No-Till Pasture & Hayland Renovation:
A Guide to No-Till Drill Seeding and Frost Seeding

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ABOUT NO-TILL PASTURE & HAYLAND RENOVATION

Pasture/hayland renovation is the practice of seeding desired forage species into existing pasture/hayland to improve field productivity and/or quality. Renovations can range from minor inter-seeding work to the complete reseeding of a field. Various renovation methods can be used to improve pastures & haylands, including both tillage-based and non-tillage-based approaches. The suitability of different methods depends on field conditions and renovation goals. No-till renovation methods are recommended, where possible, because of their environmental and agronomic benefits compared to tillage-based seeding and preparation methods. In Vermont, two of the most popular no-till pasture & hayland renovation methods are no-till drill seeding and frost seeding. Both of these methods can be used to meet pasture/hayland renovation goals while promoting soil health, water quality, and field resilience.

OVERVIEW OF NO-TILL RENOVATION METHODS

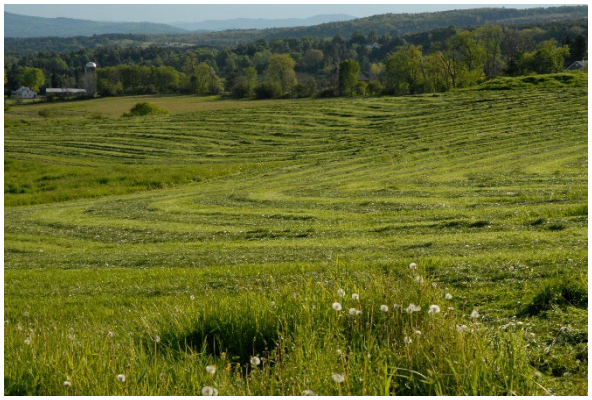
No-Till Drill Seeding: No-till drills cut narrow furrows into the soil, place seed, and then re-cover the seed & furrow with soil. Drill seeding provides excellent seed-to-soil contact, precise seed placement, and minimizes soil disturbance. No-till drills can be used to facilitate minor to major changes in pastures and haylands. They are suitable for seeding most common forage species, both grasses and legumes. Drills can be successfully used across sites with varying soil textures and vegetative cover. They are best suited for moderate to large-scale seeding. Drill seeding works best in fields with even seedbeds. It is important to properly set up and calibrate the drill for successful results. In Vermont, no-till drill pasture/hayland seeding can be done either in spring or late summer.

Frost Seeding: Frost seeding is a method of strategically broadcasting seeds on the land during the dormant season to allow the freeze-thaw cycle & spring rains to work seeds into the soil. It imitates the natural self-seeding process of many forage and grassland plants. Frost seeding can be a cost-effective way to facilitate minor to moderate-scale changes in pastures and haylands. It is most effective at seeding dense-seeded legumes. Frost seeding works best in spots with fine-textured soils and limited vegetative cover (over 50% exposed soil is best). It is not recommended for large-scale seeding. Soil-to-seed contact and sufficient moisture for germination is critical to success. Frost seeding has lower germination & establishment rates than no-till drill seeding, it is successful about 60-70% of the time. Frost seeding should occur early within or shortly before the freeze-thaw cycle (which is typically late February to early April in Vermont).

No-till drill seeding is a highly effective renovation method suitable for a wide variety of field conditions.

Frost seeding should be done early within the freeze-thaw cycle.

A variety of factors should be considered when deciding between these two methods, including the existing vegetation in the field, equipment availability, renovation goals, soil texture, and seed costs. Table one provides a comparative overview of the strengths and tradeoffs of no-till drill seeding versus frost seeding.



No-till renovation methods can be successfully used on both pastures and haylands.

Table 1. The comparative advantages & disadvantages of using no-till drill seeding versus frost seeding methods for renovating pasture/hayland.

