Conservation in Vermont

Best Management Practices for Farm and Forest Owners

Vermont Natural Resources Conservation Districts

In this guide, new and small farmers, forest and agricultural landowners will be introduced to a number of Best Management Practices for protecting water quality.

Introduction

VERMONT CONSERVATION PRACTICES GUIDEBOOK

A growing number of new farmers, part-time producers and small value-adding enterprises are showing up on the land — establishing diversified fruit and vegetable operations, making artisanal cheeses, starting mechanized logging companies or specializing in organic products, for example.

In this guide, new and small farmers, forest and agricultural landowners will be introduced to a number of Best Management Practices for protecting water quality. Nearly all of them will protect or improve the community resource that is clean water. Many will additionally enhance soil health, improve crop yields or save energy. Just as importantly, however, these practices will also help producers improve their business's bottom line. That is how Vermont's working landscape and agricultural economy will survive and continue to grow.

The alternative water source above, a water tub with a solar-powered pump, provides fresh water, and is located near a fenced livestock exclusion area to protect the stream.

Conservation in Vermont: Best Management Practices for Farm and Forest Owners

This guide has been prepared by Vermont Natural Resources Conservation Districts (NRCD) through a special allocation to the Natural Resources Conservation Council from the Vermont Legislature to address agricultural water quality. The purpose of this guide is to provide Vermont farmers, producers and partnering organizations with a technical but clear document reviewing conservation practices on farms that help protect water quality and enhance agronomic benefits.

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Acknowledgements:
We thank the members of our advisory committee, many of whom not only suggested practices or reviewed copy but also contributed photographs, web links, and much personal experience.

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Special thanks to the dairy farm family owners of Cabot Creamery for their support of this project.

Designed by Laughing Bear Associates

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Cost Share Programs Table

Practice	NRCS	VAAFM	FSA	UVM Extension	USFWS	VACD / NRCDs
Roof Runoff Structures	EQIP	BMP		ACAP		
Spill Prevention and Containment	EQIP	BMP		ACAP		
Animal Trails and Walkways	EQIP or CREP	BMP			PFW	
On-Farm Composting	EQIP	BMP		ACAP		
Alternative Water Sources	EQIP or CREP	BMP		ACAP		
Conservation Crop Rotation	EQIP	FAP		ACAP		
Conservation Tillage	EQIP	FAP		ACAP		
Cover Cropping	EQIP	FAP		ACAP		
Strip Cropping	EQIP	FAP				
Grassed Waterways	EQIP or CREP	VABP	CREP			
Rotational Grazing	EQIP		GRP			
Nutrient Management	EQIP	NMP		ACAP		LTP
Soil and Manure Testing				ACAP		LTP
Forest Management Plan	EQIP					
Forest Roads and Landings	EQIP					
Portable Skidder Bridges						PSBP
Grass Filter Strips	EQIP or CREP			ACAP	PFW	
Riparian Forest, Herbaceous Buffers	EQIP or CREP	VABP	CREP	ACAP	PFW	TFS
Stream Crossings	EQIP	CREP	CREP		PFW	LEX
Livestock Exclusion	EQIP or CREP		PFW	ACAP	PFW	LEX
Seasonal High Tunnels	EQIP					
Efficient Irrigation	EQIP					

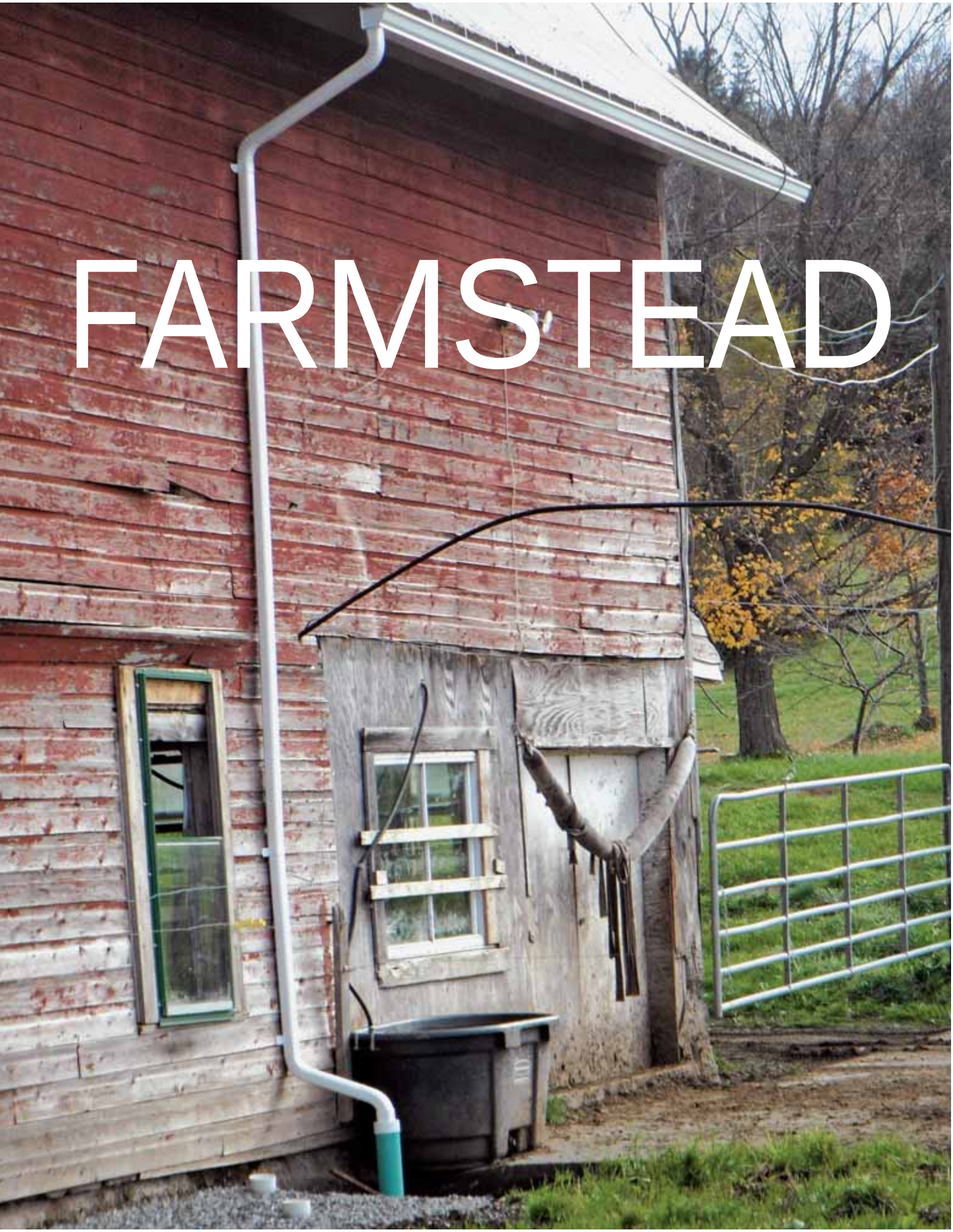
CONSERVATION PRACTICES

FARMSTEAD

FIELD

FOREST

RIVERS, LAKES, PONDS & WETLANDS


FARMSTEAD

Roof Runoff Structures

Gutters and a concrete use area ensure that water is properly directed away from farmstead.

What

Roof runoff structures collect, control and transport precipitation. Gutters and downspouts, perimeter drainage systems, or French drain structures function to collect, divert, and promote infiltration of clean water. Some structures may discharge into a collection system of containers or tanks to be utilized on the farm to water animals, wash equipment, or for other uses. Other structures divert and transport clean water off site to tile drains, grassed waterways, and other farmstead or field features which promote infiltration.

Why

Roof runoff structures keep clean water clean and useable. A small shed or barn has a large enough surface area to generate tens of gallons of clean water in a typical rain event, sometimes even hundreds of gallons. If managed improperly, clean water can end up in stalls, feed storage areas, bedding, or the barnyard, leading to unsafe conditions and contaminated water. When managed appropriately, cleaner, drier barnyards and feedlots create better conditions and healthier livestock. Additionally, buildings are protected from water-related damage such as undercutting of foundations or rot.

How

To install a roof runoff structure, mapping the placement of the collection device will help guide the sizing of gutters, downspouts, and drainage channels to handle a ten-year frequency storm event of five minutes duration as well as snow loads. In Vermont, a storm of such magnitude and duration would generate about 0.3 gallons of runoff for each square foot of roof surface, or 750 gallons for a 25 foot by 100 foot cistern.

Gutters attached to fascia boards or rafter ends, with downspouts directing runoff away from heavy use areas are relatively low cost solutions to roof runoff. Drainage channels under the roof eaves are a somewhat more costly but lower maintenance option for handling roof runoff. Drainage channels can be open surface channels or gravel-filled trenches with perforated pipe in the bottom. Unlike gutters, they aren't subject to snow and ice problems, and they may be easier to keep clean. In general, slope at a 1 to 5 percent grade away from the building to their outlet location. All drainage channels should also be protected from erosion by vegetation, gravel or concrete.

Costs

Installing gutters and other roof runoff structures on your farm is a long-term investment that will benefit you for many years to come. Typically gutters and downspouts cost a little more than $7.00 per foot installed. A conservative estimate for a stone French drain costs about $13.00 per foot installed (or considerably less if the farmer can supply the equipment). Storage tanks for clean water collection come in a variety of shapes and sizes, and range from less than $1.00 a gallon to over $2.00 a gallon depending on the material.

Associated and Complimentary Practices

- Alternative Water Sources
- Grassed Waterways

Benefits

Animal Trails and Laneways

What

Establishing animal trails and laneways is one of the most efficient and sustainable ways to move animals across farmland. These access routes are usually fenced and occasionally gated, and provide animals access to forage, water, handling facilities, and shelter while protecting adjacent lands and water bodies from erosion and runoff.

This designed animal trail has permanent fencing, rubber waterbars (the dark lines across the trail) to direct water off the trail, and a grassed ditched to catch the side-slope runoff of water (left). This combination ensures water doesn't remain on the trail or pool in the barnyard.

Why

Well planned and constructed animal lanes can help farmers improve grazing efficiency and distribution. Laneways limit soil disturbance to areas that can be routinely and easily maintained. Well maintained laneways also help animals stay cleaner and can improve overall herd health and wellbeing. Concentrating animal traffic to laneways can reduce erosion and improves water quality.

How

Sufficiently draining or diverting runoff from animal trails and walkways to vegetated buffer areas can ensure that runoff is filtered and cleaned before it reaches any water body.

Crowning the surfaces will facilitate the movement of water off the trail. In some circumstances, water bars or culverts may be necessary and can help keep clean water away from the herd.

Surfaces should withstand heavy animal traffic only, rather than continual use. Plan to regularly rotate and reseed grassed laneways. Gravel over geotextile laneways last longer but are pricier. In general, gravel/geotextile surfacing is more necessary in closer proximity to the barnyard and where soils tend to be clayey/silty or wet in nature. Gravel should be a graded, coarse aggregate mix that does not hold water. Where gravel or other coarse surfacing materials are used, the laneway slope should not exceed ten percent. Periodic grading and resurfacing may be needed to maintain the trail's cross section. Manure should be routinely removed from the trail surface to protect water quality. Concrete or asphalt laneways have limited utility. They are expensive and are appropriate only on slopes of less than five percent. Concrete or asphalt surfaces should be roughened to provide better traction for livestock.

If fencing is used along the edges of the laneway, it can be permanent or temporary but regular maintenance will be necessary to ensure that animals remain within the laneway.

Costs

A gravel-over-geotextile laneway, unfenced, will cost around $20 per linear foot installed. Gravel-over-geotextile is a popular choice in high-rainfall areas such as Vermont.

Associated and Complimentary Practices

- Rotational Grazing
- Livestock Exclusion
- Stream Crossings

Benefits

Well drained gravel trails and laneways reduce erosion and improve areas that are continually wet. This helps to ensure the safety of animals during travel and to prevent streambank and field disturbance.

