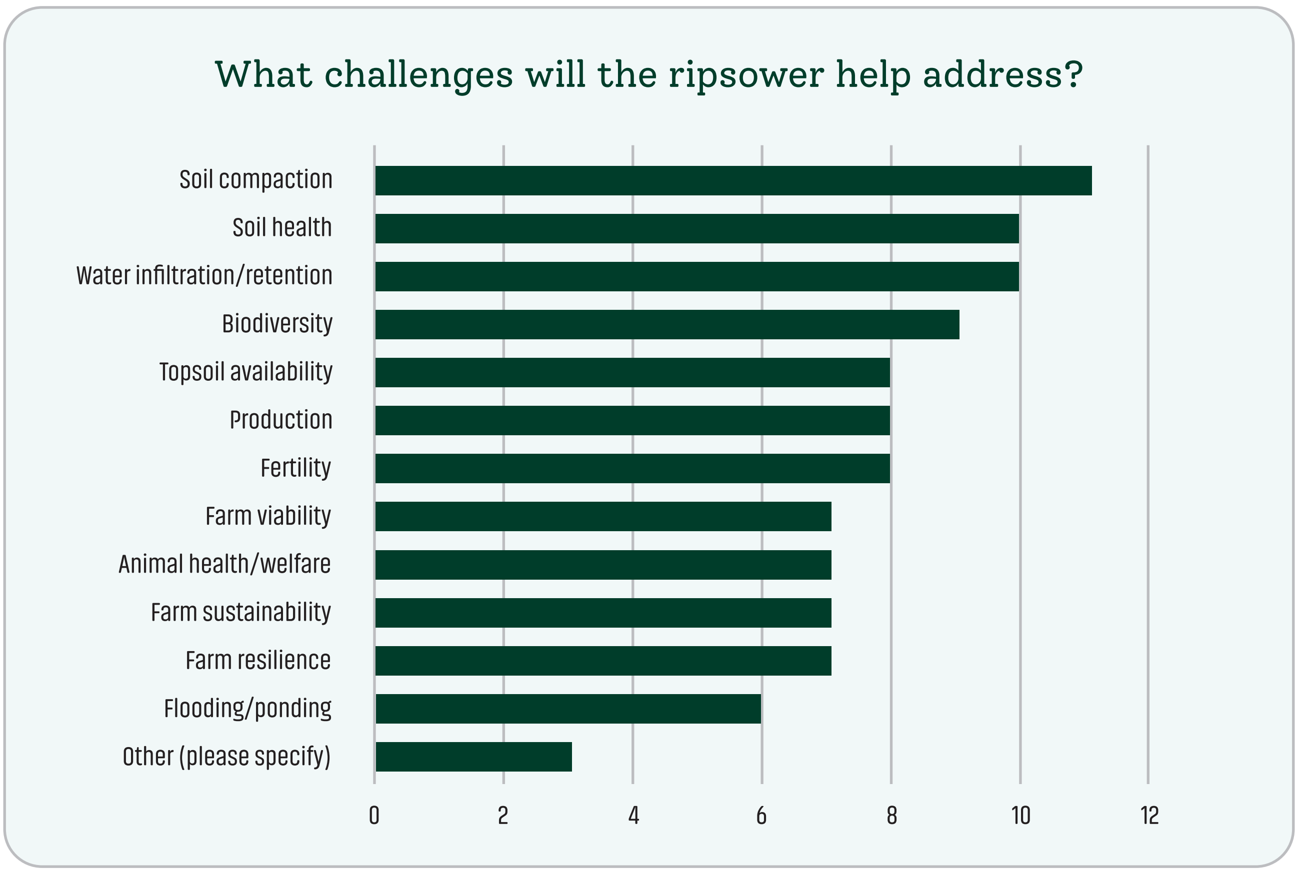


FIGURE 2. ANTICIPATED BENEFITS OF THE VERMONT RIPSOWER



FARMER EXPERIENCES WITH THE VERMONT RIPSOWER

Of the 13 farmers surveyed, 6 had already implemented the ripsower on at least some of their fields. **TABLE 3**, below, summarizes these experiences by farm. (NOTE: Farm numbers 1–6 in **TABLE 3** correspond to the same farm numbers 1–6 in **TABLE 1**). All 6 of these farmers applied the ripsower in either 2022 or 2023 with half of them conducting multiple treatments of the same or different fields. Almost all of them (n=5/6) procured the ripsower via a grant/cost-share agreement while one borrowed it from a neighbor.

In most cases, soil and weather conditions during ripsower application were dry; however, several farmers noted complications from drought conditions that followed application. In at least two cases, the ripsower was applied during moist or wet conditions. Farmers also applied the ripsower to fields with a variety of different soil types, from very sandy soils in some cases, to loamy/silty soils in others, to predominantly clay soils. Based on these responses and anecdotal information, both soil type and soil/weather conditions during and after application may be important factors in determining the success of ripsower application.