Key to Colors & Bullet Point Symbols		
Disadvantage	Mixed or Neutral	Advantage
×	○	✓

	No-Till Drill Seeding	Frost Seeding
Field/Soil Conditions	○ Best suited for medium or large-scale seedings. ✓ Appropriate for most soil textures. ○ Best suited for well-drained and open fields with level seedbeds, easy field access, and not overly steep slopes.	○ Best suited for small-scale seedings. × Only appropriate in finer-textured soils. ✓ Suitable in some field conditions which may be unsuitable for a drill (e.g., on steep slopes, in rocky areas, in overly wet fields).
Existing Vegetation	○ Most successful where there is limited vegetative competition and some exposed soil. ✓ More competitive with existing vegetation than frost seeding.	○ Most successful where there are significant amounts of exposed, bare soil. × Less competitive with existing vegetation than drill seeding.
Seeds	✓ Suitable for seeding most grasses and legumes. ✓ Generally requires lower seeding rates due to higher establishment rates, which may lead to lower seed costs.	○ Best suited for seeding heavy-seeded legumes (e.g., red clover); variable success with seeding grasses. × Generally requires higher seeding rates due to lower establishment rates, which may lead to higher seed costs.
Equipment	× Uses heavier equipment. × No-till drills can be complicated to properly set up, calibrate, and use. × Equipment is more expensive to purchase or rent.	✓ Uses lighter equipment. ✓ Equipment can be low-tech and relatively easy to use (can even be done manually on small parcels). ✓ Equipment is less expensive to purchase or rent.
Timing	○ Seeding timing & conditions is important, but more flexible than with frost seeding. ✓ Seed establishment is less vulnerable to weather conditions than with frost seeding.	○ Seeding timing & conditions is critical to success; seeds must be exposed to freeze-thaw cycle processes. × Seed establishment very vulnerable to weather conditions and soil moisture levels.
Germination	✓ Higher germination/establishment rates.	× Lower germination/establishment rates. × Larger risk of complete establishment failure.

STEP-BY-STEP IMPLMENTATION GUIDE

About: This is a step-by-step guide to renovating pastures and haylands using no-till drill seeding and frost seeding methods. There is a lot of overlap in recommended management between these two renovation methods, however, there are also some significant differences. Sections with guidance which pertains only to no-till drill seeding are marked as "FOR NO-TILL DRILL SEEDING". Sections with guidance which pertains only to frost seeding are marked as "FOR FROST SEEDING". Readers can choose to focus on the steps for just one method or simultaneously consider both methods.

1) Take inventory of the site. Make sure the chosen renovation method is appropriate for the spot. Consider the:

a. **Field Characteristics:** Look at the size, slope, and other physical characteristics of the field.

- **FOR NO-TILL DRILL SEEDING:** No-till drills work well in large, open fields. Drills may not be suitable for use in very small fields, on very steep slopes, or in places where there are lots of physical obstructions (e.g., large rocks and trees).
- **FOR FROST SEEDING**: Frost seeding can be used across all types of different terrain, including on steep slopes and close to physical obstructions. It is best suited for small seeding areas; it is not recommended for seeding large or entirely bare areas/fields.

b. **Seedbed Conditions:** The state of the seedbed may impact what preparations are needed to promote a successful seeding, depending on the seeding method used.

- **FOR NO-TILL DRILL SEEDING:** No-till drill seedings work best in consistent and even seedbeds. Fields with very bumpy or uneven seedbeds may not be suitable for no-till drill seeding. If needed, re-leveling work can be done to even out the soil/seedbed.
- **FOR FROST SEEDING:** Frost seeding can be successful in different seedbed conditions. Seedbeds do not necessarily have to be completely level or consistent.

**Please note that tillage in preparation for seeding would render the practice ineligible for VAAFM-FAP funding. **

c. **Soil Types/Textures:** Determine the types and textures of soils present. Collect physical soil samples and go online to use the NRCS Web Soil Survey to view soil maps and soil descriptions of the site.

- **FOR NO-TILL DRILL SEEDING**: No-till drill seeding works well across all soil textures. However, well-drained to excessively-drained soils may provide better field access conditions, especially during wet times of year. Using heavy drills in overly wet soils can lead to compaction issues.

- **FOR FROST SEEDING:** Frost seeding is most effective on fine-textured soils (i.e., clays, silts, and loams). Fine-textured soils expand and contract during freeze-thaw cycle processes in a way which works seeds into soil positions suitable for germination. Frost seeding is not recommended on sandy soils and soils with low organic matter levels.

d. **Existing Vegetative Cover:** Evaluate the quality of the existing vegetation. Survey the types of species present in the pasture/hayfield. Look at how much of the soil surface is exposed versus how much is covered with plants and/or thatch. Gauge the productiveness, competitiveness, and desirability of the existing vegetation.