On-Farm Composting

What

On-farm composting turns organic waste material into a nutrient-packed resource which can then be applied as a soil amendment. Waste materials can consist of raw manure, crop residuals, animal carcasses or other organic by-products. If properly managed, on-farm composting can help reduce the need for fertilizer and other inputs, decrease pollutant loading to nearby waterways, and may even net a profit if sold to local markets.

Why

Recycling organic material produced on the farm is a cost-effective way to generate needed nutrient s such as nitrogen and phosphorous. Nutrients that might otherwise be lost to the air or water can be processed into a rich, stable organic material that is cheaper than commercial fertilizers or compost and easier to transport and distribute.

How

Managing a compost pile requires monitoring temperature, oxygen and moisture. A good compost pile needs to maintain a minimum temperature of 131°F for at least three consecutive days in order to kill off pathogens and weed seeds. Temperatures throughout the pile are best between 130°F and 160°F. If temperatures fall below 110°F, increase the temperature by turning the pile. Alternatively, temperatures over 180°F risk spontaneous combustion. Adding moisture while turning will cool the pile. The temperature should be taken at least 6-8 inches deep inside the pile and recorded daily until the necessary temperature and length of time is reached.

Animal mortality being composted on-farm. This method is environmentally safer and more biosecure than burying or otherwise discarding. UVM Extension and the Vermont ANR have detailed information on-line about proper composting of livestock and other materials.

The location of a compost pile or facility is critical to success and safety. Choose a dry, slightly sloped site that has good all-weather access on sandy soils with a minimum depth to water table of at least three feet. Appropriate liners can be clay soils, a concrete slab, or a gravel bed. Additionally, depending on site topography, soils and type of composting being undertaken, a compost site must be located at least 100 to 300 feet from any surface water, well or spring, property line, neighboring dwelling, and road. Ideally, composting operations should not be located in a floodplain. If site restrictions require this, please contact the Vermont Agency of Agriculture to ensure the facility meets AAPs.

Costs

If composting on a small scale, the cost may be close to nothing aside from labor and raw materials which are already on the farm. Larger operations will require the construction of a compost pad, the size of which will be based on the number of cubic feet of materials to be managed. Some farmers who go this route may be able to sell the product and to recoup some of the cost of the operation.

Conan Eaton of Auburn Star Farm and James McSweeney, a Compost Specialist at the Highfield's Center for Composting, measure the internal temperature of a compost pile (left).

Compost being matured in fields on the Tamarlane Farm compost site in Lyndonville (center).

Associated and Complimentary Practices

- Nutrient Management Planning
- Soil and Manure Testing

Benefits

Livestock manure compost bin being constructed (above). This bin is sized to accommodate fewer than ten animals and to allow for turning / handling with a bucket loader.

This is a gravel compost pad with a grassed buffer / filtration area on the down-sloped left side. Note the finished compost storage area beyond the buffer area (to the left).

Seasonal High Tunnels

Raspberries being grown in this high tunnel are protected from harsh temperatures and precipitation, wind and pests. Fruits and vegetables may benefit from being grown in this type of controlled environment.

What

A seasonal high tunnel is a greenhouse-type structure at least 6 feet in height used to extend the season on existing cultivated cropland. Fruiting vegetables, such as tomatoes and cucumbers, leafy greens such as kale and lettuce, strawberries and herbs are some crops commonly grown in tunnels. These are grown in the natural soil profile, typically after amendment with mature compost in rows or in beds with multiple rows. Irrigation is provided through trickle or micro-sprinkler systems, and ventilation may be passive (roll-up sides) or mechanical (fans and louvered vents).

Why

A high tunnel is a relatively low-cost capital investment that extends the growing season, allowing for an earlier start in the spring, additional sowings over the course of the growing season, and a later harvest through the fall. Some cold-hardy crops, such as spinach and kale, may be maintained into winter through the use of floating row covers inside the tunnel to add additional protection from the cold. Yields in high tunnels usually exceed those in the open field. Crop quality is improved because there is protection from excessive rain and wind and also more control over environmental conditions such as temperature and soil moisture. In addition, biological controls are often more effective and economical in a tunnel as it is a confined space. This, and the reduction in plant disease due to moisture management, can allow the grower to cut back on pesticide use. The lack of leaching from rainfall can also reduce the need for fertilizer applications — thus protecting water quality and saving money.

How

High tunnels typically have a metal frame, though they may also be made of wood or for 3-season structures, PVC pipes. The frame is covered with greenhouse-grade polyethylene plastic that is stretched over the frame in a single layer, or in two layers inflated by a small fan. Inflation reduces heat loss compared to a single layer, and keeps the plastic from flapping on the frame in windy conditions, which can cause it to rip. A variety of greenhouse film sizes are available, with features such as anti-condensate to minimize moisture dripping on the crop, and infra-red reflecting to reduce heat loss through the plastic.

A structure designed to withstand worst-case snow load is recommended to avoid collapse, unless the cover is removed for the winter. “Gothic” (Peak) styles shed snow load better than “Quonset” (Round Hoop) but sticky snow may not shed off any structure unless the tunnel is heated as the snow falls. Anchoring ground posts by setting them 3 to 4 feet deep and adding cross-braces and corner braces will improve the structural stability of a tunnel. Tunnels with high sides and peaks that can be opened to allow for hot humid air to escape will be easier to ventilate passively than those with proportionally less area.

Siting the proper placement of the high tunnel with respect to drainage, irrigation, and light will insure its long term effectiveness. The high tunnel should be situated on flat ground on a slightly elevated level pad. Tunnels are usually oriented along a north-south axis for summer growing, as this provides the most even light distribution. If growing in late fall/early spring, when the sun is low in the sky, an east-west orientation allows for the most solar gain.

In areas without any slope, the pad should be high enough to account for runoff from melting snow in early spring on frozen soil. Otherwise, cold water will accumulate inside the tunnel. Runoff from the tunnel's surface should be directed away from the structure via surface or underground drains that will function when the ground is frozen. Seasonal or permanent water supply lines can be provided for irrigation.

The high tunnel air may be heated with a furnace, and the soil may be heated with a hot water heater and tubing placed about a foot below the crop rows or beds. The latter is important if trying to grow warm season crops in early spring, as the soil may remain cold even as the air warms up, since heat rises. The structure's end walls are framed-in to create door and ventilation areas.

Costs

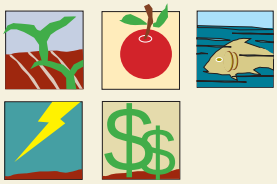
Seasonal high tunnel kits, shipped, and installed using basic tools requiring little expertise cost about $4-$5 per square foot. About 70 person-hours are required to erect a 30 foot by 72 foot structure. (This estimate does not include significant earthwork or grading.) The payback period for a high tunnel is usually 1-2 years, depending on the crops grown, yield and prices received.

Paul Harlow in his Westminster high tunnel. Note the use of roll-up side ventilation and an overhead drip irrigation system.

Associated and Complimentary Practices

- Grassed Waterways
- Nutrient Management Planning
- Efficient Irrigation
- Integrated Pest Management

Benefits



Close up of spring-sown crops within a high tunnel that utilized drip irrigation.

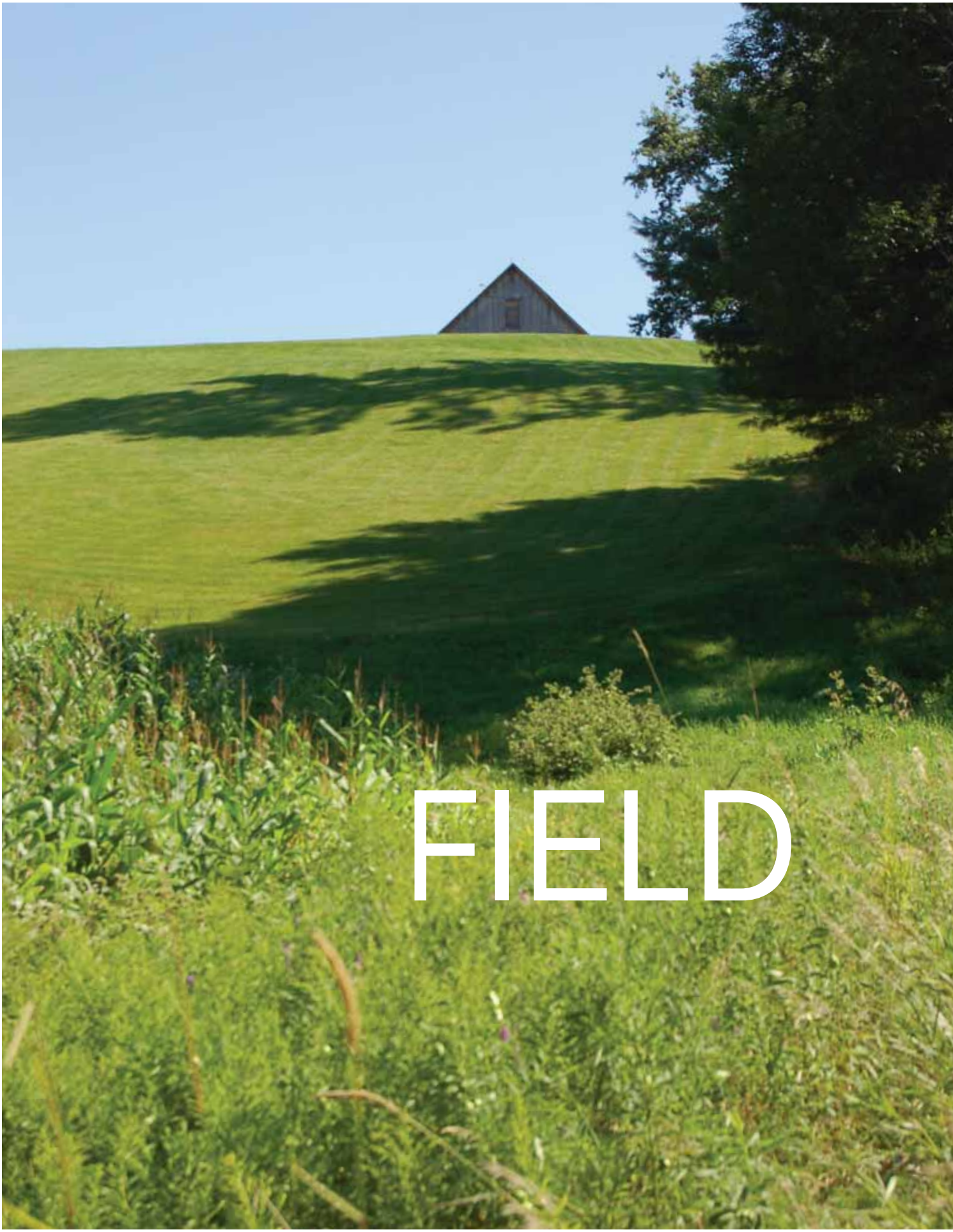
This high tunnel with efficient, drip irrigation allows for an early spring planting of cold weather crops and for fall season extension.

Case Study

Rowell Farm Albany, VT

The Rowell Farm is a 250-acre grass-based dairy located in Albany, Vermont, where Tim and Josh Rowell milk thirty-five Jersey cows. This family farm in the heart of the community has been in operation for generations. A recent upgrade to the farm was the installation of a 160 foot-long animal laneway on a steep and muddy high-traffic area. The needed improvements were made in spring of 2012 and helped facilitate animal movement to foraging areas while protecting and improving water quality in nearby Shalney Brook, a State impaired waterway. The project, which involved installing geotextile fabric under several inches of compacted base and surface materials, creating water diversion features, and installing fencing, has resulted in reduced nutrient enrichment and sedimentation in the brook. It has also improved the farm's bottom line. Tim Rowell, in expressing his gratitude for the benefits the project has provided, said "the more efficient animal movement, the reduction of cow access to muddy areas, improved udder health and thus milk quality — they will all make my job easier and the cows happier."

Tim Rowell of Albany, VT with VACD Agricultural Resource Specialist.


FIELD

Alternative Water Sources

What

As an alternative to livestock having direct access to streams and water bodies, many farms make use of water sources such as developed springs, animal-operated nose pumps, truck-mounted tanks, and portable troughs to provide their animals with clean drinking water.