Additionally, most farmers (n=5/6) made use of a number of different seed mixtures and inoculant types as part of their ripsower application. Seed mixture types included a number of legume, forb and grass species, a mix of both perennial and annual species. Commonly sown species among this cohort of farmers included:

Legumes

- Clover
- Alfalfa
- Trefoil
- Sainfoin

Forbs

- Chicory
- Plantain
- Phacelia

Grasses

- Italian ryegrass
- Perennial ryegrass

The inoculant mixtures used in the ripsower application also varied from farm to farm, but frequently consisted of some form of homemade compost tea. Notable ingredients for these mixes included mycorrhizae, lactobacillus, various minerals, and kelp and medicinal plants, especially willow. One farmer did not apply either seed or inoculant when implementing the ripsower. It remains an open question to what extent, if any, varieties of seeds and inoculant mixtures are important factors in determining the outcomes of ripsowing implementation.

TABLE 3. SUMMARY OF FARMERS WHO HAVE IMPLEMENTED RIPSOWER

	Livestock	Soil type(s)	Timing	Acres applied	Soil/ Weather conditions	Species sown	Good Germin./ Establish.	Inoculant mix	Results	Will apply again?
1	Beef, Pigs	Clay	Summer 2023	60	Dry	N/A (just used subsoiling component of ripsower)	N/A	N/A (just used subsoiling component of ripsower)	Positive	Yes
2	Dairy	Clay, Loam	Fall 2023; Summer 2023; Summer 2022	35	Clay, Loam	Clovers, chicory, smooth leaf plantain, sweet burnet, alfalfa, Italian ryegrass, perennial ryegrass, trefoil, oats, tillage, radish, buckwheat, etc.	No	Homemade compost tea	Positive	Yes
3	Sheep	Sand	Fall 2022	8	Sand	Italian rye, chicory, plantain, sainfoin, clover, alfalfa, oats, phacelia, etc.	Yes	Trace mineral mix (Green Mountain Girls) plus mycorrhizae	Negative	No
4	Pigs, Goats	Loam	Fall 2023; Summer 2023; Summer 2022	18	Loam	Plantain, chicory, alfalfa, burnett, trefoil, clover, rye	No	Mixture of whey, humic acid, sea crop, willow extract, wood ash, forest duff extract, fish emulsion	Positive	Yes
5	Dairy, Pigs, Poultry	Loam, Silt	Summer 2023; Summer 2022	50	Loam, Silt	Bloom train mix (mixture of deep rooted perennials, legumes, annuals and Forbes), Rays crazy mix (mixture of seasonal annual plants)	Yes	Homemade compost tea (lactobacillus, willow leaves, medicinal plants, kelp and other trace minerals, all condidered a bio stimulant liquid mix)	Positive	Yes
6	Sheep, Pigs, Poultry	Loam, Sand	Summer 2022	Just a few	Loam, Sand	LCC dry mix	Yes	AEA, Forage foliar blend	Mixed	Yes

For these 6 farmers, there were a number of reflections on both the immediate and longer-term impacts of the ripsower application on their fields. By and large, the impacts noted by a majority of farmers were positive, with a few notable negative or unanticipated impacts that merit mention. **TABLE 4** below shows a summary of the reported immediate impacts of ripsower application. Notable here are both positive impacts on the soil, including new soil aggregation, reduced compaction, improved water infiltration, and deeper root penetration, as well as positive impacts on forage production, including thicker swards of grass and greener, more lush growth.

Negative or unanticipated impacts were notably fewer in number but can be lumped into two general categories: 1) challenges with production, including issues with fields drying out and seed germination issues; and 2) damage of fields due to the impact of heavy machinery. While only 1 farmer out of the 6 noted negative impacts in the first of these categories, half of the farmers noted impacts in the second of these categories. For the farmer with production challenges, in particular, their response seemed to indicate that this was caused by fields drying out significantly following the ripsower application which, perhaps in combination with weather conditions, contributed to poor germination and establishment. It is interesting to note that this farmer was the only one surveyed with predominantly sandy soils.