In general, inter-seeding is less effective in competitive or dense vegetation than in sparse or weak vegetation. Consider options to weaken or terminate existing vegetation in the pasture/hayfield before seeding. If less than 50% of the soil surface is exposed at the time of seeding, drill seeding is recommended over broadcast seeding methods.

Always evaluate the existing vegetation before renovating.

- **FOR NO-TILL DRILL SEEDING:** No-till drill seeding is most effective in low-productivity fields with short, sparse vegetation. However, in fields with thicker or more competitive vegetation, no-till drilling can still be a viable option. Compared to broadcast-seeding, no-till drill seeding is significantly more effective in areas with dense/competitive existing vegetation.
- **FOR FROST SEEDING:** Frost seeding is most successful in areas where the soil is fully or partially exposed. It generally works better in pastures comprised largely of bunchgrasses (e.g., orchard-grass, timothy, and fescues) than in pastures comprised largely of sod-forming grasses (e.g., bluegrasses and bromegrass) because bunch grasses generally leave more soil exposed. Frost seeding is unlikely to be successful in spots with dense existing vegetative/thatch covers due to low soil-to-seed contact rates and/or high plant competition in those conditions. Frost seeding is not recommended where highly competitive species (e.g., quackgrass) are dominant because they will easily suppress and outcompete any potential seedlings.

e. **Renovation Goals for the Field:** Evaluate the goals for the field, and whether the renovation method can help meet those goals.

- **FOR NO-TILL DRILL SEEDING:** No-till drill seeding can help facilitate anywhere from minor to major changes to pasture cover and species composition. It is suitable for seeding most popular forage & hay species, including both grasses and legumes.

- **FOR FROST SEEDING:** Frost seeding can help facilitate minor or moderate changes to pasture cover and species composition. It is most effective at adding legumes to fields, particularly legumes with small, dense seeds. It can also be used to seed some specific species of grasses such as Italian ryegrass, perennial ryegrass, and orchard-grass.

2) Test and amend the soil, as needed. Before seeding, it is important to ensure that field conditions are conducive for a successful renovation.

a. **pH:** Proper soil pH conditions are critical for seeding establishment and persistence. Ensure the soil pH is within the recommended range of 5.6-6.8 for pastures & haylands. Most legumes do best in soils with 6.0 pH or higher. If a pH adjustment is needed, be sure to allow for sufficient time for the applied amendment(s) to take effect. Please note that no-till seeding and amendment incorporation methods require more time for amendments to take effect than tillage-based methods. For no-till seeding, amendments such as lime should be added to the field at least a year before seeding.

b. **Nutrients & Fertilizers:** Ensure that there are sufficient supplies of phosphorus (P) and potassium (K) available as these nutrients are essential for seedling establishment. Add P and K in the fall or spring before seeding, as needed. Avoid adding nitrogen (N) before or around the time of seeding, as it increases the competitivity of existing vegetation, especially grasses and weeds.

3) Control vegetation & residue in the season before seeding.

a. **Set back existing vegetation, as needed**: Deliberate over-grazing/haying in the season prior to seeding is recommended (fall for spring seedings, spring/early summer for later summer seedings). This helps to 1) increase the likelihood of soil-to-seed contact by removing vegetative material, and 2) stress existing vegetation and reduce their competitiveness against seedlings. Depending on the competitiveness and density of existing vegetation, selective herbicides and tillage can also be used to weaken or kill the stand. This may be critical to a successful renovation if there are a lot of undesirable species present. **Please note that tillage in preparation for pasture/hayland renovation would make the practice ineligible for VAAFM-FAP funding. **

4) Choose seeding mix and rate.

a. **Seeding Mixes:** Choose appropriate species & varieties. When making selections, be sure to consider field characteristics (e.g., soil types and drainage class), existing vegetation, and renovation goals. For legume seeds, biological inoculants should be used to help with establishment.

- **FOR NO-TILL DRILL SEEDING:** No-till drills are suitable for seeding most common types of forage legumes and grasses. If seeding multiple species, stratification of seeds with different weights & sizes in the seed box may occur, potentially leading to uneven species distribution. If this is an issue, consider using multiple seed boxes or stopping occasionally to manually remix the seeds in the seed box.