Why

Livestock health and vigor can be compromised and a number of other issues can arise when livestock are allowed in and near streams. Animal wastes contaminate downstream water supply systems for people and other animals and compromise stream habitat. Livestock will also erode streambanks causing muddy areas and banks that are likely to fail and release their sediments downstream. Manure deposited into water creates unsafe conditions for swimming and other recreational uses.

Providing livestock with clean drinking water away from waterways increases the reliability of the source. When properly sited and designed, alternative water sources can help ensure adequate water supplies even in times of drought.

This water storage tank on the Corse Farm in Whitingham is supplied by a solar-powered pump that is located in a nearby spring. Water is then gravity fed from the tank to a system of watering tubs that are located throughout the farms' pastures. This farm is pasture-based and uses a rotational grazing system.

If utilizing a rotational or intensive grazing system, multiple alternative water sources are extremely valuable. In such systems, livestock have consistent access to fresh water and the manure is well distributed around the pasture so the nutrients are maximally utilized at little cost to the farm.

How

All livestock farmers can incorporate alternative water sources into their farm operation to some extent. The chosen system depends on the number of animals cared for, the location and output of the water source, the availability of electricity, the farm schedule, and cost. Whether springs, ponds or pumps are powered by electricity, the sun, moving water or livestock themselves, they can help a farmer meet animals' watering needs.

Developed springs

Developed spring heads from perennial springs can be a central part of the farm's livestock watering system if the water supply is clean and the flow is adequate. When developed, springs usually supply water via gravity to a down slope tank or other collection unit. Springheads usually consist of a small concrete reservoir, such as well tile whose bottom is lined with washed stone, or sand, although a dam-style springhead is another option. The springhead is placed atop an impervious soil layer over which spring water can move into the reservoir. A rigid PVC supply pipe and an overflow pipe can run from the reservoir to points down slope. Where topography allows, ponds or deep riverine pools can provide water via buried or above-ground PVC pipe to watering tanks down slope, in the same fashion developed springs serve as a source of gravity-fed water.

The spring should be protected from surface water by a diversion ditch constructed up slope and around it. It can be seeded, or backfilled with rock and geotextile. In any case, protect the spring from livestock access.

Ram pumps, sling pumps, and solar pumps all run on renewable energy

Ram pumps require water falling from a higher to a lower point to provide the energy that drives them. Sling pumps use flowing water in a stream or river to turn propellers on the pump. Sling pumps are less adaptable than ram pumps. (It is velocity, not "head," that drives them; and streams must be at least ten inches or more in depth to permit the pump to rotate. They are also more expensive than ram pumps.) Solar pumps are the most adaptable and the most expensive of the pump options. Battery backup devices are recommended to ensure adequate water for animals even on cloudy days.

Animal-operated nose pumps (or "pasture pumps")

Beef, heifers, and horses weighing 400 or more pounds can be trained to use a nose pump. These pumps lift water as much as 20 feet vertically and 200 feet horizontally (or combinations thereof) from a surface water supply or holding unit via above-ground hoses. Pumps should be securely mounted on a raised unit inside an enclosure protecting the delivery hose from animal traffic. One pump should be provided for each twenty animals, or as the manufacturer recommends.

Truck transport

Hauling water provides a farmer with the greatest number of options for siting watering systems, and requires less capital outlay than permanent watering facilities. But it is time consuming, especially in hot weather when animals may need additional water. Beef and dairy cattle require twenty to twenty five gallons of water daily. Most farm vehicles can carry about 1,000 gallons, or about the quantity of water that 50 beef cows or 40 dairy cows drink in a day.

Costs

Solar powered pumping systems for livestock usually cost $2,000–$6,000. Winter operating solar systems are more expensive. Standard nose pump range in cost from $250 to $500 each. Frost-free units cost around $1,000 each. Ram pumps cost approximately $200–$600. Sling pumps range from $900–$1,600. Storage tanks come in a variety of shapes and sizes, and range from less than $1.00 a gallon to over $2.00 a gallon depending on the material. (All costs exclude installation).

Portable water troughs are used in pastures (top) and in the barnyard (above) to control where livestock obtain water. Using a water system and proper fencing works to keep livestock out of streams and ponds, protecting both surface water and livestock health.

Associated and Complimentary Practices

- Rotational Grazing
- Riparian Forest and Herbaceous Buffers
- Livestock Exclusion
- Efficient Irrigation

Benefits

Conservation Tillage

What

Conservation tillage is a method used to plant and grow a crop while leaving a year-round cover of living or residual plant material on the field. As opposed to conventional plowing and seed bed preparation, conservation tillage limits soil-disturbing activities to only those necessary to place nutrients and plant crops. Practices known as no-till, strip-till, ridge-till, and mulch-till are different methods of conservation tillage and managing residue. In a no-tillage or direct seeding system, plants are grown directly in residue with no full-width tillage. In strip-tillage systems, strips are tilled in narrow strips (no greater than 1/3 of the row width) and the rest of the field is left undisturbed. A ridge tillage system involves maintaining the residue as previously mentioned and preparing ridges or shallow beds for establishing crops. Mulch-tillage system preserves one third of the surface residues. These systems often use aeration and manure injection equipment to amend the soils.

Why

Conservation tillage boosts soil organic matter, improves soil tilth, and increases infiltration and the soil's capacity to hold and provide root-layer moisture — which may all together improve crop yields. Conventional tilling of soil leaves the soil surface bare and exposes it to the erosive action of water and wind, increasing erosion and sediment and nutrient losses. Conventional tillage can also create a so-called "plow pan," a zone of compaction which roots can barely penetrate. With conservation tillage, farmers instead leave much of the soil and crop residue intact, reducing compaction caused by plowing and minimizing erosion. These techniques reduce nitrous oxide emissions and create a more natural soil profile that retains nutrients and water (an added benefit during drought), prevents soil erosion, compacts less and has improved soil biology and aeration. Comparably, conservation tillage may require less time on the tractor and offer savings in labor, fuel, and equipment maintenance costs.

How

Conservation tillage is practical for any farmer who grows annual crops though it often requires the use of equipment customized for the practice. This may include devices such as no-till or strip-till planters or drills, strip-type fertilizer applicators, in-row chisels, coulters, sweeps, aeration tillers, and others. Where low-residue crops such as silage corn are grown, a fall-planted cover crop may be necessary to protect the soil surface from erosion. Fall-planted cover crops also provide a number of agronomic benefits and should be considered for those reasons as well. To reduce the need for spring-applied herbicide, consider growing a cover crop, such as forage radish, which winter-kills after producing a heavy residue. (Radishes and other brassicas may also help reduce pest pressures of many kinds.) Other cover crops may require an application of herbicide in addition to those needed to grow the main crop.

Costs

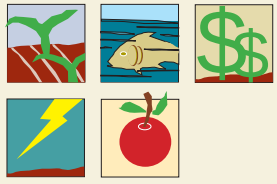
Costs will vary according to what kind of equipment is available to the farm, whether existing machinery can be adapted, and the period of time that investments will be made. While transitioning into conservation tillage may require additional capital investments, these costs are generally offset by reduced fuel, labor, and machinery maintenance expenses going forward. Studies from the Midwest have shown that no-till systems can cost less than half that of conventional tillage systems.

A corn grain field after harvest with corn stover / residue covering the ground. Corn stover protects the soil during winter which in turn helps to build up the organic material and additional nutrients.

Associated and Complimentary Practices

- Cover Cropping,
- Integrated Pest Management

Benefits



Above, left: Aerator slits in annual crop land. Right: Tines on an aerator cut into compact soil and incorporates liquid on annual crop land.

Above, left: Ryegrass planted with a no-till seeder. Right: A no-till seeder being used to plant a field.

Above, left: A corn grain field after using a tillage machine creates a seed bed. Right: A Zone Builder tillage machine. The front disk cuts through residue, an adjustable shank breaks through different lengths of compacted soil layers, and the rolling basket in the rear breaks up soil clods.

Cover Cropping

What

Cover Crops, also known as "Green Manure", benefit the soil by increasing fertility and controlling erosion. These temporary plantings can consist of grasses, legumes, or cruciferous species sown in bare or nearly bare soil, or in orchards between the rows. Depending on the crop rotation, a cover crop can be sown anytime from early spring through fall.

Why

Soils are a farm's most valuable asset. The primary purpose of growing cover crops for most farmers who use them is to preserve that asset by protecting soil from erosion by wind, rain or runoff. Soils shielded by a cover of living plant material or plant residues are kept in place on the farm, rather than transported to nearby watercourses.

Alternate rows of clover and ryegrass.

The use of cover crops can improve organic matter content, porosity, and tilth in all farm settings. For example, Legume cover crops can produce as much as 50-150 pounds/acre of nitrogen which can increase soil fertility. Some cover crop species can suppress weeds by depriving weeds of nutrients and sunlight. Others help provide food and refuge for beneficial insects and other organisms, creating a root zone rich with soil microbes found to resist diseases and pests.

Cover crops expand a farmer's feed options and efficiency. A grain cover crop sown in September can be harvested as haylage in the spring. If crop fields are fenced, livestock can graze the cover crop before or after harvesting. Prioritize cover cropping on fields close to waterways with steep slopes or where there are obvious signs of erosion. Winter cover crops are a critical piece of reducing spring runoff, which is high in nutrients.

How

Cover crops can be sown when the field is between harvests and when there is time enough for a cover crop to be established. Whether a particular cover crop species should be planted in a given situation will depend on the anticipated benefits of that seeding as compared to its known costs. Each species has its own particular characteristics (for example, buckwheat is used for weed suppression while Sudangrass is grown for biomass production), so farmer goals and the characteristics of the cover crop species should be clearly understood.

Common winter cover crops sown in the fall include winter rye, oats and winter wheat. Some crops winter-kill, such as oats, while others will start to grow again in the spring. Common summer crops that grow rapidly during June-August include buckwheat and sorghum-Sudangrass. Perennial covers include red clover and ryegrass, though these can also be grown for a single season. Covers can be sown in combination, such as hairy vetch and rye in fall, oats and field pea in the spring, or sorghum-Sudangrass and red clover in early summer.

For late summer and fall sowings, overwintering crops such as some forage brassicas, wheat, annual ryegrass, medium red clover, hairy vetch, and cereal rye (also known as winter rye) provide good to excellent erosion control and a variety of soil benefits. Each species, however, may also have drawbacks and require additional management. Most overwintered cover crops should be killed by tillage or by applying herbicide as soon as the fields are accessible in early spring, as early as April in some parts of Vermont.

Most cover crops planted for winter soil protection will be sown between August 15 and October 1. Seeding rates will depend on site conditions and whether the seed is broadcast or drilled. High seeding rates and good soil-seed contact can improve the quality of a cover crops stand and reduce subsequent weed pressure in a field. The Vermont NRCS Job Sheet suggests seeding rates for several commonly grown cover crops.

Costs

A small grain conventionally grown cover crop could cost about $85/A/year in materials and labor. A small grain

organically grown cover crop could cost about $140/A/year in materials and labor for application. A legume cover crop could cost about $120/A/year if grown conventionally, and about $150/A/year if grown organically. Seed prices may vary depending on the source. The additional costs associated with using cover crops are balanced by the savings of purchased nutrients and herbicides.

Cover Crops

Recommended Seeding Rates for Commonly Used Cover Crops

CEREAL GRAINS

Oats
90-120 lbs. per acre
If broadcast and disked into the soil, seeding rates for cereal grains shall be increased by 50%

Rye
90-120 lbs. per acre

Triticale
90-120 lbs. per acre

Winter Wheat
90-120 lbs. per acre

GRASSES

Annual Ryegrass
10-15 lbs. per acre

Seeding Mixtures on Well Drained and Droughty Sites (Pounds Live Seed)

Ladino White Clover
5-7 lbs. per acre

Sudangrass
25-30 lbs. per acre

Buckwheat
75-100 lbs.acre

Hairy Vetch
25-30 lbs. per acre

Seeding Mixtures on Somewhat Poorly Drained Soils with Moderate pH

Medium Red Clover
8-10 lbs. acre

Fall-seeded cover crop in a corn field. A fall cover crop prevents erosion from wind and rain, and helps to provide nutrients to the soil. This cover crop will likely be incorporated into the soil in the spring, before another planting of corn.