TABLE 4. IMMEDIATE IMPACTS OF RIPSOWER APPLICATION AS REPORTED BY SURVEYED FARMERS

Immediate impacts of ripsower application	
Positive	**Negative**
• New soil aggregation down to depth of subsoiler • Earthworm proliferation • Thicker swards of grass • Deeper root zone • Reduced compaction • Water distribution (no ponding) • Better signs of fertility (greener/lush grass)	• Fields drying out • Created dead areas along the rips • Made the field super bumpy when driving on it • Spotty germination (possibly due to pilot error)

TABLE 5 summarizes the medium-term impacts from the ripsower application as reported by survey respondents. Many of these medium-term impacts, both positive and negative, paralleled the immediate impacts noted by farmers. Please note that all farmers reported only having used a ripsower for 1 or 2 seasons. The positive medium-term impacts included reduced soil compaction, improved water retention and increased forage production. Additional positive medium-term impacts included improved biodiversity and decreased ponding. Negative medium-term impacts also parallel the immediate impacts and included land stress due to heavy machinery and damage to fields, such as rutting and bumpiness, as well as reduced production, likely as a result of germination challenges. As with the immediate impacts, a majority of farms noted that medium-term impacts were beneficial. Of the 6 reporting farms, 4 reported generally positive impacts, 1 reported mixed impacts, and 1 reported generally negative impacts. In all cases but 1, the negative or unanticipated impacts of ripsowing did not preclude farmers from wanting to implement it again in the future. Lastly, it is important to note that some farms, especially those that applied the ripsower only last summer noted that it was "too soon to tell" what some of these medium-term impacts would be.

TABLE 5. MEDIUM-TERM IMPACTS OF RIPSOWER APPLICATION AS REPORTED BY SURVEYED FARMERS

Impacts since implementing ripsower	
Positive	**Negative**
• Improved biodiversity • Increased forage production • Earthworm proliferation • Deeper root penetration • Decreased compaction • Increased water retention/holding capacity • Decreased ponding	• Reduced production • Land stress due to tractor impact • Damage to fields (rutting, bumpiness) • Lack of germination

Farmer voices

This section provides a deeper look at some of the voices of the 13 farmers who responded to the survey. The quotes that follow highlight not only some of the potential that farmers see in the Vermont Ripsower, but also some of the outstanding questions farmers have about ripsower implementation. In addition, some of the quotes reveal potential avenues for future research that may prove productive going forward.

"We use the machine and see amazing results: deeper root zones proven by test pits, inclusion of more species, better drought resistance."

—Dairy farm, 125 acres

"I have yet to see any actual research trials on the ripsower. I hear lots of claims about how much good it does but the fields I've visited where farmers did don't include any control strips and they were comparing 2022 to 2023, but the weather was so different I am unclear if they are seeing changes due to the ripsower usage. Some of the fields that were rip sown also don't look like they benefited. So it is just way too early for me to know which of these improvements are possible. It is also important to keep track of soil types and soil moisture conditions when doing any type of chisel plowing, so while sometimes a chisel plow or ripping will alleviate compaction, in other soil conditions it will damage soil structure. This is why trials with a control are needed in a variety of soil types and conditions. Once that happens... I'll be willing to answer this question."

—Beef farm, 180 acres

"I don't specifically have fields that are fit for the VT Ripsower (we're a permaculture farm and farm in a "food forest") but I'm thrilled by the potential of the ripsower to transform the way that more traditional farms care for their soil"

—Diversified vegetable farm, 60 acres

"I feel that the ripsower will have positive effects as previously stated but the big question is how much fertility will be needed to support the new growth and how much competition can the new growth handle? Should we use perennial or annual grasses? How much good are we doing to the soil passing the ripsower on a wet year?"

—Dairy/mixed livestock farm, 500 acres

"[After ripsower application, there were] thicker swards and deeper root zone. Soil test pits on areas of the farm show that fields have about 5" root zone, below which is gray subsoil. After two rips, test pits show the dark brown root zone (organic matter) extends to 8 to 10-inches. This is a massive increase in root depth, accessing deep soil nutrients and greatly improving drought resilience."