- **FOR FROST SEEDING:** When frost seeding, legume-only or legume-dominant seeding mixes are advised. Frost seeding is most successful for establishing plants with dense seeds which germinate at cool temperatures and establish quickly — small, heavy-seeded legumes like red clover work best. When frost seeded, most grasses have lower germination & establishment rates than legumes, in part because they are more likely to be caught in vegetation, therefore having lower soil-to-seed contact. However, researchers have shown some success with frost seeding a few grass species, specifically Italian ryegrass, perennial ryegrass, and orchard-grass. In contrast, bromegrass, timothy, and reed canary grass are specifically NOT recommended to frost seed. Note that when broadcast seeding, different seed weights/sizes within in a seed mix may mean that some seeds are 'thrown' further than others, leading to uneven seed/plant distribution.

Frost seeding is best for establishing dense-seeded legumes, like red clover.

b. **Seeding Rates:** Seeding rates should be sufficient to support full soil coverage and meet renovation goals. Optimal seeding rates & ratios may vary within and across fields depending on a variety of factors including soil types, existing vegetation, seeding method used, soil drainage class, pure live seed (pls) percentages, desired seedling density, and specific goals for the renovation. Areas with denser vegetation may require higher seeding rates to successfully establish the same desired number/density of plants than areas with sparser vegetation. Higher seeding rates generally translate to faster and denser seedling establishment. Frost seeding (& other broadcast seeding methods) generally require higher seeding rates than drill seeding methods due to comparatively lower establishment rates. Please note that there is some variation in seeding rate recommendations across different agencies and organizations.

- **FOR NO-TILL DRILL SEEDING:** Drilling into existing, living sod generally has lower establishment rates than drilling into dormant annual crop fields or evenly terminated cover crops. Table two shows USDA-NRCS Vermont seeding rate recommendations for no-till drilling common forage species mixes.
- **FOR FROST SEEDING:** The general guideline is that broadcast seeding rates should be 1.5 times drill seeding rates. Table three shows USDA-NRCS Vermont frost seeding rate recommendations for common forage species.

Table 2. USDA-NRCS Vermont Recommended Seed Mixtures & Rates for Pastures and Hay Seeding (lbs. pure live seed/acre).

Legume Seed (if one legume only, use high rate)				**Grass Seed (One Only)** (in mixes use lower rate)			
Primary Legume	**Rate (lbs.)**	**Secondary Legume**	**Rate (lbs.)**	**Orchard Grass**	**Smooth Brome Grass**	**Timothy**	**Kentucky Bluegrass**
Alfalfa	8-10			5-10	4-6	5-8	
Alfalfa	12-18	(hayland only)					
Alfalfa	6-8	Red Clover	2-4	5-10	5-7	5-8	
Alfalfa	4-6	Red Clover	2	5			
Alfalfa	6-8	Ladino Clover	1/4	5-10	5-7	5-8	
Red Clover	6-8			5-10	5-7	5-8	
Red Clover	4-6	Ladino Clover	1/4	5-10	5-7	5-8	
Red Clover	6-8						
Red Clover	6-8	Alsike Clover	2	5-10	5-7	5-8	
Alsike Clover	3-5	Ladino Clover	1/4	5-10	5-7	5-8	
Birdsfoot Trefoil	6			5-10	4-6	5-8	4- 8
Red Clover	6-10	Ladino Clover	1/2	5-10	4-6	5-8	
One Grass Only				12	10	10	15

Table 3. USDA-NRCS Vermont Recommended Seeding Rates for Frost Seeding Common Forage Species into an Existing Grass or Legume Sod.

Species	**Rate (lb/acre)**		**Expected Established Plants ***
	Seeded Alone	**As Part of Seed Mixture**	**Plants per Square Foot**
Red Clover	6-12	4 - 8	2 - 5
Ladino Clover (White)	2 - 3	1 - 2	1 - 2
Alsike Clover	2 - 4	1 - 2	2 - 3
Perennial Ryegrass	6 - 10	4 - 6	10 - 12
Orchard-grass	3 - 4	1 - 2	4

* *Expected plants based on "alone" seeding rates.*

5) Choose appropriate equipment and ensure proper set-up for seeding. Refer to the owner's manual for information and guidance specific to the equipment being used.

- **FOR NO-TILL DRILL SEEDING:** Ensure the drill and its component set-up are suitable, this includes the drill's furrow openers, coulters, and press wheels. Before seeding, make proper adjustments according to the field conditions and seeding mix. Recommended seeding depth varies based on species, but should be shallow, usually between ¼ and ½ inch in depth. Ensure everything is working properly before seeding. Regularly check equipment calibration and seeding depth during the seeding process to ensure accurate and consistent seed placement.