Strips of well-maintained grass between the orchard rows help to suppress weeds and prevent erosion.

Associated and Complimentary Practices

- Conservation Crop Rotation
- Conservation Tillage
- Integrated Pest Management

Benefits

A cover crop of ryegrass in between corn rows.

Grassed Waterways

A well-functioning Grassed Waterway. This practice provides a stable outlet to convey surface water off the field while preventing ephemeral soil erosion.

What

Grassed Waterways are a shaped or graded, perennially vegetated channel designed to carry runoff at a slow speed to a stable outlet or receiving waterway. As water travels down the waterway, the vegetation prevents erosion that would otherwise result from concentrated flows. When used in conjunction with other field practices, grassed waterways can be easily maintained and will require little cleaning and repair.

Why

Grassed waterways manage storm flows and snowmelt while protecting fields against gullies and soil loss. The vegetation in the waterway slows down and soaks up incoming water, significantly reducing erosion. The result is a drainage structure that maintains its shape and function over time. Additionally, due to the decrease in soil loss and sedimentation, water quality and habitat for aquatic organisms is protected. Grassed waterways are appropriate wherever row crops or perennial forage crops are grown, or on pastures.

How

The length, depth, and width of the waterway will depend on a number of factors, including the size, slope, and soil type of the contributing watershed, and the soil type and slope of the waterway. Most grassed waterways are sized to accommodate the ten-year storm event (a storm of such a magnitude has a ten percent chance of occurring in any one year). In Vermont, these storms produce about four inches of rainfall in twenty-four hours.

A shallow parabolic (or “U”) shape waterway will resist erosion and be easily crossed with tilling and harvesting equipment when side slopes are maintained flatter than a ratio of two horizontal to one vertical. The concave surface of a grassed waterway must be kept smooth, to maintain overland flow and avoid creating gullies. The channel slope itself should be at least one percent and shouldn’t exceed five percent. If the slope does exceed five percent, grade control structures may be needed.

Quickly establishing vegetation on a newly shaped waterway is critical and construction of the waterway should coincide with recommended planting dates for the chosen vegetation types. Use species adapted to the site conditions that can achieve the best vigorous growth and cover in stabilizing the waterway. Nurse crops may help seeds germinate and seedlings successfully grow. Straw or hay bale dikes and upslope runoff diversions using

temporary berms can help control water volumes and velocities in the waterway while plants are successfully taking root. A biodegradable erosion control mat will also increase the odds of success.

The waterway should discharge to a receiving channel such as a stream or other waterbody. (Farmers can seek advice on what sorts of discharge arrangements are legal and sustainable from their local NRCS office, from VAAFM staff, and from the VT DEC Water Quality Division.) In some cases, the discharge point from a grassed waterway may need to be stabilized with stone or other material.

If you have livestock, exclude them from the waterway to the extent possible, even if it means fencing off the waterway. Keep all traffic out of the waterway during wet periods. To maintain the waterway's capacity, mow it at least once annually, routinely remove debris that might obstruct the movement of water, and immediately repair damage caused by burrowing rodents. If herbicides are used for weed suppressant in the fields, inform operators to avoid established grassed waterways.

Costs

Grassed waterways with a stone-lined center can cost about $32 per foot. Without stone, grassed waterways can cost about $9 per foot.

Associated and Complimentary Practices

- Cover Cropping,
- Strip Cropping

Benefits

An ephemeral eroding gully (top) shaped and seeded with a conservation seed mix (center) creating a stable, grassed waterway (bottom).

Nutrient Management

What

Nutrient Management is the process of managing the addition, removal, and recycling of nutrients on the farm. A Nutrient Management Plan is used to determine what or if particular inputs are needed for a specific crop or farming practice, saving money and the unnecessary addition of nutrients into the environment. Tools that help track nutrient balances on the farm and inform a Nutrient Management Plan include farm and soil maps; soil, nitrogen and manure testing (see below); and the use of farm records to track fertilizer and manure applications, crop harvests, feed purchases, etc.

Why

Nutrient Management planning allows the farmer to identify if inputs are needed, what inputs are needed, and where they should be targeted. Additionally, Nutrient Management planning helps save money and resources by determining the return one gets from the dollars invested. Proper planning also has the potential to improve yields while lowering or minimizing costs. Nutrient Management plans are required for all medium and large farm operations, and a plan is highly recommended for small farms. Most plans also require crop field erosion be reduced to tolerable (T) levels.

Farmer spreading manure on a field that is utilized both as pasture and as hayfield. Note animal laneway in the foreground.

How

Nutrient Management planning begins with mapping the farm; its fields, acreages and soil types; the crops grown and their rotations; as well as sensitive environmental areas such as wells, ponds and other water ways. These maps help manage implementation of a Nutrient Management Plan by showing nutrient recommendations, identifying areas that may require buffers and setbacks, and as a way to keep crop records.

Record keeping is used to document the farm's nutrient activities in relation to the import, export or recycling of nutrients. When these records are reconciled with nutrient recommendations from the Nutrient Management plan, the farm can improve nutrient applications to meet economic and conservation goals. Record keeping is broken down into the four main categories: Imported Nutrients, Exported Nutrients, Removed Nutrients, or Recycled Nutrients.

A practice available for some Vermont farmers is manure injection. Manure injection is an effective way to manage manure application to maximize nutrient utilization. Compared to broadcasting liquid manure, injection can substantially reduce ammonia volatilization and retain more nitrogen for plant growth. Phosphorus in injected manure is also held in the soil and not left to runoff in subsequent stormwater events. Other advantages of manure injection include decreased odor and enhanced nutrient uptake.

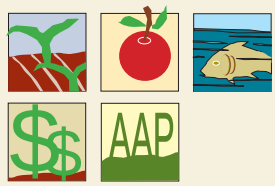
Costs

Soil sampling and testing, manure and compost sampling and testing, and record keeping can range in cost from about $35 per acre per year for field and forage crops and up to $150 per acre per year for specialty fruit and vegetable crops.

Associated and Complimentary Practices

- Conservation Crop Rotation
- On-Farm Composting
- Cover Cropping
- Soil and Manure Testing

Benefits



Soil and Manure Testing

What

Frequent testing of soil and manure is one of the first steps in the Nutrient Management Planning process. Testing facilitates accurate determination of nutrients in the soil and manure that help track nutrient levels on the farm, to identify potential problem areas and where additional nutrients may be needed.

Why

Soil testing can level out the variability in soils and determine if nutrients are needed and where / how they should be applied. By beginning with soil and manure tests, a farm saves time and money on the unnecessary application of nutrients. Testing allows for the targeting of nutrients where they are needed and will be most beneficial, maximizing the inputs and investment. This targeted approach to nutrient management has the added benefit of helping to reduce excess nutrient losses to nearby waterways.

Soil tests measure the soil's nutrient composition which is available for plants. The nutrient composition helps determine the best application rates of lime and fertilizer to meet crop needs. This is important for cost effectiveness, to provide optimum yield and quality, and to safeguard water quality. Generally, nutrients should be in the high or optimum range for good yield and quality. If a nutrient is in the Very High (Above Optimum or Excessive) range, additional amounts in most cases should not be added. If nutrients are below the optimal range, some additions may be necessary. However there may be additional factors impacting yield that should be considered prior to application.

How

UVM Extension offices and / or Conservation Districts offer soil test kits and services to assist farmers with testing. There are a variety of tests that can be done and each will give the farmer a wealth of information.

Soil Tests identify low and high nutrient soils that allow for increases and decreases in nutrients applied to specific fields, either fertilizer or manure, which can help protect the environment and save money. Modified Morgan extract for Phosphorus results and Aluminum results (UVM or request from your soil lab) allow use of Phosphorus Index developed by UVM that may allow for use of manure on high Phosphorus soils.

PSNT or Preside-dress Nitrogen Soil Test done when corn is 8-12 inches identifies whether additional nitrogen is needed. Use of this test can help you fine-tune your nitrogen applications and allow farm to apply the correct amount of nitrogen at the most beneficial time.

Manure Tests allow you to determine the actual nutrient value of manure, which will further help when applying nutrients from organic fertilizer. Proper sampling and creation of a 'library' over several years will help the farm understand its average manure composition (assuming there have been no major changes in field practices or inputs.)

Costs

Soil or manure tests can range from $10–$35 per sample depending on the type of test performed.

Special Note

On agricultural land where annual application of phosphorus exceeds its removal by crops, phosphorus will accumulate in soils. A field testing high in phosphorus can be a source of pollution to nearby waterways. When this is the case, the farmer should have the Phosphorus Index (P Index) calculated for the field. The P Index is a tool that can help identify farm fields that are a potential source of phosphorus (P) pollution of surface waters. A large number of factors determine phosphorus loss from a field including a soil test value for phosphorus; source, method, rate, distance to surface water and timing of P application; susceptibility of a given soil to erosion; and management practices. The P index quantitatively determines the relative risk of P movement from a given field by considering most of the factors that govern P losses. Contact a UVM Extension Professional for more info on P Index.

Associated and Complimentary Practices

- On-Farm Composting
- Nutrient Management Plans

Benefits

Efficient Irrigation

Drip irrigation system being used within a greenhouse for early spring seedlings.

What

An efficient irrigation program allows a farmer to meet crop soil moisture needs throughout the growing season and in all weather conditions. It controls the volume, frequency, and application rate of irrigation water, while, at the same time, minimizing energy costs and demands on farm family schedules. Overhead sprinkler and drip irrigation systems (which deliver irrigation water at the soil surface) are commonly used in Vermont.

Why

An efficient irrigation program will promote plant health and yield by ensuring adequate soil moisture is available when the plants need it. By managing for the role humidity and wetted foliage play in spreading disease, an efficient irrigation program will reduce plant susceptibility to mildews, blights, and other pathogens. By minimizing drought stress, efficient irrigation will reduce crop susceptibility to insect pests. It will optimize the use of available water supplies. And a well-designed and carefully implemented irrigation program will reduce energy consumption.

How

The primary objective of any irrigation system should be to provide the correct amount of water to the crop, when it is needed. Plant-available moisture occupies a range of values in the field, from just less than saturated to near the wilting point, and depends on the weather, the plant's stage of growth, weed pressure, and soil type. All these factors must be addressed in designing an irrigation system that adequately responds to plant needs, while promoting water infiltration and reducing runoff.

Irrigation should supplement natural precipitation to help establish seedlings, or serve as a back-up during dry and droughty periods. While these supplemental amounts may be small compared to natural precipitation, break-even or profit-making yields may depend on being able to provide them. With experience, a farmer can predict how much additional moisture must be planned for. For most crops, an appropriate goal is to irrigate when 50 percent of the available soil moisture is depleted.

Some farms may have access to plentiful water supplies from a pond or a river, while others rely on groundwater. Groundwater wells are likely to produce water at a lower rate than surface waters over any one period of time, but surface water quantities may be less reliable over the growing

season. The farmer should design an irrigation system based on how much water is available to the farm in dry periods. All irrigation water should be safe to use on crops meant for human consumption.

Overhead systems use more water than drip systems and may not be the best choice where supplemental water sources are limited. Overhead systems are also more likely to promote disease than drip systems. They are, however, significantly less expensive to install and operate and may be easier to maintain than drip systems.

All irrigation systems require routine maintenance. Pumps, gaskets, fittings, sprinkler heads and other devices should be examined regularly and replaced or repaired as needed.

Costs

For a drip system, the pump and its motor could cost about $175–$275/hp. A one-inch buried HDPE pipe will cost, installed, about $2 per linear foot; a two-inch buried pipe, about $4.50 per linear foot; and a two inch unburied pipe, about $2.75 per linear foot. The in-field system will cost about $900 to $1000 per acre, not including the laterals.

Associated and Complimentary Practices

- Alternative Water Sources
- Integrated Pest Management
- Nutrient Management Planning

Benefits

Drip irrigation systems being utilized in an orchard (top), and to help strawberries get an early start (above). Note use of mulch and fabric to help retain moisture and for weed suppression.