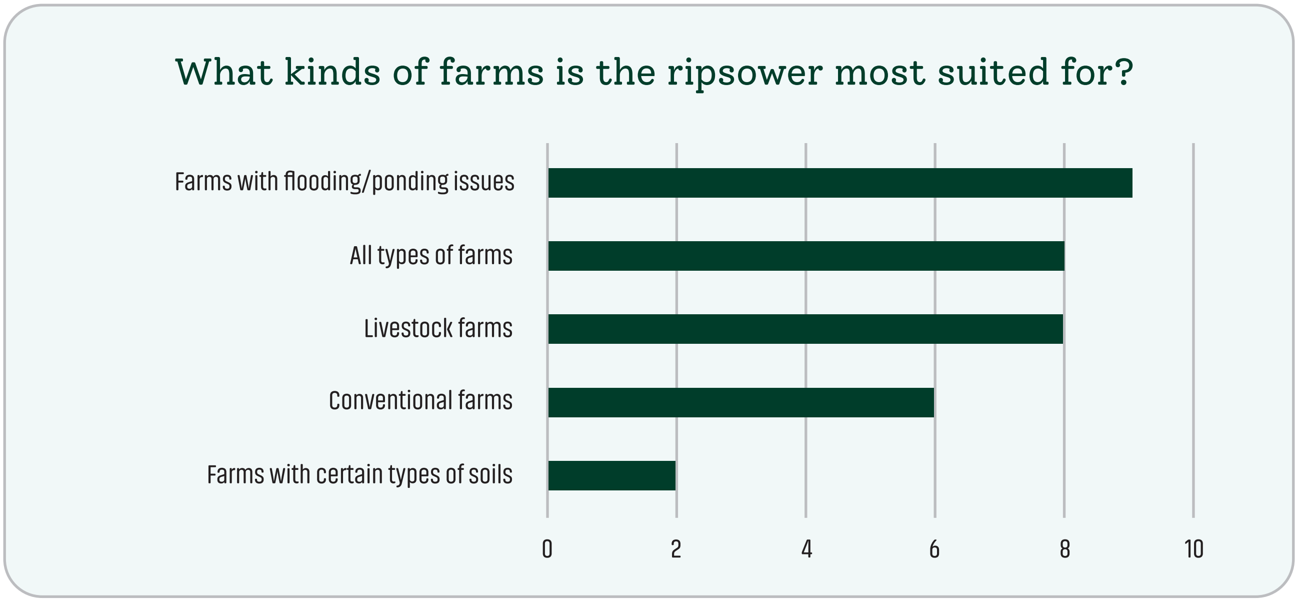
—Dairy farm, 125 acres

"[Ripsower application] dried out the field immediately and created dead areas along the rips. It also made the field super bumpy when driving on it."

—Sheep farm, 25 acres

The final figure (**FIGURE 3**) shows farmer perspectives on what types of farms the ripsower is most suitable for. Of the 13 responding farmers, 10 indicated that it was most suitable for farms with compaction issues, while 9 indicated that it was most suitable for farms with flooding/ponding issues. Just behind that were 8 farmers that thought the ripsower was most suitable for livestock farms and 8 others that thought it was most suitable for all types of farms.

FIGURE 3. FARMER PERSPECTIVE ON MOST SUITABLE FARMS FOR RIPSOWER IMPLEMENTATION



Conclusions

KEY TAKEAWAYS

There is substantial interest and many unknowns regarding the most effective, economical implementation of the Vermont ripsower among farmers in the state.

Of the 13 respondents to this questionnaire, there is, at least, a small community of farmers enthusiastic about the perceived benefits of ripsowing. The most commonly anticipated benefits associated with ripsowing were for reducing soil compaction, improving water infiltration/retention, and improving soil health. Cost share/grant programs have been critical for farmers in accessing ripsowers in Vermont — no respondents reported using ripsowers which they purchased without financial assistance. The Land Care Cooperative was the most listed source for hearing about the ripsowers.

There were 8 farmers who reported having used some sort of subsoiling equipment in the past. For those who have subsoiled in the past, half reported positive experiences with it (n=4), 1 had a mixed experience and 3 reported negative experiences. Farmers who reported having experience using the ripsower (n=6) reported largely positive impacts (4/6); 1 reported mixed impacts (1/6); and another reported largely negative impacts (1/6). The positive impacts cited by farmers who used the ripsower (n=6) were improved/deeper soil profiles, decreased compaction, increased forage production and diversity, more earthworms, and reduced ponding. Negative impacts included reduced forage production, poor germination/establishment, and damage to field from equipment. Farmer experiences reviewed in this survey are generally short-term (i.e., 1 or 2 years/growing seasons). Long-term impacts of the ripsower on these farms remain to be seen in coming years. Most farmers used the seeding and liquid injector function of the ripsower (5/6). Seed mixes included a mix of legumes, forbs, and/or ryegrass. Most used a homemade compost tea inoculant. Soil type, weather conditions, and seed/inoculant mixes were all recognized as important factors in shaping the potential impacts of ripsowing.

Despite evident enthusiasm among some Vermont farmers, there is a need for research around ripsowing and farmers shared some questions and concerns they have about the practice including, but not limited to the appropriate soil conditions in which to use a ripsower, seed germination success rates, and the economics of using a ripsower. Rigorous research to explore the impacts anecdotally reported by farmers (e.g., through replicable field trials), the costs and benefits of using a ripsower, and work to develop robust best practices and technical guidance for practitioners interested in using the ripsowers would be beneficial and recommended in better understanding the value and effects of ripsower.

POTENTIAL AVENUES FOR FUTURE RESEARCH

- What are the short-term and long-term effects of ripsower application?
- What are the types of soils and soil conditions for which the ripsower is most suitable?
- How do different seed mixes impact ripsower success?
- How do different inoculant mixtures impact germination rates and ripsower success?
- What are the economics of ripsower applications (i.e., cost/benefit)?
- How does the ripsower fit into the tool kit of other conservation practices for farmers (i.e., grazing, nutrient management, soil health/conservation, etc.)?

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