Always make sure all drill components are properly set-up and calibrated.

- **FOR FROST SEEDING**: A variety of different types of equipment & seeders can successfully be used including some very low-tech options. Some commonly used seeding equipment options include broadcast seeders attached to ATVs or tractors, or hand-held broadcast or cyclone seeders. Choose an equipment set-up that is suitable for accessing the field within the freeze-thaw cycle.

6) Seed at an appropriate time. Consider the following:

a. **Time of Year:** Seeding timing is critical to renovation success.

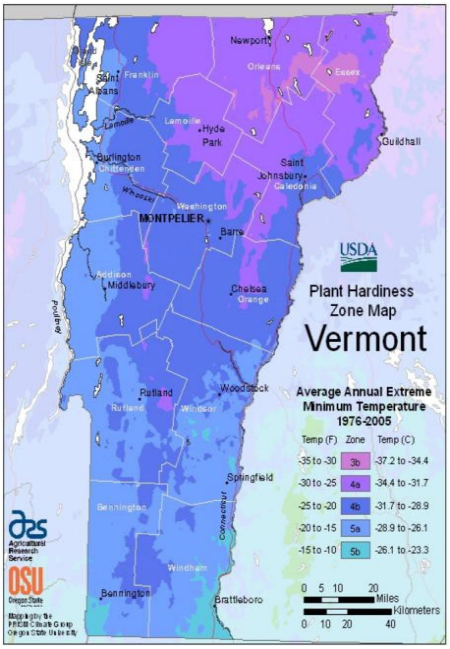
- **FOR NO-TILL DRILL SEEDING:** No-till drill seeding can be successfully done in early to mid-spring or late summer. In Vermont, late April to early May is usually the optimal spring seeding window. Be sure to wait for fields to dry out enough to avoid creating compaction issues. In Vermont, August is a good month for a late summer seeding. See table four for USDA-NRCS recommended drill seeding dates in Vermont based on plant hardiness zones.

- **FOR FROST SEEDING:** Frost seeding should be completed during or shortly before the freeze-thaw cycle. The freeze-thaw cycle occurs during a range of days in late winter/early spring in which temperatures regularly fluctuate between below freezing at night and above freezing during the day. This fluctuation between freezing and thawing of soil moisture leads to shrinking & expanding in finer-textured soils, a process which works seeds into soil positions optimal for germination. Always adapt the specific timing of frost seeding to the local climate/conditions. In Vermont, freeze-thaw cycle processes typically occur in the late February to early April time frame (similar to sugaring season timing). It is best to frost seed

at the beginning of the freeze-thaw cycle—the longer seeds are exposed to the freeze-thaw cycle processes, the better the soil-to-seed contact and germination rates. Seeding may also be done in the window between when the growing season has fully ended and when there is minimal to no snow cover (around December). If conducting a pre-freeze-thaw cycle dormant season seeding, be sure to do this after temperatures which might trigger seed germination have passed (this is particularly relevant if seeding plants which germinate in cold temperatures). **Please note that frost seeding with VAAFM-FAP funding must occur during, or shortly before, the active freeze-thaw cycle. Earlier dormant season seedings are not supported. ***

Table 4. USDA-NRCS Vermont Recommended Drill Seeding Dates based on USDA Plant Hardiness Zones.

Plant Hardiness Zone	Spring	Late Summer
3b	May 1 to June 15	July 15 to August 10
4a	May 1 to June 15	July 15 to August 10
4b	April 15 to May 30	August 7 to September 15
5a	April 15 to May 30	August 7 to September 15
5b	April 15 to May 30	August 7 to September 15



b. **Snow Cover on Ground:** (FOR FROST SEEDING) Since seed-to-soil contact is key to successful frost seeding, seeding should occur when there is little to no snow on the ground. Do NOT frost seed in deep snow. Seeding on top of deep snow may mean that seeds will not have had sufficient soil-to-seed contact during the freeze-thaw cycle, depending on how long it takes for the snow to melt and seeds to reach the soil surface. Seeding on deep snow also increases the chances that seeds will be washed away during large snow-melt events. Seeding on light snow (a couple inches or less) is usually low risk, it can even provide a helpful visualization of areas that have been seeded. **Please note that frost seeding with VAAFM-FAP funding must occur on non-snow-covered ground, defined as less than 2 inches of snow cover. ***

c. **Moisture/Precipitation:** Sufficient soil moisture and/or precipitation is critical to germination and seedling establishment. Large precipitation events or droughts may lead to plant establishment failure. In general, no-till pasture/hayland renovation methods, compared to tillage-based renovation methods, promote improved soil moisture retention and resilience to floods and droughts.