Rotational Grazing

What

Rotational grazing is a grass-based livestock feeding system in which animals are rotated from pasture to pasture. Also known as "management intensive grazing" this practice allows livestock to graze one portion of pasture or a paddock for a certain length of time, while allowing other portions to recover before being grazed again. This system provides for the health of the forage plants as well as the animals.

Temporary fencing (net or single / double strand poly-wire) is a common way to quickly and easily rotate livestock on pasture.

Why

Rotational grazing can improve farm sustainability by protecting and promoting soil health. It is a cost-effective way to maximize animal exposure to a nutritious food source while promoting a vigorous mix of perennial grasses, legumes, and forbs. It can enhance profits by reducing the need for off-farm inputs such as feed, fertilizer, and fuel. This system of grazing also promotes a more even distribution of animal waste across the landscape.

How

Rotational grazing is suited to a number of farm animals, including poultry, pigs, dairy and beef cattle, horses, goats, and sheep. The kind of animal the farm raises, their behaviors, and their weights are among the many factors to be considered in laying out the paddocks. Paddock arrangement, shape, and size; watering facilities in them; and the movement of animals through them should all be considered works in progress. They should be adjusted as needed to respond to animal impacts on them, weather events, changes in the farm schedule, or changes in the farmer's goals. It's best for farmers to research paddock size per animal unit.

Very few pastures need to be completely renovated to provide nutritious and abundant forage for grazing ani-mals, though a diversity of forage species is best. In fact, the introduction of a rotational system is likely to greatly improve pasture quality. A soil test will indicate the best type of forage to use, and whether the pasture needs liming or if macro- or micro-nutrients are lacking. Nitrogen-fixing legumes should be part of the pasture mix.

Plant growth characteristics are the foundation on which the rotational grazing plan rests. In general, in the Northeast, a pasture should be grazed no longer than three days. After that time, plants begin to regrow. Permitting animals to graze that tender growth will, over time, reduce plant diversity and cover and cause soil erosion. It's important to have a designated area for drought periods if necessary to protect regrowth in fields.

Fencing will be needed for the pasture perimeter and for the paddocks. Permanent fencing is usually used for the perimeter, and temporary fencing for the subdivided paddocks. The type of fence chosen will depend on the animal. Horses, for example, may need post and board fences on the perimeter and electric polyrope on the interior. Dairy cows adapt well to high tensile electric on the perimeter and electric polywire on the interior. All fences must be well-grounded and provided with good lightning protection.

Drinking water may be provided in moveable tubs or carried by wagon to the sites. Water pipes, whether seasonal or installed under the fence line or along a lane, are another option. Watering devices should be located, and paddocks shaped, with an understanding of animal behaviors.

Costs

The estimated costs for applying Rotational Grazing is from $35 to more than $90 per acre per year, for fencing and labor.

Associated and Complimentary Practices

- Animal Trails and Laneways
- Alternative Water Sources
- Nutrient Management
- Livestock Exclusion

Benefits

Conservation Crop Rotation

Lush grass covers what is typically a crop field. Allowing for fallow periods, rotating crops and cover cropping in spring / fall ensures that soils can recoup nutrients lost during the growing season.

What

Conservation Crop Rotation is the growing of crops, including cover crops, in a planned sequence over one year or more on the same acreage. It is an appropriate management system for any farmer who grows at least some annual crops and whose soils are for some part of the year exposed to erosion. In this system, annual crops are typically rotated in and out of production in combination with other crops and various grasses and legumes. This provides a number of benefits both from an agronomic and environmental standpoint.

Why

Crop rotations can improve soil health and increase yields by boosting soil organic matter, improving soil tilth, and producing and managing a balance of plant nutrients. In many cases, rotation can address competition from weeds. Rotations can also reduce insect and disease pressure by removing hosts and alternate hosts and by introducing species that attract beneficial organisms. The system is also designed to reduce runoff and erosion while maximizing soil health, crop returns, forage availability, and farm sustainability.

How

Planning for a conservation crop rotation includes specifying the location of plots and acreage, defining the purpose for the crop rotation, and identifying the type, sequence, and duration of the crops. State and Federal cost share funds are usually required to design crop rotations to meet standards. These standards insure soil health by building a rotation plan that takes into account rotation length, plant rooting depth, plant nutrient yield or demand, growing season requirements, fertilizer or manure application, and others.

A rotation plan might include alternating cool season with warm season crops; incorporating a nitrogen-fixing grass and legume crop grown over one or more years; following deep rooted species with more shallowly rooted species; avoiding consecutive years of annual plants in the same family and protecting soil from erosion between crops by growing green manures or ensuring a high-residue cover remains after harvest. Growers will also want to build rotations with the goal of minimizing the weed seed bank and thus the need for cultivation; to that end, it is important not to plant long-term covers when weed pressure is high and weeds are likely to go to seed within the cover crop.

Costs

While every rotation plan will be different, one commonly used practice — an autumn sowing of winter rye into a silage corn field, and terminated before spring planting — may cost about $85 an acre. Other covers are more expensive, such as hairy vetch and clovers, but these can provide significant savings because they provide legume nitrogen to a subsequent crop, reducing the need for fertilizer application. See Cover Cropping practice for more information.

Associated and Complimentary Practices

- Conservation Tillage
- Cover Cropping
- Nutrient Management
- Integrated Pest Management

Benefits

Strip Cropping

Strip cropping is one of the least costly measures available to farmers to reduce erosion.

What

Strip cropping is the planting and growing of alternating strips of erosion-resistant crops with strips of erosion-prone annual crops. The strips are systematically arranged across a field as close to the contour as possible. Strips are sized to accommodate multiple or full-width passes with tilling, seeding, harvesting or other equipment and are usually of equal width. Erosion-resistant crops such as legumes and hay and erosion-prone annual crops such as corn for silage can be used.

Why

Strip cropping can improve crop yields by encouraging infiltration and thereby increasing soil moisture. Strip cropping is one of the least costly measures available to farmers to reduce sheet and rill erosion.

By helping to keep soil in place, strip cropping protects water quality and with it aquatic habitats. Strip cropping is also visually appealing and enhances the attractiveness of the agricultural landscape.

How

Strip crops can be established on a variety of crop fields and managed to suit the field conditions. A rotation plan for the strips should balance the goals of controlling erosion, protecting soil health, and maximizing crop yields.

Choose a strip width based on the slope of the field and its soil types. Federal and State Agency professionals can help farmers choose a width based on erosion predication technology. Also consider the widths and turning radii of the equipment which will be used on the field. A width accommodating some multiple of full-width passes along the strip will be the most efficient. If possible, run strips square to fence lines or other barriers. Some smoothing of sediment at the interface of strip edges may be occasionally necessary.

Costs

Costs associated with strip cropping are similar to those for a farm's field preparation and planting rates.

Associated and Complimentary Practices

- Conservation Crop Rotation
- Conservation Tillage
- Cover Cropping
- Nutrient Management

Benefits

Case Study

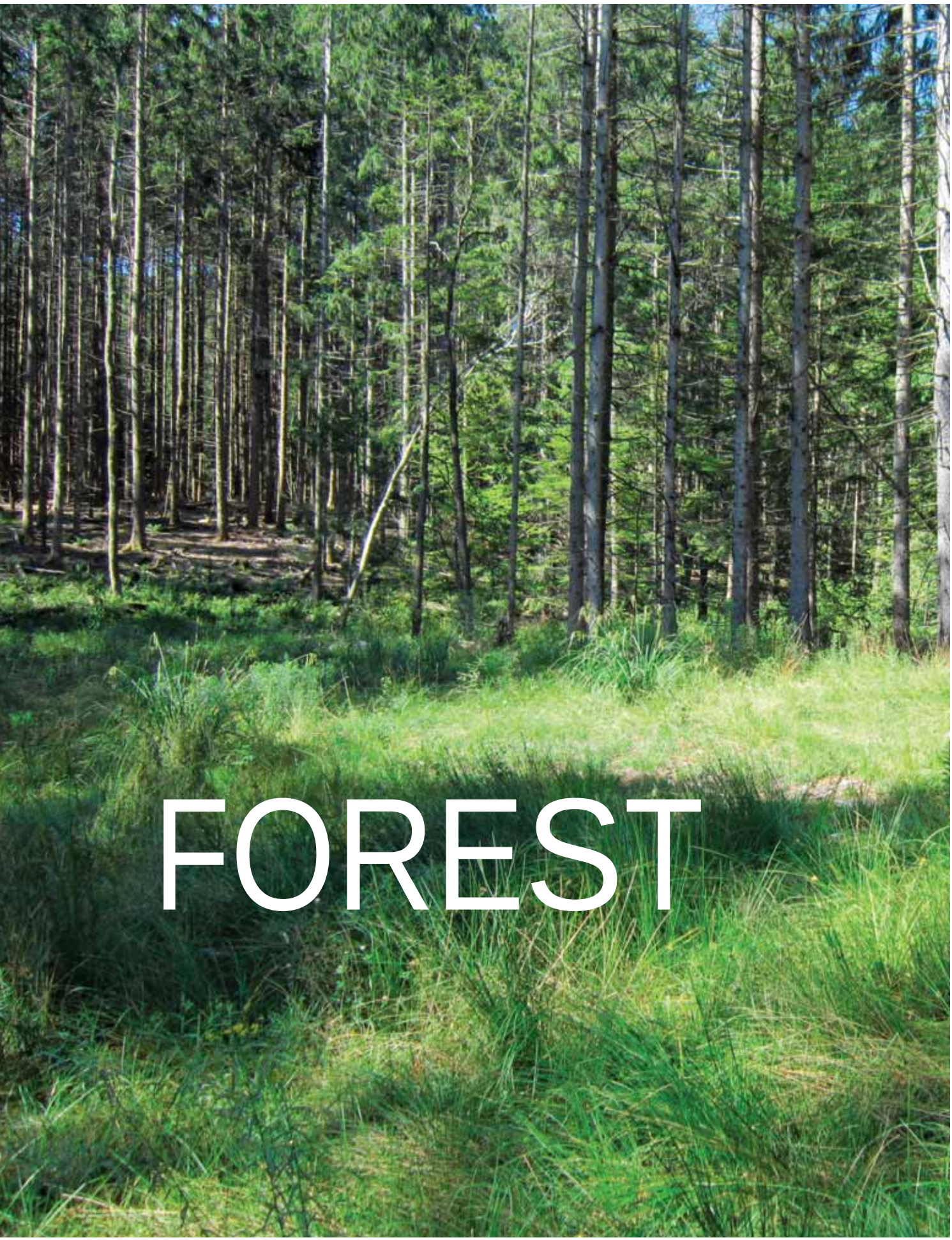
Paul Harlow at the entrance to a high tunnel on his Westminster farm.

Harlow Farm Westminster, VT

Harlow Farm is a 150-acre family farm that has operated for nearly a century along the Connecticut River in Westminster, Vermont. Third and fourth generation farmers Paul Harlow and his son Evan produce a bounty of vegetables, fruits and berries, poultry, eggs, beef, lamb and pork year-round for their local community and other New England neighbors. The farm seasonally employs 30 community members, several full time employees and includes many local growers and producers in their farmstand and CSA.

Paul was an early pioneer of organic and sustainable farming in Vermont, and continues to innovate today. In 1985 the farm was certified organic after three years of using only biological fertilizers, pesticides and crop rotation processes that are still practiced today. In addition to the farm's early organic practices, Harlow Farm worked with NRCS through the EQIP program to develop a comprehensive Nutrient Management Plan to address overall farm nutrient balance and nutrient applicant setbacks to environmentally sensitive areas, as well as a pest management plan to assess pest control materials to minimize risk to people, wildlife, water and the environment.

In 2011, with NRCS funding, they installed a seasonal high tunnel and more efficient drip irrigation in their fields which uses less water, less energy and produces healthier plants with fewer weeds. As Paul puts it, "It's been great working with NRCS on our expansion and preparing to help Vermont feed itself in the future." Harlow Farm also installed solar panels to generate most of their own energy and became certified under the USDA Good Agricultural Practices (GAP) program.