- **FOR NO-TILL DRILL SEEDING:** Drilled seeds/seedlings are generally less vulnerable to drought and washout than broadcasted seeds.
- **FOR FROST SEEDING:** The success of frost-seeded seedlings is highly contingent on appropriate soil moisture and precipitation levels. Early spring rains and sufficiently high soil moisture levels are critical to seedling establishment. On the flip side, heavy rainfall or snowmelts may result in the washout of seeds, and drought conditions can result in the complete failure of plant establishment. Avoid frost seeding in coarse-textured, excessively drained, or very dry soils, as there will likely not be sufficient moisture for seedling establishment. To mitigate the risks of establishment failure due to adverse weather conditions in a single year, consider frost seeding only a portion of your pasture/hayland in a year – it is less risky to frost seed fields in sections than to do it all at once.

7) **Manage for post-seeding/establishment success.** Continually monitor seedlings and adapt management accordingly to support establishment success.

   a. **First Year Haying/Grazing:** Recommended management depends on the seeding method used and competitiveness of the existing vegetation. Follow the guidance below which aligns with the seeding method used and/or the state of the vegetative cover:

      - **FOR FROST SEEDING** or **FOR NO-TILL DRILL SEEDING INTO SIGNIFICANT VEGETATION**: Take steps to minimize the existing vegetation's growth and competitiveness after seeding is complete, particularly during the first couple months of establishment. Use early spring flash grazing/haying to knock back existing vegetation. Selective mowing can also be used. Existing vegetation should be kept at a low to moderate height throughout the first growing season to allow seedlings sufficient time and resources to establish and gain a foothold. Provide a sufficient rest period at the end of the season (starting around mid-September) to enable seedlings to store resources needed to successfully overwinter.

      - **FOR NO-TILL DRILL SEEDING INTO NO OR MINIMAL VEGETATION**: Avoid harvesting/grazing the field's forage until seedlings reach a certain height (recommended height varies with species). Legumes should be allowed to bloom before harvesting/grazing. Do not graze/hay plants lower than 3-4 inches. Allow for a sufficient rest period at the end of the season, starting around mid-September, to allow seedlings to store resources needed to successfully overwinter. Table five outlines USDA-NRCS Vermont recommended first year minimum clipping/grazing heights.

Table 5. USDA-NRCS Vermont Recommended First Year Minimum Clipping/Grazing Heights for Common Forage Species.

Species	First Year Minimum Clipping/Grazing Height*
Alfalfa	20 inches
Smooth bromegrass	10 inches
Red Clover	8 inches
Orchard-grass	10 inches
Timothy	10 inches
Birdsfoot Trefoil	12 inches
Perennial Ryegrass	8 inches

* *Do not harvest or graze the crop until the vegetation reaches this minimum height.*

b. **Moisture Management:** Seedlings are vulnerable to drought and low moisture conditions due to their limited root systems and energy reserves. In the event of drought, irrigation can be used to help seedlings survive. Managing for soil health, in general, can help increase the water holding capacity of the soil and support improved plant resilience.

c. **Nutrient Management:** Avoid using nitrogen (N) in the season after seeding, as it will likely stimulate the growth of existing grasses and weeds. However, depending on existing cover, a late summer N application may be appropriate. Phosphorus (P) and potassium (K) need to be kept at or brought to adequate levels for successful seedling establishment, especially if legumes are seeded. Always follow best nutrient management guidelines.

d. **Promote long-term pasture/hayland health:** Continuously optimize grazing/haying plans to promote the long-term pasture/hayland health and productivity! This will promote their success and help minimize the need for future renovations (and their associated expenses)!

Financial and technical assistance for pasture & hayland renovation is available through the Vermont Agency of Agriculture, Food, & Markets (VAAFM) Farm Agronomic Practice (FAP) program and the USDA's Natural Resources Conservation Service (NRCS). Please contact UVM extension, your local NRCD or NRCS staff, or another trusted technical service provider for more information about no-till pasture/hayland renovation

Sources & Suggestions for Further Reading

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