FOREST

Forest Management Planning

What

Forest Management Planning applies the principles of forest ecology to the growth, harvest, regeneration, and conservation of forests to meet specific objectives of the landowner, whether public or private. Objectives can include producing timber income, creating and maintaining wildlife habitat, protecting soil and water quality, providing recreational opportunities, conserving native plant and animal communities, leaving a legacy for one's heirs, and more.

Why

Forest management plans help landowner's secure financial and other benefits from their forested property while protecting the long-term capacity of the resource to renew itself. Plans help the landowner and any family advisors gage the relative success of recommended management activities, and allow the landowner to choose a different course, if necessary, in a timely way. The plans help maintain the baseline data necessary to help the landowner intelligently respond to unforeseen occurrences on the land or in the life of the family.

Log corduroy help create access over wet areas and provides organic matter to soil.

Forest management plans are also one of several requirements for enrolling forest land in Vermont's Use Value Appraisal (UVA) program, entitling the landowner to a reduction in property taxes. (Enrolled land is taxed not at its "highest and best use" value but at its value as undeveloped forest.)

How

Forest management plans can take many forms, depending on the landowner's goals for the property. In Vermont, those eligible for and looking to enroll in UVA will seek the advice of a forester in developing the plan, which will contain the following components:

- **An assessment and inventory** of soil and water resources and others of importance to the landowner. These may include recreational, aesthetic, and cultural resources, ecologically significant features, and roads and trails.
- **An analysis** of the land's timber resources, forest stand by forest stand. (A stand is a group of trees similar to one another in terms of species composition, tree age, site quality, and tree health.)
- **A prescription** for treatment — harvest, thinning, invasive plant control, seeding, and others — for each stand for the life of the plan.
- **A map** illustrating features identified during the assessment and inventory and the location of each forest stand.

Plans may also contain detailed specifications for various conservation practices such as the restoration of rare and declining habitats, early successional habitat management, riparian forest buffers, erosion control on forest trails and landings during harvesting, stream habitat improvement, and fish passage. The plan may also provide information on projected revenues and expenses, taxes, various reporting requirements, and other matters.

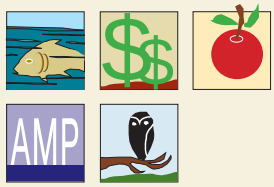
Costs

Costs for forest management plans vary depending on the forest type, landowner goals, and acreage but $12-$17 per acre should be considered a minimum fee for smaller parcels.

Associated and Complimentary Practices

- Forest Roads and Landings
- Portable Skidder Bridges
- Integrated Pest Management
- Invasive Species Management

Benefits



Portable Skidder Bridges

Many of Vermont's conservation districts have portable skidder bridge rental or loan programs.

What

Portable Skidder Bridges are temporary wooden structures used by operators for crossing streams with skidders, forwarders, and in some cases mechanized timber harvesters and other logging equipment. They are reusable, last for three to five years if well-cared for, and can be transported using a log truck. Standard or heavy duty sized bridges can be used depending on the type of equipment and load weight.

Why

The use of skidder bridges during timber harvests helps provide a safe and stable stream crossing. By removing direct access through a waterway, the bridge minimizes streambank and streambed disturbances and the soil erosion and sedimentation which can accompany them. And because the bridges are typically well above the flow of water, they also provide suitable passage for aquatic species such as brook trout.

How

Locating and installing a skidder bridge should maximize safety and minimize erosion and impacts to water quality.

Choose a crossing location carefully. Look for the narrowest possible clear span along a straight stretch of stream, and a nearly level approach for a distance of at least 50 feet on either side of the crossing.

Lay abutment logs on either side of the stream or against the stream bank. These logs will stabilize both sides of the bridge, help make the crossing level, reduce the span if necessary, and address any wet soil conditions on the stream banks.

The abutment logs should allow for placing the bridge at a height of at least two to three feet above water level to allow for high flows.

To lift the panels, wrap each with a chain. Using a log laid across the bridge as a fulcrum and to protect the bridge from the arms of the blade, secure the chain to the blade and lift the panel just high enough to clear any obstacles.

Place the panels so that three feet on each end is resting on solid ground. Place them tight to one another so soil won't fall into the stream. Be sure the bridge is level. Place bumper logs on either side of the bridge.

Waterbars should be installed on approaches to the crossing. The approaches should be brushed in. And exposed soil should be seeded and mulched if the season permits.

Returning the bridge to storage. When the bridge is no longer needed, it should be lifted, not dragged, from its location to the transport vehicle.

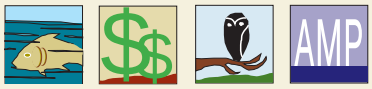
Costs

Skidder bridges can be rented from many Conservation Districts across Vermont for about a $100 monthly fee. The materials required to build a bridge based on Vermont's recommended 20' long, standard panels cost about $2,200 dollars in 2012. Design plans, a materials list, tools and accessories list, and instructions can be found on the Vermont's Department of Forests, Parks and Recreation website.

Associated and Complimentary Practices

- Forest Management Planning
- Forest Roads and Landings
- Riparian Forest and Herbaceous Buffers

Benefits



The photos above show a portable skidder bridge being sited, placed and removed from a logging operation in Bennington County. Using skidder bridges to cross streams and other waterways protects banks and prevents erosion and degradation.

Forest Roads and Landings

What

Well designed forest roads offer periodic access to forest stands for management and harvest operations. Landings provide cleared areas where equipment is staged and the harvest is sorted and temporarily stored. Both are constructed in such a way as to minimize damage to forest soils, wetlands, and water bodies by controlling water flows and soil erosion through careful siting of the roads and landings and through the use of water control measures on them.

Why

Carefully sited, well constructed, and well maintained forest roads and landings will help control damage to forest soils caused by erosion and compaction. They will reduce sedimentation in wetlands and streams and help maintain healthy aquatic habitats. They will help protect water quality downstream where people and animals may have need of those water resources.

A stone lined ditch along a forest road prevents erosion.

Forest roads and landings built and maintained to the highest standards will reduce unnecessary wear on logging and other forestry equipment caused by badly rutted access ways. They will help lengthen the harvest season by reducing puddling on and gullying of access and staging areas. And they will help maintain good neighbor relations by protecting water quality, a community resource, and by reducing mud brought on to shared roads and highways.

How

Forest roads and landings will be most effective when properly located, crowned, and protected from erosion. Locate forest roads and landings away from steep slopes and water features to avoid impacts. Truck road grades of less than ten percent are desirable and skidder trails of less than twenty percent are best. Roads and trails on steeper grades will require more careful shaping, a larger number of drainage structures, and a higher degree of maintenance.

Careful road shaping will forestall a number of erosion issues. A crowned road, with a slope of about four percent on either side of the center line, will divert runoff to the edges of the road while maintaining its shape and allowing for safe equipment access.

Waterbars are required on all forest roads. Their recommended spacing will depend on the steepness of the road. Waterbars are troughs cut across the road and angled slightly downhill. Deep waterbars are appropriate where forest roads will be closed for long periods of time. Culverts, both pipe and open top, are a more expensive but more easily traversed and maintained substitute for waterbars. Broad based dips resemble wide, shallow waterbars with a berm on the downslope edge. They are best used on roads with grades of ten percent or less.

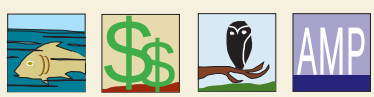
Costs

Basic shaping and grading (with water control structures) on existing forest roads and trails is just under $3 per foot. Repairing eroded sections of trails can cost $9 per foot. Shaping, grading, and seeding a landing can cost up to $2,100 per acre depending on conditions.

Associated and Complimentary Practices

- Forest Management Planning
- Portable Skidder Bridges
- Riparian Forest and Herbaceous Buffers
- Stream Crossing

Benefits



Case Study

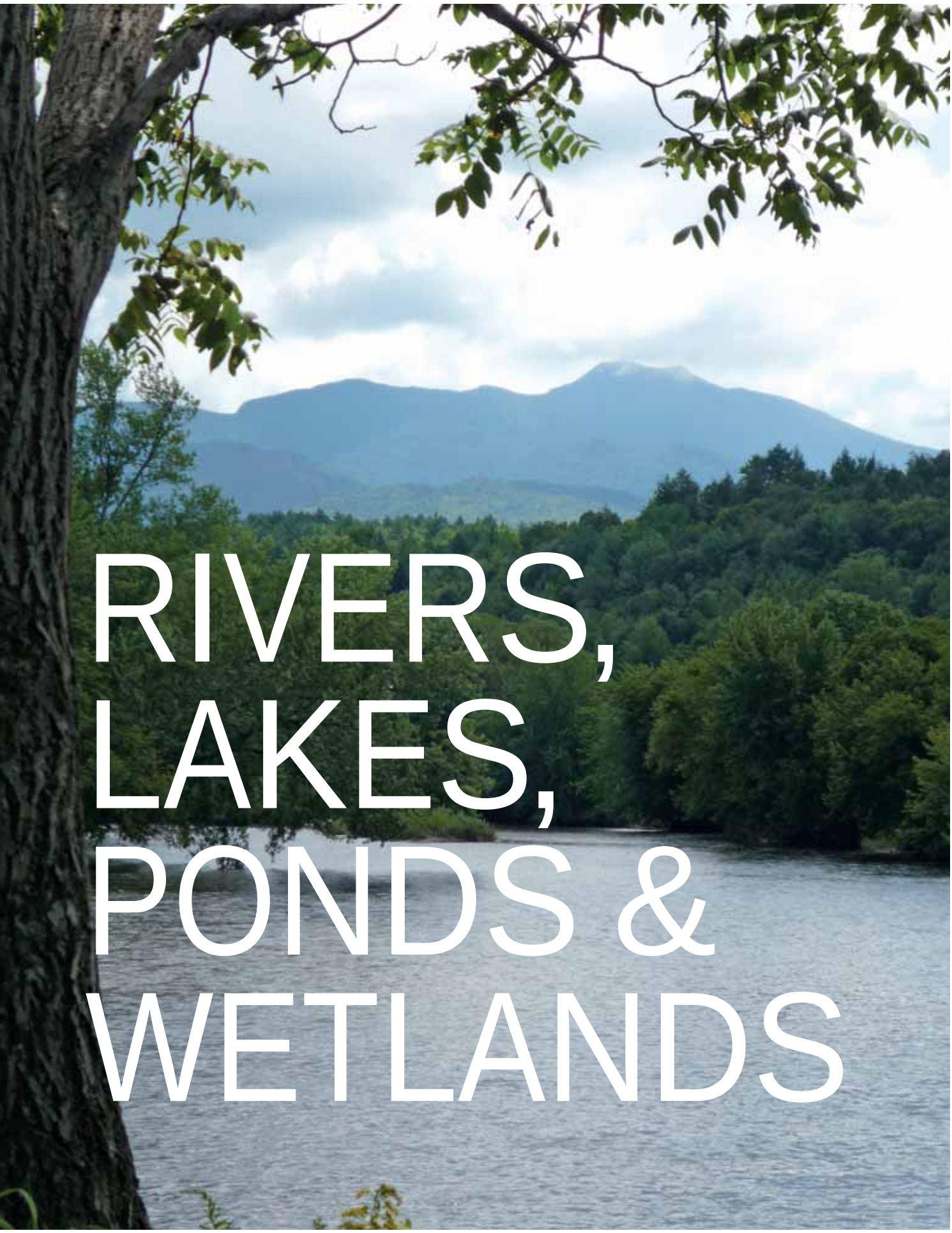
Crandall Logging Peru, VT

Will Crandall, owner of Crandall Logging in Peru, VT, built his first skidder bridge in 2007. “We used to make bridges in the woods out of whatever we could find“ he says. Then, after seeing a skidder bridge display at a workshop in Maine, he decided to it would be easier to build a portable skidder bridge he could move from job to job. He now has two twenty-foot bridges and one sixteen-footer. All were built with native hemlock he’s logged himself.

Will’s panels are slightly narrower than recommended by the Vermont Forests, Parks, and Recreation’s Skidder Bridge Program. At forty-four inches wide, he says, they’re more grapple-friendly. He says they are easy to transport on a log truck, and can be installed using a skidder with a blade or an excavator. His maintenance protocol is simple: wash them after the job is done, and stick them when stacking. He covers his bridges with tin sheets.

“Most rivers have mud banks and silty bottoms,” says Will. “The AMPs won’t allow us to skid logs through them.” (AMPs permit fords only where streambeds have stable beds and gravel or ledge approaches.) Skidder bridges help Will comply with the law, and “they make a huge difference for water quality,” he says. Will Crandall has been working in the woods December to April and June to November for thirty-four years.

Will Crandell has been building and using his own skidder bridges for several years.



RIVERS, LAKES, PONDS & WETLANDS

Grass Filter Strips

Corn fields, each with 25 foot grassed buffers, to allow for proper filtration of applied nutrients, field runoff and other potential surface water contaminants.

What

Grass Filter Strips are areas of perennial vegetation adjacent to cropland or agricultural production areas that protect waterways or wetlands. They are designed to filter and remove nutrients, sediment, organic matter, pesticides, and other pollutants from surface runoff and subsurface flow by deposition, absorption, plant uptake and other processes.

Why

Grass filter strips are a low cost and effective method of filtering agricultural field and production area runoff. They function to capture and filter sediment, pesticides and fertilizers, as well as to provide feeding and nesting habitat for wildlife. Practically, they provide an alternative for marginal, floodprone cropland, and can be used for haying or grazing. They can also provide access for agricultural operations and turn areas for equipment.

How

Grass filter strips should be located immediately down-slope from the source area of contaminants, typically on the contour of a slope along a stream or other waterway. Minimum width should be 25 feet, but wider strips are appropriate adjacent to nutrient rich cropland or adjacent to a stream noted as impaired or contaminated. Uniform sheet flow through the filter strip should be ensured by building on slopes with a grade of at least 1% and of no more than 5%, and dispersing concentrated flows before they reach the filter strip. Using filter strips as a travel lane for equipment or livestock should be avoided.

Site preparation and seeding or planting is typically done in the spring or fall to best ensure plant growth and survival, when soil moisture is most adequate for germination and/or establishment. Species selected for seeding or planting should be suited to site conditions and intended uses, and have the capacity to achieve adequate density and vigor within an appropriate period to stabilize the site. Only viable, high quality, native seed or planting stock should be used such as Kentucky bluegrass. Vermont State-listed noxious plants are not allowed. Filter strips should be maintained as necessary to ensure dense and vigorous growth.

Costs

Establishment of a filter strip typically involves a minimum of site preparation such as applying lime and fertilizer if necessary, and then the broadcast or incorporation of a seeding mix. Costs can vary depending on the grade, location and condition of the site, the density of vegetation that already exists and soil conditions. The average cost to establish a 1-acre area (or a filter strip of 25' by 1,745') in a grass hay mix with minimal site prep is about $500. Costs can be higher if the site is heavily eroded or needs additional preparation such as bank grading and shaping before establishment.

Associated and Complimentary Practices

- Riparian Forest and Herbaceous Buffers
- Conservation Tillage
- Integrated Pest Management

Benefits

Riparian Forest and Herbaceous Buffers

There are a variety of federal, state and local programs to assist with the costs and implementation of vegetated buffers, including the NRCD program Trees for Streams (TFS).

What

Riparian forest and herbaceous buffers are a slightly more advanced version of a grass filter strip. These buffers utilize woody and herbaceous vegetation to similarly remove nutrients, sediment, organic matter, pesticides, and other pollutants from surface runoff and subsurface flow. While these buffers are typically not harvested, there are some species that may be incorporated into a buffer plan which have commercial value (elderberries, etc.). These types of buffers are very similar to what would naturally occur near a river and are a preferred method of protecting water quality.

Why

Riparian forest and herbaceous buffers serve a number of functions. They capture sediment and filter runoff (e.g. pesticides and fertilizers) from agricultural fields and can provide wind shelter for crop fields. Riparian forest buffers, in particular, provide high quality fish and wildlife habitat by providing stream shading, riparian cover and food resources and travel corridors. Finally, forested buffers increase the "roughness" alongside a watercourse, slowing floodwater flows, capturing sediments and nutrients and reducing streambank erosion rates.

How

Buffers widths vary depending on the stability of the river and the management considerations for the cropland or pasture, but a minimum 35 foot average buffer is needed to accomplish the goals of filtering nutrients and protecting riverbanks from erosion. Under Vermont AAPs, all farms are required to have a 10 foot minimum buffer from crop field and the 'top of bank' of an adjacent waterway. However, a minimum 35 foot average buffer is required under many state and federal cost-share programs. Under Vermont AMP's forest landowners must maintain a protected riparian buffer along streams during harvesting operations. An area of native grasses and forbs may be added to a riparian buffer only for concentrated flow conditions, dependent on the site.

Site preparation and planting is typically done in the spring or fall to best ensure plant growth and survival, when soil moisture is most adequate for establishment. Species selected for planting should be suited to site conditions and intended uses, and have the capacity to achieve adequate density and vigor within an appropriate period to stabilize the site. Only high quality, native or adapted planting stock should be used. Species on the Vermont State listed noxious, invasive or watch list are not allowed.

Riparian forest and herbaceous buffers help with the proper filtration of nutrients, runoff and other potential surface water contaminants. They also provide shade, habitat and sustenance for aquatic life.

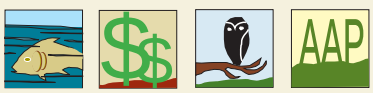
Costs

It is estimated that establishing a forested buffer can cost anywhere between $1,000-$2,000 per acre for the materials alone.

Associated and Complimentary Practices

- Grass Filter Strips
- Animal Trails and Walkways
- Livestock Exclusion

Benefits



Stream Crossings

What

Stream Crossings are stabilized areas or structures that provide a travel way for livestock, equipment, vehicles, etc. while also providing for the normal passage of water within the stream channel during all seasons of the year. Crossings are created using different structural materials depending on the type of crossing designed and the management needs of the farm.

Why

Appropriate crossings provide easy, safe access to all farm fields, improve herd health by keeping livestock out of mud, and keep farm water cleaner by keeping livestock out of waterways. Stabilized stream crossings are needed where livestock or equipment cross a stream or waterway. Without proper stabilization, these access areas become degraded over time resulting in erosion, sedimentation, bank failure, and loss of land. Additionally, improper crossings can lead to injured animals or damaged equipment. Proper stream crossings are required by the Vermont AAPs and AMPs.

A new stream crossing and vegetated buffer along a stream at the Hull's farm in Enosburg. These practices help to reduce erosion and better protect the stream during livestock use. A combination of permanent and temporary fencing is used to keep livestock off of the bank and to ensure controlled access to the stream.

How

Stream crossings can be built in several different ways using different materials. The primary tasks are to slope the banks of the stream on each side and create a firm streambed. Banks should be protected with gravel or filter fabric and made flat enough for livestock or equipment to move down safely. The streambed should be made firm enough so that livestock or equipment will not cause ruts. For gravel or bedrock streams, additional work may not be needed.

The simplest type of streambed protection is to lay rock over filter fabric, however livestock may not like walking on larger rocks and small rocks may wash out during high water flows. Plastic webbing filled with gravel or hog slats placed over filter fabric are other options for creating a stream crossing. A minimum 6 inch base of material should be placed and compacted on geotextile before placement of surfacing material. Surfacing material can be crushed stone, gravel or slag. Fine material may be added to surfacing material to allow better compaction and provide a more comfortable surface for livestock to walk over.

It is very important, regardless of the type of stream crossing created, to keep the material below the level of the streambed to prevent materials from being washed out during high flows and to keep the crossing from impeding the natural flow of the stream. If the stream crossing is to

Stream crossing and animal trail leading to the farmstead. Permanent fencing at crossing ensures that livestock have only controlled access to the waterway.

be used by livestock, it is important to properly fence off access to the stream so that livestock use the crossing and remain out of the stream itself.

Fish passage must be maintained for any new structure. Check with local and State authorities to obtain any necessary permits before working in streams. All disturbed areas shall be limed, fertilized and seeded in accordance with Vermont construction standards. Additionally, it is the excavation contractor's responsibility to call 'Dig Safe' and to comply with all Vermont laws and regulations regarding the location and work around underground utilities.

Costs

Implementation costs vary depending on the type of stream crossing constructed. For example, a 12 foot wide by 30 foot long simple ford-type crossing, as described above utilizing gravel, geotextile and seeding/mulching along disturbed banks will cost about $1,000–$1,200. A culvert stream crossing requiring an 18 inch culvert pipe that is 20 feet long, along with gravel fill and seeding/mulching will cost about $1,800–$2,000.

Geotextile fabric is placed under stone (above) to construct this ford-type stream crossing on an organic dairy farm in Guilford, VT. (Below) Completed stream crossing ready for use.

Associated and Complimentary Practices

- Livestock Exclusion,
- Riparian Forest and Herbaceous Buffers

Benefits

Livestock Exclusion

What

Livestock exclusions use temporary or permanent fencing to control animal access to ponds, rivers and streams. Fencing livestock out of streams is a simple, cost-effective way for farmers to improve water quality in waters flowing through their farm. Utilizing either temporary or permanent fencing material, livestock are limited in their ability to directly access the stream and its banks. This provides a number of benefits to the herd, the farmer, and the land.

Permanent fencing runs the length of the brook along this pasture. Keeping livestock out of waterways helps to protect water quality and herd health.

Why

Installing livestock exclusions can improve animal health and reduce farm costs. When pollutants such as animal wastes and sediment are kept from the water supply, livestock drinking water quality improves. Weight gain may increase and milk and butterfat production may improve. Overall herd health may be enhanced. Denying livestock access to streams and other water features removes them from contact with a wide range of bacteria and viruses, including those responsible for foot rot, bovine virus diarrhea, fever, tuberculosis, and environmental mastitis. Stream exclusion also prevents leg injuries that cattle may suffer on muddy banks. Finally, water quality is protected when livestock are denied access to ponds, rivers and streams. In some cases The Vermont AAP's may require livestock to be excluded from perennial streams.

How

A number of fencing options are available, depending on the type of livestock. Fencing may be woven wire, barbed wire, polywire, or single- or multi-strand high tensile. Farmers considering enrolling in State or Federal cost-share programs should be aware that those agencies will cover only certain fencing types.

Where fencing is to be strung parallel to a watercourse or pond, Vermont's AAP requirements regarding buffer width will come into play. AAPs require a perennially vegetated buffer of a minimum of 10 feet in width between a water body and annual crop land, more where runoff is by concentrated flow.

In order to be effective, exclusion fencing must be maintained. This can be problematic where the fence is located within the floodplain. In this case, a forested buffer may provide some damage mitigation from debris during high flows. Farmers should check fences regularly and address repairs as soon as possible

Where exclusion fencing denies livestock former access to drinking water, alternative water facilities must be supplied.

Costs

Electric polywire fencing can cost less than $1 per foot, installed. High tensile electric wire fence can cost about $2.50 per foot, installed. Both scenarios assume a power source. (Solar chargers are not included in the cost). A woven wire fence costs a little more than $5 per foot.

Associated and Complimentary Practices

- Animal Trails and Walkways
- Alternative Water Sources

Benefits

Case Study

Livestock exclusion fencing and an armored stream crossing on Highbrook Farm, S. Woodstock, VT.

High Brook Farm South Woodstock, VT

Matt and Laura Spittle operate a Morgan breeding farm with several stallions and a small herd of broodmares. The farm is at the headwaters of the Kedron Brook in the Ottauqueechee watershed and the stream runs through one of their pastures. The Spittles have always been concerned about their horses being in the brook but had not found a satisfactory way to limit access.

The main concern was the type of fencing that could be safely used for mares and foals. With research, a high tensile wire encased in a one inch polymer fence was found to be acceptable. Four strands were used. Due to the wet soils where the fencing had to be installed, a composite post was used for support with treated posts at corners. The composite posts were predrilled to accommodate the fence and then pounded in.

Grant funds were secured to help the owners install two livestock crossings through the stream and for the fencing materials. The Spittles supplied the labor and machinery. Not only did the fencing project look great, it was safe for the horses and the stream was protected.

RESOURCES

FARMSTEAD

ROOF RUNOFF STRUCTURES

Fulhage, Charles D. and D.L. Pfost. 1994. Roof Gutters for Dairy Barns: WQ322. University of Missouri Extension. Retrieved from http://extension.missouri.edu/p/WQ322

Minnesota Department of Agriculture. Roof Runoff Management. 2012. Minnesota Conservation Funding Guide. Retrieved from http://www.mda.state.mn.us/protecting/conservation/practices/roofrunoff.aspx

ANIMAL TRAILS AND LANEWAYS

University of California Cooperative Extension and Natural Resources Conservation Service. Animal Trails and Walkways #575. Farm Water Quality Planning Management Practice. Retrieved from http://www.awqa.org/pubs/conservation/mgmtpractices.pdf

Vermont Natural Resources Conservation Service. February, 2011. Animal Trails and Walkways #575. Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT575-0311.pdf

ON-FARM COMPOSTING

Caduto, Marie Levesque. 2003. Composting Animal Mortalities On the Farm Fact Sheet. Vermont Natural Resources Conservation Districts and the Vermont Agency of Agriculture, Food, and Markets. Vermont. Retrieved from HYPERLINK "http://www.nerc.org/documents/manure_management/VT/composting_animal_mortalities.pdf"http://www.nerc.org/documents/manure_management/VT/composting_animal_mortalities.pdf

Cornell Waste Management Institute. 2007. Composting. Cornell University College of Agriculture and Life Sciences. Retrieved from http://cwmi.css.cornell.edu/composting.htm

Vermont Natural Resources Conservation Service. April, 2004. Composting Facility #317. Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT317-0404.pdf

SEASONAL HIGH TUNNELS

Vermont Natural Resources Conservation Service. July, 2011. Conservation Programs to Support Local Food Systems: Seasonal High Tunnels. Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_010212.pdf

Vermont Natural Resources Conservation Service. June, 2011. Seasonal High Tunnel System for Crops: Interim Conservation Practice Job Sheet #798. Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/JS798VT_FillableForm.pdf

FIELD

ALTERNATIVE WATER SOURCES

Higgins, Steve F., Stamper, D. J., and Wightman, S. J. May, 2011. Alternative Water Source: Developing Springs for Livestock: AEN-98. University of Kentucky College of Agriculture Cooperative Extension. Retrieved from http://www.ca.uky.edu/agc/pubs/aen/aen98/aen98.pdf

Jemison, John M., and Jones, Chris. May, 1996. Watering Systems for Livestock. University of Maine Cooperative Extension Bulletin # 7129. Retrieved from http://umaine.edu/publications/7129e/

Stone, R.P., and Clarke, S. April, 2004. Alternative Livestock Watering Systems. Agdex # 716. Ontario Ministry of Agriculture, Food and Rural Affairs. Retrieved from http://www.omafra.gov.on.ca/english/engineer/facts/04-027.pdf

Vermont Natural Resources Conservation Service. November, 2008. Watering Facility–Nose Pumps# 614. Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/JS614VT_NosePump_FillableForm.pdf

Vermont Natural Resources Conservation Service. March, 2011. Watering Facility # 614. Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT614-0311.pdf

CONSERVATION CROP ROTATION

Iowa Natural Resources Conservation Service. January, 2008. Conservation Crop Rotation Iowa Job Sheet. Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_005649.pdf

Vermont Natural Resources Conservation Service. April, 2011. Conservation Crop Rotation #328. Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT328-0411.pdf

Vermont Natural Resources Conservation Service. July, 2009. Organic Production: Using NRCS Practice Standards to Support Organic Growers: Crop Rotation. Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1043184.pdf

Wyoming Natural Resources Conservation Service. November, 2008. Conservation Crop Rotation Fact Sheet. Retrieved from ftp://ftp-fc.sc.egov.usda.gov/WY/CSP/WY_Cons_Crop_Rot_Fact_Sheet09.pdf

CONSERVATION TILLAGE

Conservation Technology Information Center. 2013. Top Ten Conservation Tillage Benefits. Retrieved from http://www.ctic.purdue.edu/resourcedisplay/293/

Vermont Natural Resources Conservation Service. Residue Management, No-till/Strip till/Direct Seed Practice Introduction #329. Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_026327.pdf

COVER CROPPING

Cornell University College of Agriculture and Life Sciences. 2009. Cover Crops for Vegetable Growers. New York State Agricultural Experiment Stations. Retrieved from http://www.hort.cornell.edu/bjorkman/lab/covercrops/

University of Massachusetts Extension: Center for Agriculture. 2013. Brassicas: Cover Crops. Retrieved from http://extension.umass.edu/vegetable/articles/brassicas-cover-crops

Vermont Natural Resources Conservation Service. Cover Crop #340. Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT340-0411.pdf

STRIP CROPPING

Carman, Dennis. Strip Cropping. Minimizing Losses from Agriculture. Arkansas Natural Resources Conservation Service. Retrieved from http://www.sera17.ext.vt.edu/Documents/BMP_strip_cropping.pdf

Vermont Natural Resources Conservation Service. May, 2004. Strip Cropping #585. Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT585-0504.pdf

GRASSED WATERWAYS

Green, C.H. and Haney, R. Grassed Waterways. Texas Natural Resources Conservation Service. Retrieved from http://www.sera17.ext.vt.edu/Documents/BMP_Grassed_Waterways.pdf

Vermont Natural Resources Conservation Service. February, 2011. Grassed Waterways #412. Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT412-0311.pdf

ROTATIONAL GRAZING

University of Vermont Extension Service. December, 2005. *Rotational Grazing.* Vermont Pasture Network. Retrieved from http://www.uvm.edu/~pasture/?Page=mig.html

Vermont Natural Resources Conservation Service. September, 2010. *Prescribed Grazing #528*. Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_010198.pdf

Williams, J. Craig and Hall, Marvin H. *Agronomy Facts 43.* Penn State Extension College of Agricultural Sciences. Retrieved from http://extension.psu.edu/plants/crops/forages/pastures/management/four-steps-to-rotational-grazing

NUTRIENT MANAGEMENT PLANS &

Bhumbla, D.K. *Phosphorus Index for Nutrient Management.* West Virginia University Extension Service. Retrieved from http://www.caf.wvu.edu/~forage/phosman/phosman.htm

Soil, Crop and Pest Management. University of Massachusetts Extension. 2012-2013. Retrieved from http://extension.umass.edu/vegetable/soil-crop-pest-management/soil-nutrients

SOIL AND MANURE TESTING

University of Massachusetts Extension: Center for Agriculture. *New England Vegetable Management Guide 2012-2013.* Retrieved from http://nevegetable.org/index.php/cultural/soil-tests

EFFICIENT IRRIGATION

Cornell University Soil and Water Management. 2010. *Competency Area 3: Drainage and Irrigation AEM.* HYPERLINK "http://nrcca.cals.cornell.edu/"Northeast Region Certified Crop Adviser (NRCCA) Study Resources. Retrieved from http://nrcca.cals.cornell.edu/soil/CA3/

Rutgers New Jersey Agricultural Experiment Station. July, 2008. *Methodology for Calculation of Costs and Returns of Production.* Retrieved from http://aesop.rutgers.edu/~farmmgmt/ne-budgets/methodology.html#a24

University of Massachusetts Extension: Center for Agriculture. 2013. *New England Vegetable Management Guide 2012-2013.* New England Vegetable Management Guide: Irrigation. Retrieved from http://nevegetable.org/cultural-practices/irrigation

FOREST

FOREST MANAGEMENT PLANS

Beattie, M., Thompson, C. and Levine, L. 1993. *Working with Your Woodland: A Landowner's Guide. Revised Edition.* University Press of New England.

Bennett, Karen P. editor. 2010. *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire.* Second Edition University of New Hampshire Cooperative Extension, Durham, N.H. http://extension.unh.edu/goodforestry/

Smith, David M., Larson, Bruce C., Kelty, Matthew J., and Ashton, P Mark S. 1997. *The Practice of Silviculture.* Applied Forest Ecology. 9th Edition. John Wiley and Sons.

Vermont Department of Forests, Parks, and Recreation Forestry Division. March, 2010. *Use Value Appraisal Program Manual.* Vermont Agency of Natural Resources. Retrieved from http://www.vtfpr.org/resource/documents/UVAManual.pdf

FOREST ROADS AND LANDINGS

Vermont Department of Forests, Parks, and Recreation. 2009. *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont.* Vermont Agency of Natural Resources. Retrieved from http://www.vtfpr.org/watershed/documents/Amp2009pdf.pdf

Vermont Natural Resources Conservation Service. January, 2012. *Forest Trails and Landings #655.* Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT655-0112.pdf

Wesit, Richard L. 1998. *A Landowner's Guide to Building Forest Access Roads.* United States Deparment of Agriculture. Forest Service. Northeastern Area State and Private Forestry. NA-TP-06-98. http://www.na.fs.fed.us/spfo/pubs/stewardship/accessroads/accessroads.htm

PORTABLE SKIDDER BRIDGES

Vermont Department of Forests, Parks, and Recreation. 2001. *Wooden Portable Skidder Bridge Information Sheet.* Vermont Agency of Natural Resources. Retrieved from http://www.vtfpr.org/watershed/portbridgebroc.cfm

Vermont Department of Forests, Parks, and Recreation. 2001. Better Stream Crossings Using Portable Skidder Bridges Video. Vermont Agency of Natural Resources. Retrieved from http://www.youtube.com/watch?v=myEotaZGdEI

RIVERS, LAKES, PONDS & WETLANDS

GRASS FILTER STRIPS

Natural Resources Conservation Service. *Filter Strip Practice Introduction #393.* Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_025826.pdf

USDA Farm Services Agency. July, 2010. *Agricultural Resource Conservation Program Handbook 2-CRP, Rev 5.*

Vermont Natural Resources Conservation Service. *Filter Strip #393.* Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT393_0109.pdf

RIPARIAN FOREST AND HERBACEOUS BUFFERS

USDA Farm Services Agency. July, 2010. *Agricultural Resource Conservation Program Handbook 2-CRP, Rev 5.*

Vermont Natural Resources Conservation Service. January, 2009. *Riparian Forest Buffer #391.* Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT391-0109.pdf

STREAM CROSSINGS

Vermont Natural Resources Conservation Service. March, 2007. *Stream Crossings #578.* Retrieved from http://efotg.sc.egov.usda.gov/references/public/VT/VT578-0307.pdf

LIVESTOCK EXCLUSION

Zekoski, R., Benham, B., and Lunsford, C. September, 2007. *Streamside Livestock Exclusion: A Tool for Increasing Farm Income and Improving Water Quality.* Virginia Department of Conservation and Recreation, VCE #442-766.

ABBREVIATIONS AND ACRONYMS

ACAP	Agronomy & Conservation Assistance Program (limited to Lake Champlain Basin Area)
BMP	Best Management Practices
CREP	Conservation Reserve Enhancement Program
EQIP	Environmental Quality Incentive Program
FAP	Farm Agronomic Practices Program
GRP	Grassland Reserve Program
LTP	Land Treatment Planning
NMPIG	Nutrient Management Plan Incentive Grants Program
PFW	Partners for Fish and Wildlife Program
PSBP	Portable Skidder Bridge Program
PGMP	Pesticide and Groundwater Monitoring Program
REAP	Renewable Energy for Agriculture Program
TFS	Trees for Streams Program
VABP	Vermont Agricultural Buffers Program

ORGANIZATIONS

FSA	Farm Service Agency
NRCD	Natural Resoruces Conservation District
NRCS	Natural Resoruces Conservation Service
USDA	United States Department of Agriculture
USDA RD	USDA Rural Development
USFWS	United States Fish and Wildlife Service
UVM Extension	University of Vermont Extension
VAAFM	Vermont Agency of Agriculture, Food & Markets
VACD	Vermont Association of Conservation Districts
VT DEC	Vermont Department of Environmental Conservation
VT DPS	Vermont Department of Public Services

Conservation in Vermont

Best Management Practices for Farm and Forest Owners

Vermont Natural Resources Conservation Districts